Oesterreichische Nationalbank

Eurosystem

Workshops

Proceedings of OeNB Workshops

Macroeconomic Models and Forecasts for Austria

November 11 to 12, 2004

No. 5

The issues of the "Workshops – Proceedings of OeNB Workshops" comprise papers presented at the OeNB workshops at which national and international experts – including economists, researchers, politicians and journalists – discuss monetary and economic policy issues.

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Publisher and editor:
Oesterreichische Nationalbank
Otto-Wagner-Platz 3, AT 1090 Vienna
Günther Thonabauer, Secretariat of the Governing Board and Public Relations
Internet: www.oenb.at
Printed by: Oesterreichische Nationalbank, AT 1090 Vienna

DVR 0031577

Vienna, May 2005

Contents

Opinions expressed by the authors of studies do not necessarily reflect the official viewpoint of the OeNB.

The presented articles were prepared for an OeNB workshop and therefore a revised version may be published in other journals.

Editorial

On November 11 and 12, 2004, the Oesterreichische Nationalbank (OeNB) held a workshop on "Macroeconomic Models and Forecasts for Austria" (in German language). As *Josef Christl* (OeNB) emphasized in his introductory remarks, forecasts are of utmost importance for economic policymaking Due to their important role, transparency on the forecasting tools and methods used by policy makers and policy advisors is highly desirable Accordingly, the first aim of the workshop was to enhance such transparency. Indeed, the workshop – the first of its kind held in Austria – covered the bulk of the econometric models used regularly in Austria. Its nearly 100 participants bear witness of the strong interest in such information.

A second goal of the workshop was to encourage an exchange of expertise and experiences between the main institutions that work on macroeconomic modeling in Austria, namely WIFO (the Austrian Institute of Economic Research), IHS (the Institute for Advanced Studies), the OeNB and Joanneum Research. The OeNB warmly thanks all the participating institutions for their readiness to embark upon, and contribute to such an active and open exchange. The purpose of this volume is to document the proceedings and to make them available to a wider national and international public.

The workshop was organized into four sessions. Topic of **session 1** was a comparison of the **structural macroeconomic models** of the OeNB, IHS and WIFO. *Gerhard Fenz* (OeNB) presented the OeNB's macromodel (AQM – Austrian Quarterly Model). This model follows the neoclassical synthesis tradition. Equilibrium is neoclassical in the long run, where output is supply-determined, but Keynesian in the short run, where output is demand-determined. The rationale is that frictions on the goods and labor markets slow the adjustment of the economy to its equilibrium level. The OeNB uses this model to prepare its semiannual macroeconomic forecast and to perform simulations. In the Multi-Country Model, the model used by the Eurosystem and coordinated by the European Central Bank (ECB), AQM represents the country block for Austria and it is linked to the other As the only quarterly model for Austria, AQM captures intra-year trends.

Next, *Helmut Hofer* (IHS) and *Robert Kunst* (IHS and University of Vienna) elucidated the IHS's econometric model. This model, the LIMA (Link Model Austria) model, is Keynesian, meaning that output is demand-determined. The model is used primarily for economic forecasting purposes; in addition, it serves to perform simulations. LIMA is the Austrian contribution to the United Nations' LINK project, an international research activity which integrates independently developed national econometric models into a global econometric model.

The first session concluded with a presentation by *Josef Baumgartner* (WIFO), of WIFO's macroeconomic model, WIFO-Macromod, which is also a typical demand-determined model. Supply factors are taken into account in price and wage determination. WIFO utilizes its Macromod model for its annual medium-term forecast (with a five-year forecast horizon) and for simulations. However, WIFO does not use the model for its quarterly economic forecast.

The discussants (*Rudolf Zwiener,* German Institute for Economic Research – DIW; *Thomas Warmedinger,* ECB) concurred in emphasizing that while the details differed, the models nevertheless had many features in common. All three models are error correction models that capture both long-term equilibrium effects and short-term adjustment effects. Simulations comparing the reactions of the models to specified shocks produced comparable and broadly plausible results according to the dicussants. The reactions of the three models are characterized by a rather strong wage-price spiral in Austria, a small, open market economy. Conversely, the reactions to changes in price competitiveness in foreign trade are fairly weak.

Session 2 dealt, first of all, with **short-term forecasts using statistical models**. *Martin Schneider* (OeNB) presented the OeNB's short-term economic indicator, which is based on the results of two econometric models: a state space model and a dynamic factor model. The state space model uses six selected indicators (ifo business climate index, credit volume, number of vacancies, real exchange rate, employment, new car registrations) to estimate GDP. The dynamic factor model employs a set of 143 indicators, from which it extracts the major driving forces behind the business cycle by means of dynamic time series techniques. To adjust the models for discretionary economic policy measures, institutional issues or structural breaks, expert judgement is incorporated into the result. In his comment, *Robert Kunst* (University of Vienna) provided some fundamental thoughts on business indicators and on the standard tests used in the empirical part to assess the quality of forecasts.

Sylvia Kaufmann (OeNB) discussed her work on the identification of cyclical turning points for Austria. To this end, information about cyclical conditions is extracted from a large number of Austrian and other countries' economic time series. The method groups those time series together which display similar dynamics over the business cycle. The classification is not specified a priori; rather, it is estimated together with the model parameters. The model identifies a group of series that leads another one, while a third group of series moves independently from two former series. To determine turning points, the economic cycle is modeled using a Markov process which identifies periods of below- and above-average growth. The turning points determined by this process are compared with those identified by the Economic Cycle Research Institute. It turns out that in the first half of the 1990s, the turning points are nearly identical whereas minor deviations occur subsequently. *Robert Kunst* (University of Vienna) emphasized the innovative character of this approach. He pointed out that describing an economy by means of just two states was an extreme simplification.

The first day of the workshop concluded with a presentation by *Thomas Url* (WIFO) of a **long-run economic model (A-LMM)** for Austria. A-LMM was developed jointly by WIFO and IHS. This model is suited to simulating the long-term effects of aging on employment, output growth and the solvency of the social security system. The long-run equilibrium solution of the model is determined by supply-side factors and is derived from neoclassical theory. Demand components are modeled by means of dynamic optimization, which takes into account the forward-looking behavior of economic agents and allows for a smooth transition to the long-term growth path. By disaggregating the population into six age cohorts, the model is able to account for future demographic trends. Alternative scenarios were developed to highlight the effect on the economy of aging from different perspectives. In his comment, *Heinz Glück* (OeNB) underlined that on a scale from theoretical to empirical coherence, the long-run nature of the model clearly placed the main focus on its theoretical foundation.

Session 3 on the second day of the workshop was devoted to **inflation and exchange-rate forecasts**. To start with, *Gabriel Moser* and *Fabio Rumler* (both OeNB) presented model-based inflation forecasts. These forecasts use various models to project changes in the Harmonised Index of Consumer Prices and its five sub-indices. Factor models as well as VAR (vector autoregressive) and ARIMA (auto-regressive integrated moving average) models are employed. The factor models are identified as exhibiting the highest forecasting accuracy for five out of six indices; in two cases, forecasting accuracy may be improved further by combining factor model forecasts with forecasts made using VAR models. All ARIMA models produce less accurate forecasts. Moreover, the aggregation of the forecasts for the sub-indices produce a marginally better result than the forecast of the overall index itself. In his comment, *Gerhard Rünstler* (ECB) identified the problems inflation forecasting faces. Using empirical evidence for the euro area, Rünstler showed that non-stationarity or near-non-stationarity of inflation generally limit predictability.

Ines Fortin (IHS) presented the model used by the IHS for exchange rate forecasting. In general, exchange rate developments are hard to forecast. More complex models do not succeed in producing significantly better exchange rate forecasts than simpler models, such as extrapolating the last available value (random walk forecasting). This applies particularly to short-term forecasts. However, experience with the IHS exchange rate model also shows that the longer the forecasting horizon is, the better the model's forecasting quality is compared to that of random walk forecasting. In his comment, *Harald Grech* (OeNB) clearly established that even though the IHS's monetary exchange rate model is frequently used in the literature, it rarely delivers significantly better results over short-term horizons of up to 12 months. Harald Grech briefly sketched some of the weak points of the monetary model, touched upon empirical estimation methods (VARs), and then made two proposals which could possibly improve forecasting quality (use of real-time data or panel estimates).

Finally, **session 4** of the workshop covered **input-output models**. *Kurt Kratena* (WIFO) described the most recent version of WIFO's MULTIMAC IV input-output-based macroeconomic model. The model integrates econometrically estimated behavioral equations for goods and factor demand, prices, wages and employment using input-output relations for 36 sectors. WIFO regularly uses the MULTIMAC IV model to simulate the sectoral impact of shocks and economic policy measures Kurt Kratena applied the model to two simulations (the expansion of investment in information and communication technology including counterfinancing, the impact of road pricing) to demonstrate its possible uses.

Oliver Fritz (WIFO) and *Gerhard Streicher* (Joanneum Research) reported on work in progress on developing MULTIREG, the first multiregional input-output model for Austria. The model consists of three main parts: first, the regional input-output tables of all nine Austrian federal provinces with time-variant coefficients (based on the make-use approach); second, a trade matrix that captures the delivery linkages between the provinces; third, econometrically estimated behavioral equations. The two discussants (*Karin Wagner*, OeNB, and *Josef Richter*, University of Innsbruck) drew attention to the contradictory context in which such models are built. The demands on an ideal input-output model cannot be fulfilled in practice. Hence, all models invariably represent a compromise in terms of coherence, data timelines, the degree of detail etc. Josef Richter concluded his contribution with a discussion of the demands on the statistical system in Austria from the perspective of input-output modeling.

In conclusion , the workshop succeeded in giving a snapshot of the current state of macroeconomic modeling in Austria. The range of models presented is directly related to the variety of requirements which guided their development. Different forecasting horizons (short versus medium versus long-term), different aggregation levels (sectoral and regional), different numbers of variables to be forecast require different model types. But it is also interesting to see that models designed in different institutions for the same or very similar purposes, such as the macroeconomic models of WIFO, IHS and OeNB, are also shaped by the institutional context in which they were developed. They reflect the views and preferences of their designers, the resources available in designing them, and the various pragmatic adjustments made over time in view of problems encountered, changing demands, and, last but not least, changing data. It is likely that the landscape of economic models used in Austria will undergo major changes over the next decade. Progress in economic theory, more sophisticated econometric methods as well as rapidly increasing computing power have prepared the ground for a new generation of macroeconomic models. For instance, dynamic stochastic general equilibrium models are now becoming a standard tool for forecasting and policy simulations.

All in all, the workshop showed that both economists in the academic and research profession and in policy work, are keenly interested in the design and use of macroeconomic models for forecasting purposes. Thus, the call by many participants for a follow-up event seems to be more than warranted and will hopefully be taken up not too far away in the future.

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AQM
The Austrian Quarterly Model of the Oesterreichische Nationalbank

Gerhard Fenz
Martin Spitzer

Oesterreichische Nationalbank

Abstract

The modeling strategy of the Austrian Quarterly Model (AQM) is in the tradition of the "neoclassical synthesis", a combination of Keynesian short-run analysis and neo-classical long-run analysis. The short run dynamics are based on empirical evidence, the long-run relationships are derived from a neoclassical optimization framework. Adjustment processes to the real equilibrium are sluggish. Imperfections on goods and labor markets typically prevent the economy to adjust instantaneously to the long-run equilibrium. In the current version of the AQM the formation of expectations is strictly backward looking. The relatively small scale of the model keeps the structure simple enough for projection and simulation purposes, while incorporating a sufficiently detailed structure to capture the main characteristics of the Austrian economy. The main behavioral equations are estimated using the two-step Engle-Granger technique. The AQM constitutes the Austrian block of the ESCB multi-country model (MCM).

1. Introduction

Traditionally, the range of econometric models used by a central bank consists of a set of time series models for short-term assessments, calibrated theoretical models, and traditionally estimated structural models. The present paper deals with the last but currently at the OeNB most frequently used element of this range, the Austrian Quarterly Model (AQM). At the same time, the model constitutes one of the building blocks of the Multi-Country-Model (MCM) of the European System of Central Banks (ESCB). The purpose of the AQM is twofold. First, it is used in preparing macroeconomic projections for the Austrian economy, published twice a year in June and December. Second, in scenario analysis the effects of economic shocks on the Austrian economy are simulated. The specification of the AQM is not fixed. The equations are frequently reviewed in the light of new data, information and research.

The model shares the general features of the modeling strategy of the Multi-Country Model (MCM). One element of this strategy involves the decision to build a relatively small-scale model to keep the structure simple enough for projection and simulation purposes while incorporating a sufficiently detailed structure to capture the main characteristics of the Austrian economy. Another element of the modeling strategy is to embody the "neoclassical synthesis", a combination of Keynesian short-run analysis and neoclassical long-run analysis popularized by Samuelson (1967). More precisely, the short run dynamics are estimated to conform to empirical evidence, while the long-run relationships are derived from theoretical optimization. An aggregate neoclassical production function is the central feature of the long-run behavior with a vertical supply curve. The neoclassical relationships ensure that the long-run real equilibrium is determined by available factors of production and technological progress. Therefore real output growth in the long run is independent both of the price level and of inflation. Imperfections in the markets for goods and labor prevent the economy from returning instantaneously to the long-run equilibrium. Thus, the economy converges slowly towards its equilibrium in response to economic shocks. Simulation exercises with the AQM typically show that the adjustment process is rather long, reflecting past experience in the Austrian economy and the fact that expectations formation is strictly backward-looking in the current version of the model. Extensions to include forward-looking elements in the price and wage block are straightforward.

A typical macroeconomic model for an economy with an independent monetary policy incorporates a monetary policy rule. By choosing a target level for a nominal anchor this rule ensures a nominal equilibrium by defining an appropriate feedback rule for nominal interest rates. Typical examples for nominal target variables are price levels or more recently, inflation rates. As long as monetary aggregates are not targeted by interest rate rules, there is no specific role for money in this kind of models. Thus, monetary aggregates typically influence neither output nor prices. Assuming that the velocity of money is constant, money supply can be thought of moving in line with nominal GDP. Since Austria is part of the euro area and monetary policy decisions are based on an assessment of euro-area-wide conditions, a national interest rate rule is not appropriate. Thus, interest rates are typically kept exogenous in projection and simulation exercises. The model incorporates a fiscal policy rule along a public debt criterion of 50% of GDP. However, in most cases fiscal policy is assumed to be exogenous and the fiscal closure rule is not activated and only standard automatic fiscal stabilizers are at work.

Further important features of the AQM follow from the main behavioral equations. The long run equilibrium levels of the three main variables – investment, employment, and the GDP-deflator at factor costs – are determined simultaneously in the neoclassical supply block. The coefficients of the production function were estimated treating the supply block as a nonlinear system. The equilibrium level of investment depends on output and relative factor costs. The long-run employment equilibrium is defined by the inverse of the production function. The GDP deflator at factor costs, the key price variable, is set as mark-up over marginal costs. Foreign prices enter the model via import prices. In the long run, real wages are set in line with productivity while the short run dynamics are characterized by a Phillips curve relationship. Consistent with the permanent-income hypothesis, private consumption is a function of real disposable household income and real wealth in the long-run. Nominal short-term interest rates also determine the equilibrium level of consumers' expenditures, capturing substitution effects and credit constraints. Consumption is not further disaggregated into durables and non-durables due to data constraints. Finally, foreign trade is determined by measures of world demand, domestic demand, and competitiveness.

The main behavioral equations are estimated using the two-step Engle-Granger technique. Long-run relationships are estimated in levels and then enter the dynamic equations as error-correction terms. The simulation and projection features of the AQM are driven by 38 behavioral equations. An additional 107 equations contain linking relationships, identities and transformations to ensure consistency and a sufficiently detailed analysis. Overall 217 variables enter the model.

The paper is organized as follows. In section 2 the theoretical background and the estimation results of the supply block which determine the long-run equilibrium of the model are presented. Section 3 gives a bird eye view of the AQM-structure. Sections 4 to 6 deal with the main behavioral equations of the AQM. We start with the demand components of real GDP private consumption, investment, foreign trade and stocks. Then the estimation results for the labor market, i.e. employment and the labor force, are presented. Finally the price block concludes the presentation of the main behavioral equations. In section 7 the steady state properties of the AQM are described and illustrated by two long-run simulations. Finally in section 8 results for three standard short run simulation exercises – a fiscal policy, a monetary policy and a world demand shock – are discussed.

2. Theoretical Background and the Supply Block

Consistent with the neoclassical framework, the long-run aggregate supply curve is assumed to be vertical and the long-run equilibrium is solely supply driven. The economy is assumed to produce a single good (YER). The technology is described by a standard constant-returns-to-scale Cobb-Douglas production function with two input factors, capital (KSR) and labor (LNN). Technological progress is exogenously given at a constant rate (γ) and enters in the usual labor-augmenting or Harrod-neutral manner. The long-run properties of the model can be derived by standard static optimization techniques. A representative firm maximizes profits (π) given the technology constraints:

$$\max \pi(YER, LNN, KSR) = YFD \cdot YER - WUN \cdot LNN - CC0 \cdot KSR$$
$$s.t. \quad YER = \alpha \cdot KSR^{\beta} \cdot LNN^{1-\beta} \cdot e^{(1-\beta)\cdot\gamma\cdot T}$$

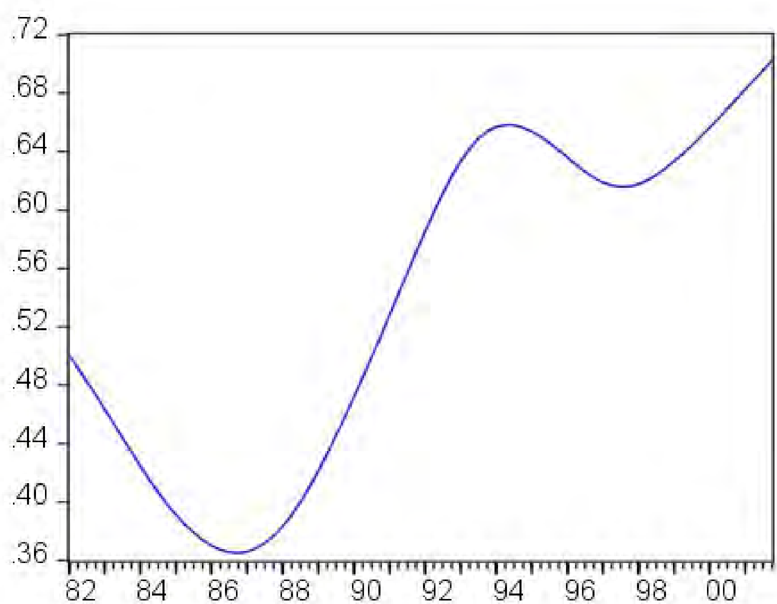
where YFD denotes the price level, WUN the wage rate, CCO the user cost of capital, α a scale parameter, β a technology parameter and T a time index. For estimation purposes we use seasonally-adjusted quarterly ESA95 data for employment, GDP, the GDP deflator and compensation to employees (as a measure of labor income). Quarterly ESA95 data are only available from 1988Q1. In order to extend the data to 1980Q1, we used growth rates from ESA79 data. This procedure causes a break in some time series around 1988 and made it necessary to introduce shift dummies in certain equations. Data for the gross capital stock were provided by Statistik Austria. Employment data include both employees and the self-employed, whereas our measure of labor income includes only employees. Therefore we used compensation per employee as a proxy for the "wages" of the self-employed to calculate total labor income. The real user cost of capital is defined as the sum of the real interest rate, the depreciation rate, and a risk premium:

$$\frac{CC0}{ITD} = \frac{LTI}{400} - infl + \delta_{KSR} + RP$$

where ITD denotes the investment deflator, LTI long-term interest rates, infl the inflation rate, δ_{KSR} the depreciation rate and RP the risk premium. The inflation rate is defined as a moving average of changes in the investment deflator over the current and the past four quarters. The risk premium is provided by the trend component of the difference between the marginal product of capital and the sum of the real interest rate and the average depreciation. The average risk premium is slightly above 0.5% per quarter and shows an increasing trend during the nineties (see chart 1). Solving the profit maximization problem of the firm leads to equations defining the static steady-state levels of prices, employment and capital, which enter the dynamic model specification via ECM-terms. The three equations were estimated as a system.

Initial estimation results indicated residual non-stationarity caused by two different data problems. First, the sample combines two data sets calculated according to different national account systems (ESA79 and ESA95). In order to address this problem, we introduced a shift dummy (D_884) running from 1980 to 1988. Secondly, since quarterly data for full-time equivalents are not available, we initially used unadjusted employment figures. As part-time employment is growing in importance, especially among the self-employed, this may also distort the estimators. Thus, we interpolated annual data for full-time equivalents using a cubic spline and constructed an employment series adjusted for full-time equivalents. Both modifications (introduction of dummies and adjustment for full-time equivalents) strongly improved the estimation results.

Chart 1: Risk Premium[1]



Finally, we introduced a permanent dummy starting in 1996Q1 in the price equation. This period was influenced by the accession to the European Union and characterized by a nationwide agreement to wage moderation. Incorporating the dummies mentioned above, the profit function becomes

[1] All numbers of charts and tables in this paper are based on authors' calculations.

$$\pi\left((YER+\delta\cdot D_{884}),LNN^{FE},KSR\right)=\\ YFD\cdot(YER+\delta\cdot D_{884})-WUN^{FE}\cdot LNN^{FE}-CC0\cdot KSR \tag{1}$$

The new profit maximization problem of the representative firm is given by:

$$\begin{aligned}&\max_{LNN^{FE},KSR}\quad \pi\left((YER+\delta\cdot D_{884}),LNN^{FE},KSR\right)\\ &\qquad s.t.\quad (YER+\delta\cdot D_{884})=\alpha\cdot KSR^{\beta}\cdot(LNN^{FE})^{1-\beta}\cdot e^{(1-\beta)\cdot\gamma\cdot T}\end{aligned} \tag{2}$$

This leads to the following system of equations for prices, employment and capital stock:

$$\begin{aligned}\ln(\mathrm{YFD})\quad &=\ln(\eta)+\ln(\mathrm{WUN^{FE}})-\gamma\cdot\mathrm{T}+\frac{\beta}{1-\beta}\cdot\ln\left(\frac{\mathrm{YER}+\delta\cdot\mathrm{D_{884}}}{\mathrm{KSR}}\right)\\ &\quad-\ln(1-\beta)-\frac{\ln(\alpha)}{1-\beta})-\ln(1-\mathrm{TIX})+\varepsilon\cdot\mathrm{D_{961P}}\end{aligned} \tag{3}$$

$$\ln(\mathrm{LNN^{FE}})\quad=\ln(\mathrm{YER}+\delta\cdot\mathrm{D_{884}})-\beta\cdot\ln\left(\frac{\mathrm{KSR}}{\mathrm{LNN^{FE}}}\right)-\ln(\alpha)-(1-\beta)\cdot\gamma\cdot\mathrm{T} \tag{4}$$

$$\ln(\mathrm{KSR})\quad=(1-\beta)\cdot\left[\begin{aligned}&-\ln(\mathrm{CC0})+\ln(\mathrm{WUN^{FE}})-\gamma\cdot\mathrm{T}+\frac{1}{1-\beta}\cdot\ln(\mathrm{YER}+\delta\cdot\mathrm{D_{884}})\\ &+\ln\left(\frac{\beta}{1-\beta}\right)-\ln\left(\frac{\alpha}{1-\beta}\right)\end{aligned}\right] \tag{5}$$

YFD denotes the GDP deflator, η the mark-up, $\mathrm{WUN^{FE}}$ the nominal wage per full time equivalent , YER real GDP, KSR the real capital stock, TIX the effective indirect tax rate, $\mathrm{LNN^{FE}}$ total employment adjusted for full time equivalents, CCO the nominal user costs of capital, α the scale parameter in the production function, β the output elasticity of capital and γ the technological progress. According to equation (3) the GDP-deflator after indirect taxes is determined by a mark-up (η), wages and the output to capital ratio which should be constant in the long-run. Employment depends on the inverse of the production function (equation (4)) and the capital stock on relative factor costs and output (see equation (5)). The equations of the supply block have been estimated simultaneously as a system. The estimation results are reported in table 1. Firms are assumed to have a certain market power and fix their prices above marginal costs. The estimator of the mark up (η) is slightly smaller than one (0.91) indicating that the risk premium captures all capital costs beyond the real interest rate and the depreciation of the capital stock. The output elasticity of capital is estimated to be 0.367, the scale parameter α equals 1.70 and the technological progress parameter γ is 0.0042 which implies an annual exogenous growth of 1.1%.

The residuals of the supply-side equations are shown in (chart 2), the optimal or desired equilibrium levels, labeled as "STAR" variables, in (chart 3). While the optimal values for employment and prices follow actual data quite closely, the optimal capital stock is much more volatile. This arises from the fact that the desired capital stock reacts very sensitive to changes in the user costs of capital. Therefore, in simulation exercises changes in interest and/or inflation rates typically have a strong impact on investments.

Table 1: Estimated Coefficients of the Supply Block

Coefficient	Estimate	Std Error	T-Stat
η	0.91	0.0066	138.5
β	0.37	0.0057	64.6
α	1.70	0.043	39.7
γ	0.0042	0.0002	24.6
δ	1249.7	205.3	6.1
ε	0.04	0.0055	7.3
Phillips-Perron test statistic with 8 Lags: Equation 3: −5.05323 Equation 4: −4.65435 Equation 5: −2.07279			

The residuals of the supply-side equations, i.e. the deviations of actual from desired levels, enter the dynamic specifications of the equations for the GDP-deflator at factor costs, for employment and for investment as error correction terms.

Chart 2: Residuals from the Supply Block

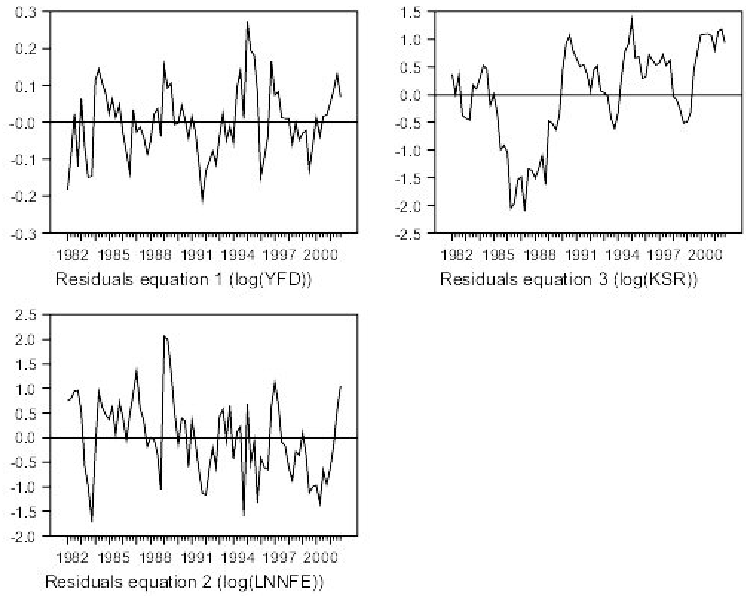


Chart 3: Actual and Optimal Values from the Supply Block

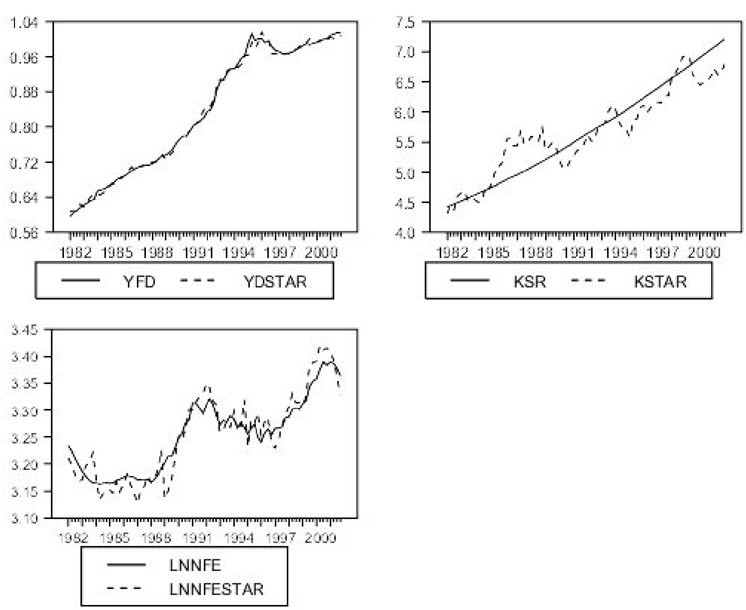
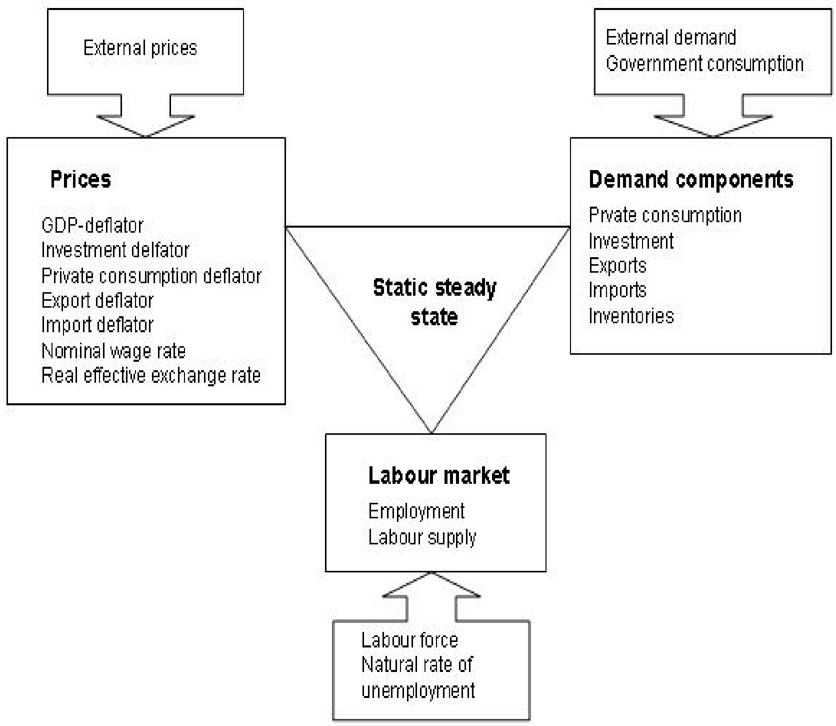


Chart 4: An Overview of the AQM Structure



3. The AQM-Structure

The theoretical foundations of the AQM were outlined in the previous section. The long-run equilibrium is determined in a static optimization framework leading to three steady state equations for the GDP deflator at factor costs, the capital stock (investments) and employment.

Within this theoretical framework the overall structure of the AQM becomes already apparent. The model consists of three major building blocks: prices, output and the labor market (see chart 4) for a graphical illustration of the model structure). The static steady state framework links these three building blocks. It determines how in the long-run changes in output feed into prices and labor demand, how changes in relative factor costs influence investment activity, output and employment and how changes in employment trigger adjustments of prices and the capital stock.

The overall structure of the AQM is of course more complex and involves many other variables. Within the output block the crucial demand components are investment activity, private consumption, exports, imports and inventories. The price block includes the deflators for private consumption, investment, exports and imports, the nominal wage rate and the real effective exchange rate. In the labor market block the level of employment and labor supply are determined. The unemployment rate which is at its natural rate in the long only is decisive for adjustment processes in the short run. Additionally, important variables enter the AQM as exogenous components. Concerning external prices this regards nominal exchange rates, competitors' prices on the import and export side and oil and non-oil commodity prices. Interest rates are exogenous and typically held constant in simulation and forecast exercises in order to derive forecasts and simulation results for policy makers under the assumption of no monetary policy change. Also a great deal of the government sector including several tax rates and government consumption are exogenously given. Finally demand for Austrian exports is independent of domestic developments as is typically the case for small open economies.

Various transmission channels between the three building blocks and the exogenous variables have to be taken into account. Although this list is by far not complete, such mechanisms are: The affection of the disposable income of households by wages and employment. The unemployment rate triggers via the Philips curve changes in the wage rate and determines the amount of transfers paid to households. Changes in prices and interest rates cause substitution and wealth effects. Investments are sensitive to the user costs of capital. The size of exports and imports depends on the international price competitiveness of the exposed sector. Output and employment feed back via productivity on wages and prices. Moreover important transmission mechanisms appear directly between variables within building blocks. Examples are the accelerator mechanism in the case of investments, the pro-cyclical behavior of labor supply or interdependencies between wages, domestic prices and import prices.

In order to get a broad idea of the key equations, single equation responses to shocks are reported in table 2. The shocks typically constitute 10% increases in one of the explanatory variables. The dynamic specifications of the key equations incorporate the long-run behavior as error correction terms. The speed of adjustment in the single equation simulations is strongly determined by the loading factors of the error correction terms in the dynamic specifications which are listed in table 2.

The loading factors of the ECM-terms are typically around 10% implying that in single equation simulations about one third of a disequilibrium are dissolved within the first year. The speed of adjustment is significantly lower in case of

Table2: Single Equation Responses to 10% Shocks of Explanatory Variables

Endogenous variable Shocked exogenous variables	Year 1	Year 2	Year 3	Year 5	Year 10	ECM-coefficient
Private consumption						–0.094
Disposable income	2.32	6.00	7.65	8.85	9.22	
Financial wealth	0.05	0.34	0.53	0.67	0.71	
Long-term interest rates (+100bp)	–0.05	–0.29	–0.45	–0.57	–0.60	
Investment						–0.051
Output	12.5	15.50	15.00	12.6	10.3	
Wage rate	0.46	1.82	3.10	4.78	6.03	
User cost of capital	–0.45	–1.78	3.01	–4.56	5.69	
Exports						–0.226
World demand	8.50	9.39	9.72	9.94	10.00	
Export prices	–3.03	–3.27	–3.45	–3.57	–3.59	
Competitors' prices	3.10	3.36	3.54	3.67	3.70	
Imports						–0.355
Domestic demand	9.70	10.30	10.00	10.00	10.00	
Import prices	–6.03	–8.32	–8.63	–8.69	–8.69	
Oil prices	0.22	0.46	0.50	0.50	0.50	
GDP deflator at factor costs	6.09	8.35	8.67	8.71	8.71	
Employment						–0.112
Output	3.00	5.70	7.90	11.00	14.70	
Wage rate	–1.53	–1.40	–1.10	–0.68	–0.20	
GDP deflator at factor costs						–0.137
Output	0.69	2.64	3.87	5.05	5.64	
Indirect taxes to GDP ratio	0.13	0.57	0.84	1.05	1.19	
Wage rate	4.04	7.12	8.29	9.40	9.96	
Private consumption deflator						–0.117
GDP deflator at factor costs	6.98	7.72	8.17	8.61	8.85	
Import deflator	1.27	1.18	1.12	1.07	1.04	
Investment deflator						–0.412
GDP deflator at factor costs	8.04	8.26	8.29	8.29	8.29	
Import deflator	1.79	1.66	1.59	1.58	1.58	
Import deflator						–0.229
Competitors' prices	3.29	4.91	5.43	5.65	5.67	
GDP deflator at factor costs	1.14	2.85	3.39	3.62	3.63	
Oil prices	0.44	0.44	0.43	0.43	0.43	
Export deflator						–0.127
Competitors' prices	1.67	2.84	3.39	3.86	4.06	
GDP deflator at factor costs	3.35	4.97	5.30	5.58	5.70	
Nominal wage rate						–0.110
Private consumption deflator	0.00	2.57	6.24	9.36	10.00	
Labor productivity	2.95	5.29	7.67	9.61	10.00	
Unemployment rate	–0.02	–0.23	–0.43	–0.58	–0.61	

investments as the ECM term is formulated with respect to the optimal capital stock which is rather volatile (see chart 2). In the short run accelerator effects cause an overshooting of investment with respect to output. Higher than average are the loading factors in the export and import equations indicating that changes in demand and competitiveness pass through quickly to trade flows. Effects of changes in the wage rate on employment are only significant in the short run. Since the wage rate does not enter the optimal employment level directly effects are fading out over time in single equation simulations.

Table 3: Estimation of Transfers Received in % of GDP

$TRX_t = C(1) + C(2) \cdot (URX_t) + res_t^{TRX}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.224754	0.002003	112.2091	0.0000
C(2)	0.005469	0.000602	9.092174	0.0000
R-squared:	0.502027		Durbin-Watson stat:	0.296245

4. Estimation of Demand Components

4.1 Private Consumption

Households' consumption behavior is mainly determined by disposable income and financial wealth. Nominal financial wealth plays a crucial role in determining the stock-flow relations in the AQM. Under the assumption that households own all firms in the economy, it can be shown that a disaggregation of financial wealth into assets of the household sector, the government sector, the corporate sector and the foreign sector is not necessary (see William and Estrada, 2002). Financial wealth of the total economy is identical to financial wealth of the household sector and defined as the sum of the private capital stock (KSN), government debt (GDN) and net foreign assets (NFA):

$$FWN_t = KSN_t + GDN_t + NFA_t \tag{6}$$

Nominal disposable income is given by the sum of compensation to employees (WIN), other personal income (OPN) and transfers received by households (TRN) minus transfers (TPN) and direct taxes (PDN) paid by households:

$$PYN_t = WIN_t + OPN_t + TRN_t - TRP_t - PDN_t \tag{7}$$

Transfers and direct taxes paid by households are assumed to be proportional to nominal GDP during the forecasting horizon. For long-run simulations a fiscal rule prevents an unlimited increase of government debt. Transfers received by households (TRX denotes the ratio of transfers received by households to nominal GDP) are a function of the unemployment rate. An increase in the unemployment rate according to the EUROSTAT definition by 1 pp causes additional transfers to households of about 0.5% of nominal GDP (see table 3).

Compensations to employees are determined by wages and employment (see sections 5.1 and 6.2). Growth of other personal income (i.e. gross mixed income and property income) depends in the long-run on the gross operating surplus (GON), minus the depreciation of the capital stock (KSN·depr) and wealth income out of liquid assets (LTI/400·0.23·FWN).[2] While income effects of interest rate changes are captured in the equation for other personal income, substitution effects are modeled in the long-run equation for private consumption (see table 5). The short run dynamics of other personal income are only driven by changes of the gross operating surplus. As sectoral National Accounts data for other personal income are only available on an annual basis the equation is estimated in annual growth rates (see table 4).

Table 4: Estimation of other Personal Income

$$\Delta_4 \ln(OPN_t) = C(1)\cdot(1/4)\cdot\sum_{i=1}^{4} \left(\ln(OPN_{t-i}) - \ln(GON_{t-i} - KSN_{t-i}\cdot depr + LTI_{t-i}/400\cdot 0.23\cdot FWN_{t-i})\right) + C(2)\cdot\Delta_4\ln(GON_t) + res_t^{OPN}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.068575	0.041099	–1.668515	0.0991
C(2)	0.728521	0.105224	6.923521	0.0000
R-squared:	0.193119		Durbin-Watson stat:	0.419010

The long-run behavior of private consumption is based on the concept of permanent income. Given backward looking behavior by households permanent income can be approximated by current disposable income and wealth. Combining ESA95 with ESA79 data caused major problems in estimating the private consumption equation, so the sample was restricted to 1989Q1 to 2001Q4. This

[2] The share of liquid assets of households in total nominal wealth equals 0.23.

period is characterized by a pronounced decline in the household savings ratio from well above 10% to just above 5%. Although the savings ratio is subject to frequent and major revisions, these usually concern only the absolute level and not changes in the savings ratio. The decline can only be partly explained by the rise in the wealth-to-income ratio and probably reflects changes in household habits and preferences. In order to capture this shift in preferences, a negative trend was introduced in the long-run consumption equation.

The bulk of financial wealth are illiquid assets. Liquid assets amount to about one fourth of total assets. Using a weighted average of liquid and illiquid assets yields an adjusted wealth variable which corresponds to one third of the original series. This results in a reasonable asset-to-income ratio of about 2, in line with other international studies (see Muellbauer and Lattimore, 1995). Finally, real interest rates were allowed to enter the long-run specification of the consumption equation capturing substitution effects and liquidity constraints. Estimates of the long-run consumption equation indicate an average household savings ratio of 7.5%. The trend and the interest rates enter the equation with the expected negative coefficients (see table 5). Wealth effects appear in the long-run equation but are limited in size.

Table 5: Estimation of Long-run Consumption

$$\ln(CSTAR_t) = C(1)\cdot\ln(PYR_t) + (1 - C(1))\cdot(0.23)\cdot\ln(FWR_t/4) + C(2)\cdot(10/Time) + C(3)\cdot(LTI_t/100)$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.925828	0.008394	110.3019	0.0000
C(2)	–0.661674	0.082358	–8.03413	0.0000
C(3)	–0.607803	0.228308	–2.66220	0.0107

R-squared: 0.872928 Durbin-Watson stat: 0.900179

In the dynamic specification for real private consumption the ECM term is significant with a lag of two periods. Furthermore, changes in real disposable income and an autoregressive term serve as explaining variables in the short run. Lagged growth in real private consumption captures consumer habits which offer an explanation for observed "excess smoothness" (see table 6).

Table 6: Estimation of Real Private Consumption

$\Delta\ln(PCR_t) = C(1) + C(2)\cdot(\ln(PCR_{t-2}/CSTAR_{t-2})) + C(3)\cdot\Delta\ln(PYR_{t-1}) + C(4)\cdot\Delta\ln(PCR_{t-1}) + res_t^{PCR}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.003444	0.000890	3.871969	0.0004
C(2)	–0.094520	0.046460	–2.03443	0.0481
C(3)	0.191638	0.050607	3.786783	0.0005
C(4)	0.263034	0.128457	2.047647	0.0467

R-squared: 0.312365 Durbin-Watson stat: 2.030268

4.2 Investment

Modeling investment in Austria raised the well-known difficulties encountered elsewhere. Deviations of current from optimal capital stock led to poorly determined coefficients and implausible simulation results, so we used the ratio of the previous period's investment to the optimal capital stock as the ECM term. The optimal capital stock has been estimated separately in the supply block of the model. In the steady state the capital stock and real GDP must grow at the same pace (g_{STAR}) to ensure that the capital to GDP ratio remains constant over time as is typically the case in neoclassical growth models. Given a constant capital to GDP ratio, a constant investment share in GDP and a constant depreciation rate (depr), the investment to capital stock ratio converges to a constant which equals the steady state growth rate plus the depreciation rate of real capital:

$$\frac{ITR_t}{KSTAR_{t-1}} = g_{STAR} + depr$$

This ratio is used to determine the long-run behavior of investment. Since the interest rate has a strong influence on the optimal capital stock via the user cost of capital, the investment equation represents the main transmission channel of monetary policy in the model. Cost factors have a direct influence in the ECM term but are not relevant in the short-run dynamics, which are dominated by accelerator effects represented by an autoregressive term and a coefficient on real output growth that is larger than one.

Table 7: Estimation of Real Gross Investment

$\Delta\ln(ITR_t) =$ C(1) +C(2)·$\ln(ITR_{t-1}/KSTAR_{t-1})$ + C(3)·$\Delta\ln(YER_t)$ +C(4)·$\Delta\ln(ITR_{t-2})$ +C(5)·$\Delta\ln(ITR_{t-3})$ + C(6)·D_{861} + C(7)·D_{862} +C(8)·D_{871} + C(9)·D_{872} +res_t^{ITR}

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.070303	0.026513	–2.65164	0.0098
C(2)	–0.051604	0.020203	–2.55428	0.0127
C(3)	1.110107	0.251406	4.415586	0.0000
C(4)	0.117159	0.070883	1.652843	0.1026
C(5)	0.243847	0.075193	3.242926	0.0018
C(6)	–0.077009	0.016993	–4.53172	0.0000
C(7)	0.045352	0.017221	2.633457	0.0103
C(8)	–0.122070	0.017905	–6.81749	0.0000
C(9)	0.098917	0.017472	5.661302	0.0000
R-squared:	0.687612	Durbin-Watson stat:	2.080469	

4.3 Foreign Trade

In the equations for real exports and real imports, market shares with respect to foreign (WDR) and domestic demand (WER) are used as dependent variables in the long-run. Specifically, real exports are modeled with unit elasticity to demand on markets for Austrian exports. In turn, these export market shares are explained by a price-competitiveness indicator and a time trend (see table 10). Competitiveness is measured by the ratio of Austrian export prices to competitors' prices. This indicator has the expected negative impact on market shares. The trend term contributes about 0.2 percentage points to real export growth, reflecting rapidly increasing trade links.

Import demand was modeled by aggregating real GDP components weighted by their respective import content as appears in the current input-output table.

$$WER_t = 0.197 \cdot PCR_t + 0.01 \cdot GCR_t + 0.298 \cdot ITR_t + 0.477 \cdot SCR_t + 0.536 \cdot XTR_t$$

In the long-run, imports depend negatively on a competitiveness variable defined as the ratio of import prices to the deflator of GDP at factor cost. Due to the relatively high weight of exports in the domestic demand indicator, the impact of intensified trade links is better captured than in the export equation. Nevertheless, a time trend starting in 1997 had to be introduced to capture the recent surge in trade volumes. Moreover, the special role of oil prices had to be considered. Real imports are very inelastic with respect to oil prices. To control for this fact the effect of the price competitiveness variable on real imports was corrected for oil prices. Otherwise, oil price simulations would produce the perverse result that an increase in oil prices improves the price competitiveness of the Austrian import-competing sector leading to an increase in real GDP (see table 8).

In the dynamic specifications of real imports and exports both error-correction terms are significant with rapid adjustment of 35% and 17% respectively. Changes in demand and competitiveness variables are also relevant in the short run. In the equation for real exports, a negative autoregressive term reflects the high volatility present in the data (see tables 9 and 11).

Table 8: Estimation of Long-run Relationship Imports

$$\ln(MSTAR_t) = C(1) + \ln(WER_t) + C(2)\cdot[(1/(1 + C(3)))\cdot(\ln(MTD_t) + C(3)\cdot\ln(POILU_t) - \ln(YFD_t))] + C(4)\cdot TR_{971}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.237770	0.047748	–4.979644	0.0000
C(2)	–0.888146	0.134797	–6.588753	0.0000
C(3)	–0.055182	0.018623	–2.963096	0.0041
C(4)	0.001202	8.76E-05	13.71960	0.0000

R-squared: 0.990162 Durbin-Watson stat: 1.399563

Table 9: Estimation of Real Imports

$$\Delta\ln(MTR_t) = C(1)\cdot\ln(MTR_{t-1}/MSTAR_{t-1}) + C(2)\cdot\Delta\ln(WER) + (1 - C(2))\cdot\Delta\ln(WER_{t-2}) + C(3)\cdot\Delta\ln(MTD_t/YFD_t) + res_t^{MTR}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.351035	0.105569	–3.325150	0.0021
C(2)	0.809069	0.143118	5.653138	0.0000
C(3)	–0.374019	0.343955	–1.087408	0.2843

R-squared: 0.546213 Durbin-Watson stat: 1.839300

Table 10: Estimation of Long-run Relationship Exports

$\ln(XSTAR_t) = C(1) + \ln(WDR_t) + C(2) \cdot TREND + C(3) \cdot \ln(XTD_t/CXD_t)$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	8.685912	0.176453	49.22506	0.0000
C(2)	0.002383	0.000383	6.219390	0.0000
C(3)	–0.382664	0.065612	–5.832198	0.0000

R-squared: 0.988159 Durbin-Watson stat: 0.465805

Table 11: Estimation of Real Exports

$\Delta\ln(XTR_t) = C(1) \cdot \ln(XTR_{t-1}/XSTAR_{t-1}) + C(2) \cdot \Delta\ln(WDR_t) + (1 - C(2)) \cdot \Delta\ln(WDR_{t-1}) + C(3) \cdot \Delta\ln(XTD_t/CXD_t) + C(4) \cdot \Delta\ln(XTR_{t-1}) + res_t^{XTR}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.177244	0.075987	–2.332548	0.0230
C(2)	0.759752	0.123693	6.142254	0.0000
C(3)	–0.374163	0.097573	–3.834692	0.0003
C(4)	–0.281413	0.089575	–3.141666	0.0026

R-squared: 0.501759 Durbin-Watson stat: 2.054105

Table 12: Estimation of Long-run Stocks

$\ln(LSSTAR_r) = C(1) + C(2) \cdot \ln(YNR_t)$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	2.871705	0.165589	17.34240	0.0000
C(2)	0.708023	0.015780	44.86771	0.0000

R-squared: 0.959030 Durbin-Watson stat: 0.107677

4.4 Stocks

The inventories equation is derived from a theoretical framework developed by Holt, Modigliani, Muth and Simon (1960)based on a cost function that includes linear and quadratic costs of production and holding inventories. Pro- or counter-cyclical inventory behavior, depends on the relative costs of adjusting production and of holding inventories (stockout or backlog costs).

The desired long-run level of inventories (LSSTAR) is entirely determined by the normal level of production (YNR), disregarding any such cost factors, which only enter the dynamic specification. The normal or desired level of production is given by the estimated production function with the current levels of capital and employment as input factors. As reflected in the parameters of the long-run relationship, the ratio of inventories to output shows a declining trend over the nineties.

In the short run, cost factors and the economic cycle play an important role. Opportunity costs of holding inventories are approximated by the product of the normal level of production and the real interest rate (REALI). The real interest rate is defined as the average of real short-term and long-term interest rates. Differences between year-on-year changes in sales and year-on-year changes in normal output reflect the business cycle, since during an economic upswing growth of sales within the last year will exceed growth of normal output, while the reverse holds in recessions. Since we lack accurate data for sales on a quarterly basis the sum of real private consumption and real exports was used as a proxy. The positive coefficient found for this variable indicates that inventories behave procyclically in Austria. More inventories imply higher holding costs but reduce the probability of stockout or backlog costs. The level of inventories that equalizes this counteracting cost increases with economic activity, causing a simple accelerator effect.

Table 13: Estimation of Stock Building

$$\begin{aligned}\Delta(SCR)_t = \; & C(1)\cdot(LSR_{t-1} - LSSTAR_{t-1}) \\ & + C(2)\,[\Delta_4 SALE_{t-1} - C(3)\cdot\Delta_4 YNR_{t-1}] \\ & + C(4)\cdot REALI_t\, YNR_t + C(5)\cdot D_{004} + res_t^{SCR}\end{aligned}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.040781	0.008828	–4.619766	0.0000
C(2)	0.019012	0.006075	3.129633	0.0029
C(3)	0.804039	0.542437	1.482271	0.1445
C(4)	–0.000164	7.33E-05	-2.243936	0.0293
C(5)	-961.4468	30.51439	-31.50798	0.0000

R-squared: 0.956520 Durbin-Watson stat: 2.613117

Table 14: Estimation of Labor Demand

$$\Delta\ln(LNN_t^{FE}) = C(1)\cdot\ln(LNN_{t-1}^{FE}/LSTAR_{t-1}) + C(2)\cdot\sum_{i=0}^{1}(\Delta\ln(WUN_{t-1}^{FE}/YFD_{t-i}) + C(3)\cdot\Delta\ln(YER_t) + C(4)\cdot D_{911} + res_t^{YFD}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.112493	0.039393	–2.855634	0.0055
C(2)	–0.206512	0.065522	–3.151784	0.0023
C(3)	0.202497	0.040791	4.964290	0.0000
C(4)	0.009164	0.002785	3.290788	0.0015

R-squared: 0.318476 Durbin-Watson stat: 1.549794

5. Estimation of Labor Market Equations

5.1 Employment

The equilibrium level of employment depends solely on the supply side and is obtained by inverting the production function. The corresponding ECM term has the expected negative coefficient. In the short run, demand and cost factors have an impact on employment growth. The pro-cyclical response of employment to output fluctuations is captured by contemporaneous GDP growth. Wages in Austria are typically set in a highly centralized bargaining process. Given the resulting real wage, firms choose the desired level of employment. Increases in real wages in the last two quarters lead to a lower employment level.

5.2 Labor Force

In the long-run, the labor force follows demographic developments and is given exogenously by LFNSTAR In the short run, cyclical fluctuations in output lead to variations in employment but also trigger responses in labor supply. The effect of output variations on the unemployment rate is cushioned by a pro-cyclical reaction of the labor force – a pattern which was especially clear in past Austrian data. The second important short run determinant in the labor supply equation is real wage growth. As real wages in Austria are known to be very flexible, they tend to reinforce the pro-cyclical behavior of employment.

Table 15: Estimation of the Labor Force Equation

$$\Delta\ln(LFN_t) = -0.025\cdot\ln(LFN_{t-1}/LFNSTAR_{t-1}) + C(1)\cdot\Delta\ln(WUN_{t-1}/PCD_{t-1}) + C(2)\cdot\Delta\ln(LNN_t) + res_t^{LFN}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.079683	0.023976	3.323473	0.0014
C(3)	0.711938	0.056323	12.64033	0.0000
R-squared:	0.710998	Durbin-Watson stat:	1.321416	

6. Estimation of Price Equations

The long-run properties of the price block are jointly determined by two key variables, the GDP deflator at factor costs and the nominal wage rate dealt with in section 6.1 and section 6.2, respectively. In addition, external price developments are captured by the import price deflator (see section 6.5). Other domestic price deflators like the private consumption deflator and the investment deflator feature a long-run unit elasticity with respect to these key variables. This assumption of static homogeneity implies that the corresponding error correction terms are modeled in terms of relative prices.

6.1 GDP-Deflator at Factor Costs

The long-run behavior of the GDP deflator at factor costs is given by the supply block, with the corresponding error-correction term – formulated as a moving average over the past two periods – entering the dynamic specification significantly. The ECM-coefficient implies an adjustment to the equilibrium of 14% per period. In the short run, wages, the second key domestic price component, play a prominent role. In order to rule out explosive wage-price spirals in simulation exercises, nominal wage growth enters with a one quarter lag. This also reduces the effect of wages on prices. Since Austria is a small open economy, prices should also depend strongly on foreign developments. Foreign competitors' prices were not included in the static steady-state solution of the supply block but enter through import price inflation. The estimated coefficient of 0.10 seems rather low, but import prices tend to be more volatile than domestic prices, reflecting the high volatility of exchange rates and commodity prices.

6.2 The Nominal Wage Rate

In the AQM, the nominal wage rate is approximated by average compensation per employee as recorded in National Accounts data. These quarterly data are adjusted to full-time equivalents using interpolated annual data. During the sample period, the income share of labor dropped from almost 68% in 1980 to slightly less than 60% in 2000 (see chart 5). The rebound in 2001 mainly reflects cyclical factors in the course of the recent economic slowdown. This is inconsistent with the assumption of a constant-returns-to-scale Cobb-Douglas production function underlying the supply side of the AQM which implies constant factor income shares in equilibrium equal to the output elasticities. We therefore included a trend in the long-run wage equation starting in 1988Q1 (see table 17).

In the dynamic specification, nominal wages adjust only slowly to the long-run equilibrium, reflecting adjustment costs and bargaining (see table 18). The short-run dynamics are characterized by a Phillips curve linking wage growth to the deviation of the unemployment rate from a constant NAWRU which is exogenous to the model. However, the long-run Phillips curve is vertical. Productivity determines not only the equilibrium level of the wage rate but enters also the dynamic specification. The contemporaneous inflation rate measured by the GDP deflator at factor costs is highly correlated with nominal wage growth leading to a rigid behavior of real wages in simulation exercises. [3] We therefore decided to use only lagged inflation as this better reflects the high real wage flexibility characteristic of the centralized wage setting process in Austria.

Table 16: Estimation of GDP-Deflator at Factor Costs

$$\Delta\ln(YFD_t) = C(1)\cdot 0.5\cdot\sum\nolimits_{i=1}^{2}\ln(YFD_{t-i}/YDSTAR_{t-i}) + C(2)\cdot\Delta\ln(MTD_t) + C(3)\cdot\Delta\ln(WUN_{t-1}^{FE}) + C(4)\cdot D_{841} + C(5)\cdot D_{924} + C(6)\cdot D_{952} + res_t^{YFD}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.137458	0.046980	–2.925868	0.0045
C(2)	0.101125	0.040117	2.520774	0.0137
C(3)	0.407432	0.044078	9.243519	0.0000
C(4)	0.021604	0.005602	3.856311	0.0002
C(5)	0.022381	0.005800	3.858447	0.0002
C(6)	0.020227	0.005639	3.586923	0.0006
R-squared:	0.565859	Durbin-Watson stat:	2.334825	

[3]The high correlation between inflation and nominal wage growth is mainly driven by the period from 1988 to 1995. As there is no economic reason why wage setting in this period should have been markedly different we interpret this mainly as a data problem.

6.3 Private Consumption Deflator

Within the model, we distinguish between two consumer prices: the private consumption deflator found in National Accounts data and the HICP published by Eurostat. The HICP is not modeled directly but via its two subcomponents, HICP-energy and HICP-excluding-energy, with the more volatile energy component carrying a weight of less than 10% on average in overall HICP. HICP inflation does not feed back onto other variables in the model. On the other hand, the private consumption deflator is a central variable with strong feedbacks especially via real wages and real wealth. In the long-run, the private consumption deflator depends on the GDP deflator at factor costs, with static homogeneity imposed. In the short run, the private consumption deflator is affected by changes in the GDP deflator at factor costs, in the import deflator, and in nominal wages after correcting for productivity. External price pressures are captured by the difference between the import deflator and the GDP deflator at factor cost. The HICP excluding energy turned out to be very difficult to model, with equations featuring poor statistical properties and generating implausible simulation results. Therefore we decided to let the HICP excluding energy move one-to-one with the GDP deflator at factor costs. On the other hand, the HICP energy subcomponent depends mainly on oil prices.

Chart 5: Wage Share in Austria

Table 17: Estimation of Long-run Real Wages

$\ln(WSTAR_t) = \ln(PCD_t) + \ln((1-\beta)\cdot YER_t/LNN_t^{FE}) + C(1)\cdot TR_{881} + C(2)\cdot D_{951}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.001735	7.36E-05	–23.56229	0.0000
C(2)	0.039370	0.018052	2.180900	0.0319

R-squared: 0.772205 Durbin-Watson stat: 0.214611

Table 18: Estimation of Wages

$\Delta\ln(WUN_t^{FE}) = C(1) + C(2)\cdot\ln(WUN_{t-4}^{FE}/WSTAR_{t-4}) + C(3)\cdot 1/3\cdot\sum_{i=2}^{4}\ln(URX_{t-i}) + C(4)\cdot 1/2\cdot\sum_{i=2}^{3}\Delta\ln(YFD_{t-i}) + C(5)\cdot 1/2\cdot\sum_{i=0}^{1}\Delta\ln(PRO_{t-1}^{FE}) + C(6)\cdot D_{824} + C(7)\cdot D_{924} + C(8)\cdot D_{951} + res_t^{WUNFE}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.021766	0.010780	–2.019104	0.0472
C(2)	–0.110036	0.050954	–2.159529	0.0341
C(3)	–0.007792	0.003133	–2.487079	0.0152
C(4)	0.397905	0.143749	2.768054	0.0072
C(5)	0.343437	0.200025	1.716969	0.0903
C(6)	0.018240	0.007941	2.297045	0.0245
C(7)	0.036907	0.007797	4.733148	0.0000
C(8)	0.032253	0.007854	4.106655	0.0001

R-squared: 0.496887 Durbin-Watson stat: 2.063025

Table 19: Estimation of Private Consumption Deflator

$\Delta\ln(PCD_t) = C(1) + C(2)\cdot\ln(PCD_{t-1}/YFD_{t-1}) + C(3)\cdot\Delta\ln(YFD_t) + C(4)\cdot\Delta\ln(MTD_t) + C(5)\cdot\ln(MTD_t/YFD_t) + C(6)\cdot\Delta\ln(WUN_{t-1}^{FE}/PRO_{t-1}^{FE}) + res_t^{PCD}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.001542	0.000794	1.941635	0.0562
C(2)	–0.117086	0.050117	–2.336260	0.0223
C(3)	0.684736	0.065458	10.46064	0.0000
C(4)	0.124102	0.033286	3.728411	0.0004
C(5)	0.012702	0.006309	2.013422	0.0479
C(6)	0.082176	0.039792	2.065144	0.0426

R-squared: 0.789004 Durbin-Watson stat: 2.219394

Table 20: Estimation of HICP Subcomponent Energy

$$\Delta \ln(HEG_t) = C(1) + C(2)\cdot \Delta \ln(POIL_t) + C(3)\cdot \ln(HEG_{t-1}/YED_{t-1}) + C(4)\cdot \ln(POIL_{t-1}/YED_{t-1}) + res\ HEG_t^{HEG}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.348422	0.141734	2.458288	0.0171
C(2)	0.085448	0.015833	5.396854	0.0000
C(3)	–0.090897	0.032707	–2.779157	0.0074
C(4)	0.025025	0.009720	2.574616	0.0128

R-squared: 0.407030 Durbin-Watson stat: 2.217577

Table 21: Estimation of Private Investment Deflator

$$\Delta \ln(OID_t) = C(1)\cdot \ln(MTD_{t-1}/XTD_{t-1}) + C(2)\cdot[\ln(OID_{t-1}) - C(3)\cdot \ln(YFD_{t-1}) + (1 - C(3))\cdot \ln(MTD_{t-1})] + C(4)\cdot \Delta \ln(MTD_t) + C(5)\cdot \Delta \ln(YFD_t) + C(6)\cdot D_{861\ 2} + C(7)\cdot D_{871\ 2} + res_t^{OID}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.109373	0.059783	1.829497	0.0713
C(2)	–0.412114	0.098188	–4.197205	0.0001
C(3)	0.835710	0.015924	52.48260	0.0000
C(4)	0.106517	0.058399	1.823950	0.0721
C(5)	0.790375	0.114509	6.902321	0.0000
C(6)	0.036109	0.006189	5.834523	0.0000
C(7)	0.026018	0.005781	4.500429	0.0000

R-squared: 0.722189 Durbin-Watson stat: 2.275062

6.4 Private Investment Deflator

Deflators for private and public investment are modeled separately. For the private investment deflator we impose a long-run unit elasticity with respect to the GDP deflator at factor costs and the import deflator. This reflects the higher import content of this GDP component compared to private consumption. Changes in import prices and the GDP deflator at factor costs are also relevant in the short run. In addition, a deterioration of the terms of trade has a positive impact on the private investment deflator: an increase in import prices relative to export prices tends to increase the price pressure on investment goods. Data for the government investment deflator are only available on an annual basis. The interpolated time series has much less variation than other quarterly series, rendering estimation difficult. Therefore the government investment deflator depends solely on the GDP deflator at factor costs both in the short run and in the long-run.

6.5 Import and Export Price Deflator

The export and import deflators follow competitors' export and import prices in the long-run. Competitors' import prices (CMD) are calculated as the sum of our trade partners' export prices weighted by their import shares; competitors' export prices (CXD) are a double weighted sum of the export prices of countries also exporting on Austrian export markets.

Table 22: Estimation of Long-run Import Prices

$$\ln(MDSTAR_t) = C(1) + C(2)\cdot\ln(CMD_t) + C(3)\cdot\ln(YFD_t) + (1 - C(2) - C(3))\cdot\ln(POILU_t)\ C(4)\cdot D_{971P}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–1.483100	0.052483	–28.25889	0.0000
C(2)	0.579128	0.031427	18.42758	0.0000
C(3)	0.375414	0.022635	16.58527	0.0000
C(4)	–0.046739	0.005866	–7.967807	0.0000

R-squared: 0.945749 Durbin-Watson stat: 0.601633

The first weight is the export share of a competing country on a specific export market. The second weight is the share of that market in total Austrian exports. In modeling the steady-state import deflator, static homogeneity was imposed with respect to competitors' import prices, the GDP deflator at factor costs and oil prices. In an unrestricted version, the coefficient on the competitors' import prices was too low, leading to an unreasonably slow transmission of external price pressures to import prices. The steady-state export deflator depends on competitors' export prices and the GDP deflator at factor costs. Both ECM terms are significant in the dynamic specifications. The short-run dynamics are determined by the growth rates of the same variables that define the steady state.

Table 23: Estimation of Import Prices

$\Delta\ln(MTD_t) = C(1)\cdot\ln(MTD_{t-1}/MDSTAR_{t-1}) + C(2)\cdot\Delta\ln(POILU_t) + C(3)\cdot\Delta\ln(CMD_{t-1}) + C(4)\cdot D_{821} + C(5)\cdot D_{804} + res_t^{MTD}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.229327	0.062757	–3.654215	0.0005
C(2)	0.039112	0.013262	2.949068	0.0042
C(3)	0.223719	0.072768	3.074421	0.0029
C(4)	0.059505	0.012657	4.701484	0.0000
C(5)	–0.034880	0.012762	–2.733048	0.0077

R-squared: 0.394654 Durbin-Watson stat: 1.813696

Table 24: Estimation of Long-run of Export Prices

$\ln(XDSTAR_t) = C(1) + C(2)\cdot\ln(CXD_t) + (1 - C(2))\cdot\ln(YFD_t) + C(3)\cdot D_{971P}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.973916	0.032571	–29.90154	0.0000
C(2)	0.418123	0.012278	34.05494	0.0000
C(3)	–0.056948	0.006381	–8.924267	0.0000

R-squared: 0.957776 Durbin-Watson stat: 0.436232

Table 25: Estimation of Export Prices

$\Delta\ln(XTD_t) = C(1)\cdot\ln(XTD_{t-1}/XDSTAR_{t-1}) + C(2)\cdot 1/2\cdot\sum_{i=0}^{1}\Delta\ln(CXD_{t-i}) + C(3)\cdot\Delta\ln(YFD_{t-i}) + C(4)\cdot D_{844} + C(5)\cdot D_{851} + C(6)\cdot D_{881} + res_t^{XTD}$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	–0.127327	0.054143	–2.351679	0.0212
C(2)	0.121622	0.045425	2.677435	0.0091
C(3)	0.367228	0.088094	4.168590	0.0001
C(4)	–0.025859	0.009279	–2.786915	0.0067
C(5)	0.047503	0.009776	4.859121	0.0000
C(6)	0.029149	0.008986	3.243953	0.0017

R-squared: 0.473967 Durbin-Watson stat: 2.173595

7. The Long-run of the Model

7.1 The Theoretical Steady State

Assuming that factor markets are competitive and taking the Cobb-Douglas function in equation (2) as a starting point, the following relations must hold in the long-run:

$$\beta \cdot \frac{YER}{KSR} = (\delta + r + RP) \tag{8}$$

$$(1-\beta) \cdot \frac{YER}{LNN^{FE}} = \frac{WUN^{FE}}{YFD} \tag{9}$$

The marginal product of capital must equal the sum of the depreciation rate (δ), the real interest rate (r), and the risk premium (RP). The marginal product of labor should grow in line with the real wage rate. In equations (8) and (9) the output-capital and the output-labor ratio are determined by factor input costs. Rearranging the production function yields an expression for employment growth:

$$LNN^{FE} = \left(YER \cdot KSR^{\beta} \cdot TFT\right)^{\frac{1}{1-\beta}} \tag{10}$$

The steady state growth of labor force (LFNSTAR), trend total factor productivity (TFT), and the natural unemployment rate (URT) are set exogenously. The trend labor supply (LNT) follows from the relation

$$LNT = LFNSTAR \cdot (1 - URT) \tag{11}$$

The steady state level of output follows from equations (8), (10) and (11):

$$YSTAR = TFT^{\frac{1}{1-\beta}} \cdot \left(\frac{\beta}{r + \delta + RP}\right)^{\frac{\beta}{1-\beta}} \cdot LNT \tag{12}$$

Equation (12) refers to the steady state output, which is reached when the capital stock has converged to the steady state level. The potential output (YET) which is used in the model to calculate the output gap is defined in terms of the actual capital stock instead and can be understood as a medium term concept:

$$YFT_t = TFT_t \cdot KSR_t^{\beta} \cdot LNT_t^{1-\beta} \tag{13}$$

Equations (8), (9), (10) and (13) define together with the condition that the unemployment rate equals the natural rate the steady state. Condition (8) is implemented in the error correction term of the investment equation (see table 7), condition (10) in the error correction term of the equation for labor demand (see table 14) and condition (9) in the error correction terms of the wage equation (see table 18) and the price equation (see table 16). Finally the condition that the unemployment rate must equal the natural rate of unemployment enters the wage equation in terms of the Philips curve. These four conditions ensure that output in the long-run is given by the supply side of the model.

Finally the condition that demand equals supply must be fulfilled. Actual output which in the short run is determined by the sum of the demand components enters the supply side of the model in equations (3) to (5) and bridges the gap between actual and potential output. In the long-run the components of aggregate demand must sum to the steady state level of output:

$$YSTAR = PCR + GCR + ITR + XTR - MTR + SCR \tag{14}$$

Which mechanism ensures that (equation (14)) holds in the long-run? As explained in Fagan, Henry and Maestre (2001) the equality between supply and demand is achieved by a stock flow interaction which determines the equilibrium level of the real effective exchange rate. To see this, notice that in the long-run investment is determined by the supply side, that the ratio of inventories to GDP is constant and that government consumption is given exogenously. The remaining two demand components, net exports and private consumption, are linked via the real exchange rate. Net foreign assets, defined as cumulated trade balances, enter the equation for private consumption as an integral part of wealth of households. Consistency between private consumption and net exports that ensures that equation (14) holds yields an equlibrium condition for the real effective exchange rate.

7.2 Necessary Conditions for Convergence and the Characteristics of the Steady State

In order to ensure that the model converges to its long-run equilibrium a monetary and fiscal policy rule have to be included. Regarding monetary policy, keeping nominal interest rates exogenous and constant in simulation exercises either produces cyclical patterns or non-convergence to the steady state. We therefore introduced a Taylor rule with an inflation target (π*) of 2%. Moreover it is assumed that the central bank keeps the nominal interest rate permanently below the equilibrium growth rate of nominal GDP (see Bossay and Villetelle, 2004).

$$\begin{aligned} STI = &\left\{400 \cdot \left[\Delta \ln(YSTAR) + \Delta \ln(YDSTAR)\right] - 1\right\} \\ &+ 1.5 \cdot \left(\pi - \pi^{*}\right) + 0.5 \cdot YGAP \end{aligned} \tag{15}$$

Keeping nominal interest rates below the nominal growth rate of the economy rules out explosive debt paths as the debt burden grows slower than the economy. Regarding the public sector, we used a fiscal closure rule that limits growth in public debt. We calibrated the public debt to GDP ratio to be equal to 50%. Any deviation from this ratio triggers an adequate adjustment of the direct tax rate of households. As can be seen in section (7.3) the fiscal rule causes a slight cyclical pattern in the adjustment to the steady state.

To construct a steady state balanced growth path the AQM was simulated for 500 years. As outlined above potential output in the AQM follows a medium term concept and the output gap mirrors deviations of the unemployment rate from the NAIRU. To guarantee that the output gap actually closes and the unemployment rate reaches the NAIRU in the steady state, dynamic homogeneity had to be imposed on the price, wage, labor demand and labor supply equations. Otherwise the long-run solution would depend on arbitrary constants and the unemployment rate could deviate from the exogenous NAIRU. Consequently also the output gap would not close.[4]

In simulation exercises with the AQM it turned out that price elasticities in the trade block and the coefficient of the Philips curve in the wage equation are crucial for assuring convergence towards the steady state. Regarding the trade block we found that the transition to the steady state is typically much smoother and faster when the Marshall Lerner condition is satisfied, i.e. if the sum of the absolute values of the price elasticities in the static real import and export equations is larger than one. This result is not surprising. In the long-run the equilibrium is determined by supply factors and prices adjust fully. Real variables converge to their steady state values as they respond to relative price changes. The adjustment of trade

[4]An equation fulfills the condition of dynamic homogeneity if the sum of the coefficients of the explanatory variables/terms weighted by their steady state growth rates plus the constant equals the steady state growth rate of the dependent variable. Usually this implies a constraint on the constant in the estimation. Dynamic homogeneity is only imposed throughout section 7 to derive a theoretical consistent steady state baseline. For forecasting and short to medium term simulations the unconstrained version of the AQM as presented in the remaining sections is used.

variables to price changes is one main mechanism that supports the convergence towards the steady state. Furthermore, if the Philips curve coefficient in the wage equation is too high the model typically produces cycles in simulation exercises which can be explosive. A small coefficient on the other hand leads to long adjustment periods to the new equilibrium and unreasonable simulation results in the short run. [5] [6] Furthermore assumptions for the exogenous foreign variables have to be made to construct a steady state baseline. For the sake of simplicity it is assumed that the rest of the world grows at the same pace as the home economy and that real interest rates are equal. Relaxing these assumptions would make an endogenous risk premium in the exchange rate equation necessary in order to rule out an explosive path for net foreign assets. Finally, we let all residuals return to zero by using an autoregressive process of order one with an coefficient of 0.2. This constitutes a major shock to the economy and triggers an adjustment process to the steady state equilibrium.

In the steady state real variables grow by the sum of technological progress γ and growth in labor supply n, both given exogenously. The domestic inflation rate π is determined by foreign inflation π^f. As the steady state unemployment rate equals the NAIRU employment growth is equal to labor supply growth (n). Under the conditions outlined above the AQM converges to its long-run equilibrium. This steady state can be described by the following important economic ratios. The GDP shares of exports and imports rise to more than 60%, the GDP share of investment to 25%. The size of these shares crucially depends on price elasticities and the real interest rate, respectively. The output gap closes and the unemployment rate is equal to the NAIRU.

The ratio of investment to the capital stock is determined by the depreciation rate (see section 4.2) and equal to 7.6%. The capital stock to GDP and wealth (defined as the sum of physical capital, net foreign assets and public debt) to GDP

[5] For the steady state baseline and the long-run simulations a modified equation for the GDP deflator at factor costs was used in order to ensure that the output gap closes. Similar to the wage equation, the first order condition of the profit maximizing representative firm with respect to labor directly acts as the ECM-term instead of the one derived in section 2. This ECM-term in the equation for the GDP deflator at factor costs assures that the first-order-labor-demand condition holds, while the Philips curve in the wage equation assures that the unemployment rate converges to the NAIRU. By using this modified specification the long-run properties of the model become better apparent, but since the short run dynamics are less satisfying this specification will only be used in this section 7.

[6] For long-run simulations the Philips curve coefficient had to be calibrated. Its value of -0.001 is significantly lower than the estimated value and implies that a 1 percentage points deviation of the unemployment rate from the NAIRU triggers an adjustment of the wage rate of 0.1 percentage points per period.

ratios are equal 322 and 372%, respectively. Government debt is calibrated to 50% of GDP. Giving a growth rate of nominal GDP of 0.0678% per quarter, net lending of the public sector in % of GDP must equal 2.113. The trade balance and the current account in % of GDP are close to zero. The latest result is not a necessary condition for convergence but evolved by chance.

Chart 6: GDP-Shares in the Long-run

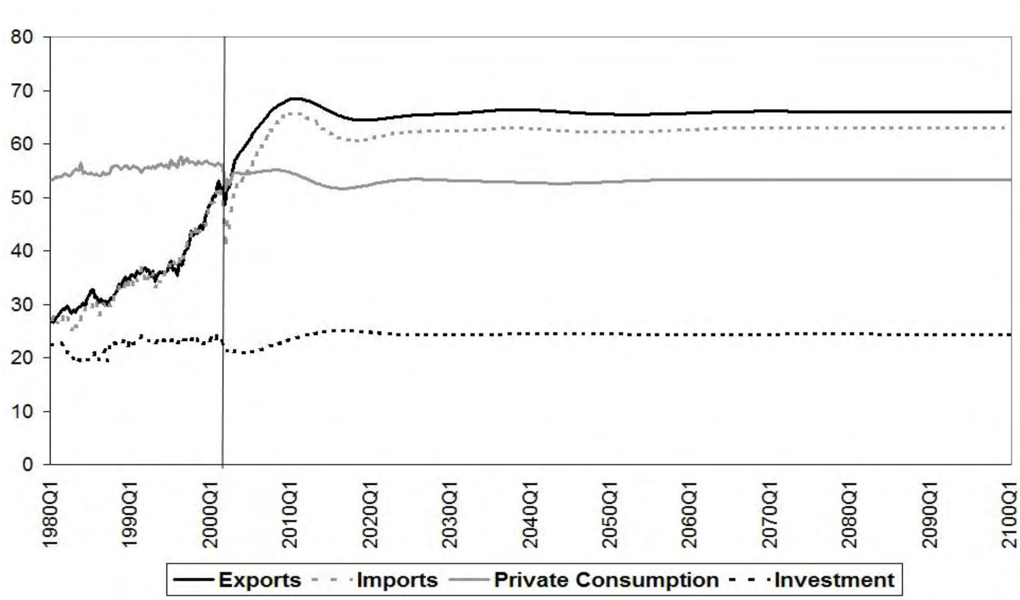


Chart 7: Unemployment Rate in the Long-run

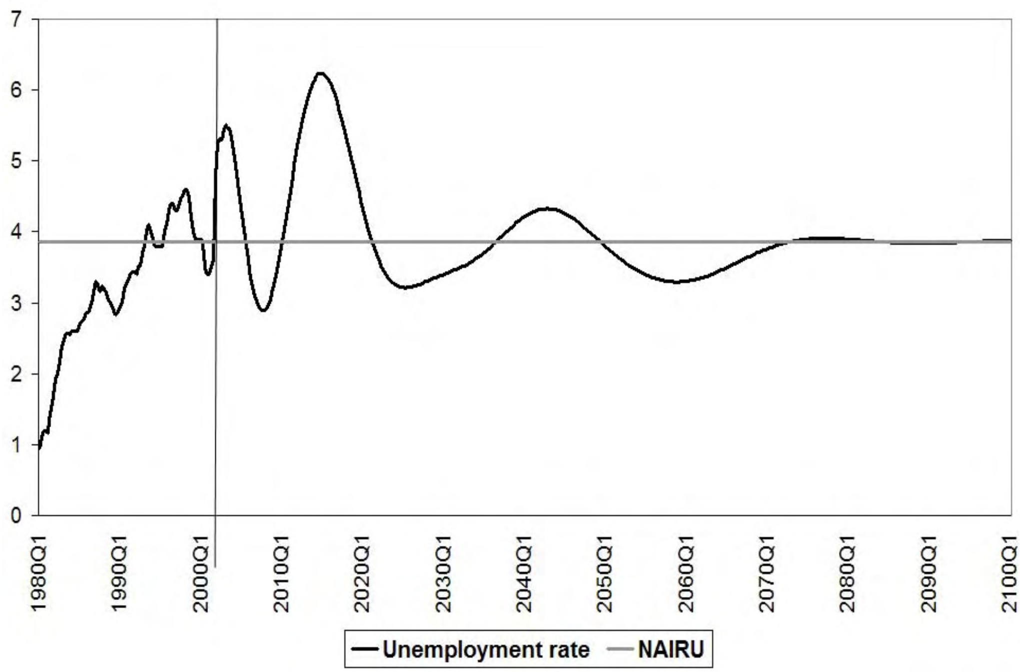


Table 26: GDP Ratios in the Steady State (in %)

	ITR/YER	PCR/YER	XTR/YER	MTR/YER	GCR/YER
1982-2001	22.3	55.6	36.7	35.8	20.3
2001Q3	22.6	56.1	52.0	50.3	19.0
steady state	24.4	53.4	66.2	63.3	19.0

Table 27: GDP Ratios in the Steady State (in %)

	(4·ITR)/ KSR	KSR/ (4·YER)	FWR/ (4·YER)	GLN/ YEN	GDN/ (4·YEN)	NFA/ (4·YEN)	BTN/ YEN	CAN/ YEN
1982–2001	6.5	347.7	407.9	–3.1	58.1	–7.86	–0.48	–1.95
2001Q3	6.6	340.4	399.5	0.3	66.2	–26.14	–0.19	–2.17
steady state	7.6	321.9	372.2	–2.1	50.0	0.53	0.00	0.022

Table 28: GDP Ratios in the Steady State (in %)

	WIN/ YEN	OPN/ YEN	TRN/ YEN	TPN/ YEN	TIN/ YEN	PDN/ YEN	ODN/ YEN
1982–2001	54.1	18.2	24.3	21.7	10.9	10.8	9.1
2001Q3	52.9	18.2	24.0	22.3	10.3	12.0	10.7
steady state	56.9	18.0	24.5	22.0	10.5	10.9	7.8

Finally in the steady state the wage share (excluding self employed incomes) rises to 57% as the effect of the ad hoc trend, introduced in the wage equation to capture the decline in the wage shares in the 1980s and 1990s, fades out. The share of transfers is determined by the evolution of the unemployment rate, the share of direct taxes by the fiscal rule. Overall, most economic ratios are remarkably stable.

7.3 Long-run Simulations

The best way to illustrate the long-run properties of a model is via simulation results. We therefore present two exemplary simulations: a foreign price shock and a labor supply shock. The foreign price shocks shows the neutrality of the model with respect to the price level and the labor supply shock demonstrates how a disequilibrium on the labor market is resolved. In all simulations interest rates are set according to the Taylor rule specified in section (7.2) while the fiscal policy rule is not activated. The Simulations are run around the steady state baseline described in section (7.2).

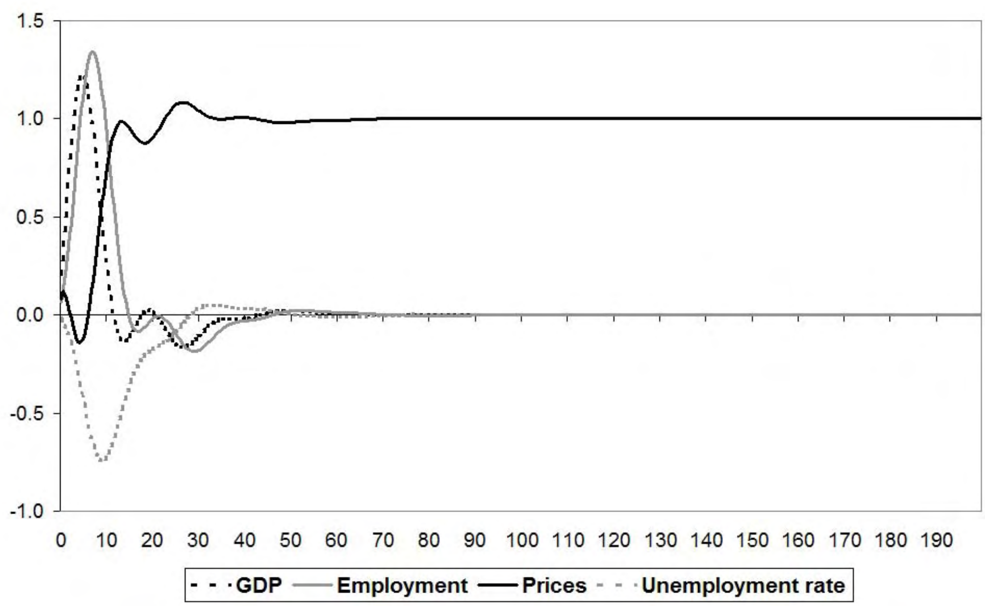
7.3.1 Foreign Price Shock

All foreign prices, i.e. competitors prices on the import and the export side and oil and non-oil commodity prices, are permanently increased by 1%. Due to rigidities on goods and labor markets domestic agents do not immediately adjust to the new equilibrium price level. Thus the international price competitiveness increases in the short run and causes output and employment to rise above baseline levels. In the long-run all domestic prices increase by 1% and real variables return to baseline. Since the supply side is not affected by the price level in the long-run there is no shift in the composition of output as regards the demand components.

7.3.2 Labor Supply Shock

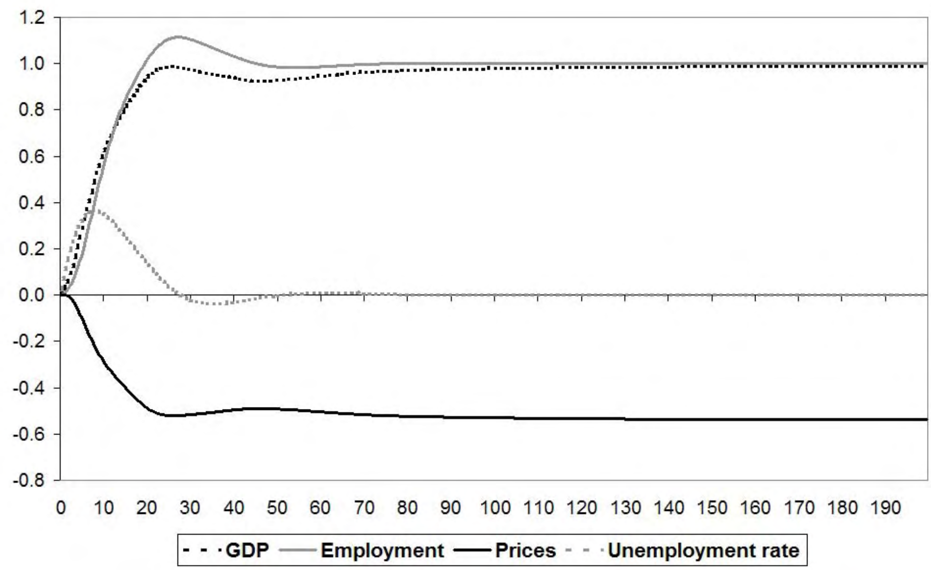
The level of labor supply is increased permanently by one percent above the baseline. To resolve the disequilibrium on the labor market nominal wages have to decline according to the Philips curve.

Chart 8: Permanent Increase of Foreign Prices by 1%



In the long-run the unemployment rate slowly returns to the NAIRU and the output gap closes. Both employment and output increase by 1%. The level of nominal wages and consequently also the overall level of domestic prices as measured by the GDP deflator at factor costs remain below baseline levels in the long-run. Since foreign prices and world demand for Austrian exports are assumed to be exogenous price competitiveness increases permanently. Consequently the composition of output changes not only in the short run but also in the long-run. Real net exports remain permanently above baseline. Nevertheless the (nominal) trade balance worsens slightly as export prices react more sensitive to domestic prices than import prices. This causes net foreign assets to fall below the baseline level. Consequently the increase in wealth and private consumption remain below 1%.

Chart 9: Permanent Increase of Labor Supply by 1%



8. Short-run Simulation Results

For a better understanding of the short-run dynamics of the AQM, three representative simulation exercises are performed to analyze fiscal, monetary and external shocks. All simulations are run without imposing the fiscal closure rule that limits growth in public debt or the monetary closure rule that stabilizes prices. Thus, interest rates and nominal exchange rates are assumed to remain constant at their baseline levels over the whole simulation horizon as well as direct taxes and transfers paid by households as a percentage of GDP. Automatic stabilizers work only through transfers received by households and are assumed to depend positively on the unemployment rate. Exogenous (i.e. constant) nominal interest rates imply that real interest rates are endogenous via changes in inflation. The backward-looking behavior of inflation expectations can thus lead to highly variable real interest rates and user costs of capital in simulations. This can generate a relatively strong reaction of real investment to a shock. All simulations are run within the sample and cover a period of 40 quarters. The following five simulations were carried out:

1) Increase of government consumption for five years.
2) Increase of short-term interest rates for two years.
3) Increase in world demand for five years.

8.1 Simulation 1: Increase of Government Consumption for FiveYears

(See table B1 and chart C1 in the Appendix)

Real government consumption which is strictly exogenous in the model is assumed to increase for five years by 1% of GDP. A surge in government consumption automatically causes an increase in output and employment is affected with a certain lag. Demand side pressures lead to an increase in inflation reinforced by the labor market via the Phillips curve. Real investment activity is boosted for two reasons. First, output expansion operates directly by the common accelerator effect and second, higher inflation rates imply lower real interest rates and therefore a lower user cost of capital. Households' real disposable income rises as employment expands and other personal income increases. This is only partly offset by slightly lower real wages in the first years. Increased prices lead to an erosion of international competitiveness which – together with higher domestic demand – reduces the contributions to growth of net exports, thereby dampening the positive output effect. After five years government consumption is assumed to return to baseline. This constitutes a major negative demand shock and reverses most of the results. Domestic demand drops, prices follow with some lag. The stickiness of prices causes long lasting dampening effects on real GDP and employment over the following five years.

8.2 Simulation 2: Increase of Short-term Interest Rates for Two Years

(See table B2 and chart C2 in the Appendix)

In the monetary policy shock the short-term interest rate is raised by 100 basis points for two years and then returned to its baseline level for the next eight years. Nominal exchange rates move according to a simple uncovered interest rate parity condition (UIP). The euro area share in total trade is approximately 40%. The long-term interest rate (10 years) is assumed to move according to a simple interest rate parity condition, by which agents trade in different maturity assets in the knowledge of future movements of short-term interest rates. The corresponding risk premia are kept at pre-shock levels. (See table 29)

Table 29: Assumptions for the Monetary Policy Shock

	Y1	Y2	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Short-term interest rate (increase in basis points)	100	100	100	100	100	100	100	100	100	100
Long-term interest rate (increase in basis points)	16.3	6.3	20	17.5	15.0	12.5	10.0	7.5	5.0	2.5
Nominal exchange rates (appreciation in %)	1.63	0.63	2.0	1.75	1.50	1.25	1.0	0.75	0.5	0.25

The most important transmission channel of monetary policy is through the user cost of capital. Real investment reacts very sensitive to changes in capital costs and in the real long-term interest rate. The direct effect of monetary tightening on the user cost of capital via nominal interest rates is amplified by the indirect effect via lower inflation. After three years real investment levels are almost 0.7% below their baseline values. Other direct transmission channels are mainly present in the household sector. The substitution effect which reflects the increase in relative costs of present versus future consumption dominates the wealth effect which captures the fall of the market value of household's financial wealth. Income out of wealth increases as a rise in financial yields increases the disposable income of households, who are net lenders. But the overall effect of the income channel is small. The fall in households' real disposable income is mainly due to weaker employment and lower other personal incomes. Overall real private consumption falls much less than investment activity. The appreciation of the exchange rate causes a drop in net-exports in the first year of the simulation. From the second year onwards increased price competitiveness and weaker domestic demand translate into higher growth contributions of net-exports. After two years the interest rate shock is assumed to end. Prices return only slowly to their baseline levels while the effect on real GDP fades out faster. [7]

8.3 Simulation 3: Increase in World Demand for Five Years

(See table B3 and chart C3 in the Appendix)

[7]International trade spillovers of a monetary tightening in the euro area on the Austrian economy are not considered. Results in the course of the WGEM Monetary Policy Transmission Exercise show that for a small open economy like Austria the impact of these transmission channels can be substantial.

An increase in demand for Austrian exports by 1% triggers a rise in exports and in all other GDP components. Due to the high import content in exports and the increase in domestic demand, the effect on real imports of the positive foreign demand shock is also substantial. The additional contribution of net exports to GDP growth remains rather low, peaking at 0.13% in the first year. From the second year onwards, GDP is dominated by the positive effect of rising domestic demand. Private consumption grows in line with employment and investment is boosted by accelerator effects and the impact of higher inflation on the user cost of capital. Higher domestic demand and lower unemployment increase the pressure on prices. The associated loss in competitiveness gradually reduces the contribution to growth of net exports. After five years world demand is assumed to return to baseline. This negative shock triggers reverse adjustment processes. Exports fall not only because of the drop in world demand but also due to lower competitiveness caused by sticky prices. Austrian exporters lose market shares while imports remain above the baseline. This causes a small drop in output and employment. Investments are supported by lower user costs of capital over the whole simulation period as the slow adjustment of prices keeps real interest rates relatively low and financing conditions favorable. Nevertheless, weaker demand causes investments to return to baseline levels at the end of the simulation horizon.

Appendix: List of Variables

Table 30a: Endogenous Variables

ATX	Austrian Stock Index
BTN	Balance of trade of goods and services
CAN	Current account
CC0	User cost of capital
CEX	WIN / LEN
CMD	Competitor's import price in domestic currency
CPN	Credit, privat, amount outstanding, nominal
CXD	Competitor's export price in domestic currency
DDR	Domestic Demand, real
FWN	Financial wealth, nominal
FWR	Financial wealth, real
GB	Government balance
GCD	Government consumption deflator
GCN	Government consumption, nominal
GDN	Government debt, gross
GDNRAT	Ratio of government debt to nominal GDP
GID	Government investment deflator
GIN	Government investment, nominal
GLN	Government net lending
GON	Gross operating surplus
GPB	Government primary balance
GSN	Government gross savings
GTE	Government total expenditure
GTR	Government total receipts
GYN	Government disposable income
HEG	HIC - energy
HEX	HIC - non-energy
HIC	Harmonised index of consumption prices
IER	Equipment investment, real
IHR	Housing (residential) investment, real
IHX	Housing Price Index
INFA	Annual rate of inflation
INFE	Inflation expectatios, adaptive
INFQ	Quarterly rate of inflation
INN	Interest payments on government debt
IOR	Other investment, real
IPD	Private sector non-residential investment, deflator
IPN	Private sector non-residential investment, nominal

Table 30b: Endogenous Variables

IPR	Private sector non-residential investment, real
ITD	Total investment deflator
ITN	Total investment, nominal
ITR	Total investment, real
KGN	Government capital stock, nominal
KGR	Government capital stock, real
KSN	Total capital stock, nominal
KSR	Total capital stock, real
LEN	Employees
LENFE	Employees, full time equivalents
LFN	Total labour force
LNN	Total employment
LNNFE	Total employment, full time equivalents
LNNFE_W	LNNFE / LNN
LNT	Trend employment
LPN	Total employment, private sector
LSN	Self employed
LSNFE	Self employed, full time equivalents
LSNFE_W	LSNFE / LSN
LSR	Stock of inventories
LTI	Long-term nominal interest rate
LTR	Long-term real interest rate
MTD	Import deflator
MTN	Imports, nominal
MTR	Imports, real
NFA	Net foreign assets
NFN	Net factor income
NXR	Netexports, real
ODN	Other direct taxes
OID	Private investment deflator
OIN	Private investment, nominal
OIR	Private investment, real
OLN	Net lending by other private sector
OPN	Other personal income
OWN	Private compensation to employees
OYN	GON+TWN+NFN+INN - ODN+OPN+OGN)
PCD	Private consumption deflator
PCN	Private consumption, nominal
PCR	Private consumption, real
PDN	Income tax and social security contributions, paid by households
PDNB	Tax base for direct taxes
PDX	Ratio between direct taxes and its tax base
PEI	Price of energy and raw materials, domestic currency
PLN	Net lending by private sector

Table 30c: Endogenous Variables

POIL	Oil price in domestic currency
PRO	Average labour productivity
PROFE	Average labour productivity, full time equivalents
PSN	Private sector savings
PSNQ	Private sector savings ratio
PYN	Private sector disposable income, nominal
PYR	Private sector disposable income, real
REALI	The real interest rate for inventories
SALE	Sales of storable goods (PCR + XTR)
SCAN	Cumulated current account
SCD	Changes in inventories, deflator
SCN	Changes in inventories, nominal
SCR	Changes in inventories, real
SGLN	Cumulated government net lending
SMC	Short-run marginal cost of production
STI	Short-term nominal interest rate
SZD	Inventories and statistical discrepancies deflator
SZR	Inventories plus statistical discrepancies
TIN	Indirect taxes less subsidies, total
TIR	Indirect taxes less subsidies, real
TIX	Ratio between TIN and YEN
TOT	Terms of Trade
TPN	Transfers from households to government
TRN	Transfers from government to households
TPX	Ratio between TPN and YEN
TRX	Ratio between TRN and YEN
ULA	ULC adjusted (employees)
UNN	Total unemployment
URX	Unemployment rate
WER	Import demand indicator
WGN	Compensations to employees, government
WPN	Compensations to employees, private
WIN	Total compensation to employees, nominal
WUN	Compensation per employee
WUNFE	Compensation per employee, full time equivalents
WUP	Compensations per employees, private
WURPD	Real compensation per employee, with PCD deflator
WURYD	Real compensation per employee, with YED deflator
XTD	Exports deflator
XTN	Exports, nominal
XTR	Exports, real
YED	GDP expenditure deflator

Table 30d: Endogenous Variables

YEN	GDP expenditure, nominal
YER	GDP expenditure, real
YFD	GDP at factor cost deflator
YFN	GDP at factor cost, nominal
YFR	GDP at factor cost, real
YFT	Potential output
YGA	Output gap
YNR	Production using available inputs
ZYEN	Inventories and statistical discrepancies, nominal

Table 31: Definition – Variables

CSTAR	Long-run equilibrium level of private consumption
CDSTAR	Long run behaviour of Consumption deflator
GDSTAR	Long run behaviour of Government investment deflator
KSTAR	Long-run equilibrium level of capital stock
LSSTAR	Long-run equilibrium level of real stocks
LSTAR	Long-run equilibrium level of employment
MDSTAR	Nominal effective exchange rate on the import side
MSTAR	Long-run equilibrium level of imports
WSTAR	Long run wage rate
XDSTAR	Government investment, real
XSTAR	Long-run equilibrium level of exports
YDSTAR	Long-run equilibrium level of GDP deflator at factor costs

Table 32: Exogenous Variables

CMD_EX	Competitor's import price - extra Euro Area
CMD_IN	Competitor's import price - intra Euro Area
CXD_EX	Competitor's export price - extra Euro Area
CXD_IN	Competitor's export price - intra Euro Area
D8	Change in net equity of households in pension funds reserves (D.8)
EEN	Nominal effective exchange rate on the export side
EEN0	Nominal effective exchange rate on the import side
GCR	Government consumption, real
GDNRAT	Ratio of Gov. debt to nominal GDP
GIR	Government investment, real
HICWE	Weights for HICP
IHN	Housing investment (private and gov't), nominal
IPX	Industrial production to GDP ratio
LEX	Employees to employment ratio
LFNSTAR	Total labour force, hp filtered with lamda = 40
LGN	Government employment
OGN	Other sector transfers to/from government
PEX	Ratio between MTD and WUN, exogenous in forecast
POILU	Oil price in USD
RP	Risk premium
TWN	Transfer from rest of the world
URT	Trend unemployment rate
USD	Exchange Rate US dollar for 1 Euro
WDR	World demand indicator
WDR_EX	World demand indicator - extra Euro Area
WDR_IN	World demand indicator - intra Euro Area
WUG	Compensation per goverenment employee
ZCC0	Statistical discrepancy on user cost of capital
ZGDN	Statistical discrepancy on government debt
ZGYN	Discrepancy in gov disp income equation
ZHIC	Discrepancy in HICP equation
ZKGN	Statistical discrepancy on gov capital stock, nominal
ZKGR	Statistical discrepancy on capital stock
ZKSN	Statistical discrepancy on capital stock, nominal
ZKSR	Statistical discrepancy on capital stock
ZUNN	Statistical discrepancy on labour force
ZNFA	Statistical discrepancy on net foreign assets
ZPSN	Statistical discrepancy on private saving
ZURX	Statistical discrepancy on unemployment rate
ZYER	Statistical discrepancy on GDP expenditure

Appendix B: Simulation Results – Tables

Table B1: Simulation 1: Increase of Government Consumption for Five Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
HICP	0.20	0.63	1.10	1.57	2.01	2.21	2.12	1.93	1.68	1.44
Consumption Deflator	0.13	0.54	1.02	1.52	1.98	2.28	2.25	2.05	1.79	1.53
GDP Deflator	0.08	0.54	1.03	1.52	1.97	2.31	2.22	2.00	1.73	1.48
Investment Deflator	0.14	0.51	0.94	1.36	1.77	1.98	1.94	1.75	1.53	1.31
ULC	-0.59	-0.09	0.53	1.21	1.93	3.14	3.27	3.09	2.77	2.40
Compensation per employee	0.16	0.42	0.88	1.38	1.93	2.33	2.55	2.54	2.43	2.31
Productivity	0.75	0.51	0.35	0.17	0.00	-0.79	-0.69	-0.53	-0.33	-0.09
Export Deflator	0.04	0.23	0.46	0.72	0.97	1.18	1.21	1.16	1.05	0.92
Import Deflator	0.01	0.11	0.26	0.43	0.60	0.76	0.82	0.80	0.73	0.64
GDP and Components	*Levels, percentage deviations from baseline*									
GDP	1.12	1.30	1.48	1.57	1.55	0.47	0.14	-0.13	-0.32	-0.41
Consumption	0.17	0.49	0.71	0.88	0.99	0.89	0.60	0.33	0.10	-0.07
Investment	1.40	2.12	2.88	3.64	4.06	2.96	2.14	1.23	0.39	-0.19
Of which: Residential Inv.	1.13	1.71	2.32	2.94	3.27	2.38	1.74	0.99	0.32	-0.15
Gov. Consumption	5.04	4.87	4.70	4.56	4.50	0.00	0.00	0.00	0.00	0.00
Exports	-0.01	-0.06	-0.13	-0.21	-0.28	-0.35	-0.37	-0.36	-0.34	-0.30
Imports	0.83	1.30	1.70	2.03	2.20	1.52	1.05	0.67	0.38	0.25
Contributions to Shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic Demand	1.41	1.73	2.02	2.28	2.42	1.20	0.84	0.47	0.15	-0.08
Inventories	0.01	0.05	0.09	0.10	0.06	-0.01	-0.10	-0.16	-0.14	-0.05
Trade Balance	-0.30	-0.47	-0.63	-0.81	-0.93	-0.72	-0.60	-0.45	-0.33	-0.28
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	0.37	0.79	1.13	1.40	1.55	1.27	0.84	0.40	0.01	-0.32
Employees in employment	0.37	0.79	1.13	1.40	1.55	1.27	0.84	0.40	0.01	-0.32
Unemployment rate	-0.09	-0.24	-0.38	-0.52	-0.63	-0.63	-0.55	-0.45	-0.32	-0.19
Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	0.74	0.89	1.06	1.16	1.18	0.51	0.22	-0.02	-0.18	-0.24
Saving rate	0.48	0.36	0.33	0.25	0.18	-0.36	-0.36	-0.33	-0.27	-0.17

Table B2: Simulation 2: Increase of Short-term Interest Rates for Two Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
HICP	-0.04	-0.10	-0.16	-0.19	-0.19	-0.17	-0.14	-0.13	-0.12	-0.11
Consumption Deflator	-0.06	-0.11	-0.16	-0.19	-0.20	-0.18	-0.16	-0.13	-0.12	-0.11
GDP Deflator	-0.06	-0.12	-0.17	-0.20	-0.20	-0.18	-0.15	-0.13	-0.12	-0.11
Investment Deflator	-0.06	-0.12	-0.16	-0.18	-0.18	-0.16	-0.13	-0.11	-0.10	-0.10
ULC	0.05	0.01	-0.12	-0.22	-0.27	-0.27	-0.23	-0.19	-0.16	-0.15
Compensation per employee	-0.02	-0.08	-0.15	-0.20	-0.22	-0.23	-0.22	-0.21	-0.20	-0.20
Productivity	-0.08	-0.09	-0.04	0.02	0.05	0.04	0.01	-0.02	-0.04	-0.04
Export Deflator	-0.16	-0.20	-0.16	-0.15	-0.13	-0.12	-0.10	-0.09	-0.08	-0.07
Import Deflator	-0.19	-0.18	-0.10	-0.08	-0.08	-0.08	-0.07	-0.06	-0.05	-0.05
GDP and Components	*Levels, percentage deviations from baseline*									
GDP	-0.12	-0.19	-0.17	-0.11	-0.05	-0.02	-0.01	-0.02	-0.03	-0.02
Consumption	-0.02	-0.09	-0.13	-0.12	-0.10	-0.07	-0.04	-0.03	-0.03	-0.03
Investment	-0.23	-0.57	-0.68	-0.59	-0.42	-0.28	-0.17	-0.11	-0.07	-0.04
of which: Residential Inv.	-1.88	-2.15	-0.55	-0.47	-0.34	-0.23	-0.14	-0.09	-0.05	-0.03
Gov. Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	-0.18	-0.05	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.02
Imports	-0.11	-0.17	-0.20	-0.15	-0.08	-0.04	-0.05	-0.08	-0.11	-0.09
Contributions to Shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic Demand	-0.07	-0.18	-0.23	-0.21	-0.15	-0.10	-0.07	-0.04	-0.03	-0.02
Inventories	-0.03	-0.05	-0.02	0.03	0.06	0.06	0.02	-0.02	-0.05	-0.05
Trade Balance	-0.03	0.04	0.08	0.07	0.04	0.03	0.03	0.05	0.06	0.06
Labor Market	*Levels, percentage deviations from baseline, except unemployment:percentage points, absolute deviations from baseline*									
Total employment	-0.04	-0.10	-0.14	-0.13	-0.10	-0.05	-0.02	0.00	0.02	0.03
Employees in employment	-0.04	-0.10	-0.14	-0.13	-0.10	-0.05	-0.02	0.00	0.02	0.03
Unemployment rate	0.01	0.03	0.05	0.05	0.05	0.04	0.03	0.02	0.02	0.01
Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	-0.05	-0.12	-0.13	-0.10	-0.05	-0.02	-0.01	-0.02	-0.02	-0.02
Saving rate	-0.03	-0.02	0.00	0.02	0.04	0.04	0.03	0.01	0.01	0.01

Table B3: Simulation 3: Increase in World Demand for Five Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
HICP	0.04	0.13	0.23	0.33	0.42	0.46	0.45	0.41	0.37	0.33
Consumption Deflator	0.03	0.11	0.22	0.32	0.42	0.48	0.47	0.43	0.39	0.35
GDP Deflator	0.04	0.13	0.24	0.34	0.44	0.48	0.47	0.43	0.38	0.34
Investment Deflator	0.03	0.10	0.20	0.29	0.37	0.42	0.41	0.37	0.34	0.30
ULC	-0.12	-0.03	0.10	0.25	0.40	0.64	0.67	0.63	0.57	0.52
Compensation per employee	0.03	0.09	0.18	0.29	0.40	0.48	0.52	0.53	0.51	0.50
Productivity	0.15	0.12	0.08	0.04	0.00	-0.16	-0.14	-0.10	-0.06	-0.01
Export Deflator	0.01	0.05	0.11	0.16	0.22	0.26	0.26	0.25	0.23	0.21
Import Deflator	0.00	0.02	0.05	0.09	0.13	0.16	0.17	0.17	0.16	0.14
GDP and Components	*Levels, percentage deviations from baseline*									
GDP	0.23	0.28	0.32	0.34	0.33	0.11	0.05	0.00	-0.02	-0.04
Consumption	0.04	0.11	0.16	0.21	0.23	0.22	0.16	0.10	0.06	0.04
Investment	0.28	0.45	0.61	0.76	0.85	0.63	0.46	0.29	0.14	0.04
Of which: Residential Inv.	0.23	0.37	0.49	0.62	0.69	0.51	0.38	0.24	0.12	0.03
Gov. Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	0.85	0.93	0.94	0.94	0.93	0.06	-0.02	-0.05	-0.06	-0.06
Imports	0.51	0.70	0.79	0.85	0.88	0.39	0.23	0.18	0.15	0.13
Contributions to Shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic Demand	0.09	0.17	0.23	0.29	0.33	0.27	0.20	0.13	0.07	0.03
Inventories	0.01	0.03	0.02	0.01	-0.01	-0.03	-0.04	-0.02	0.00	0.03
Trade Balance	0.13	0.09	0.06	0.03	0.01	-0.13	-0.11	-0.10	-0.10	-0.10
Labour Market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	0.07	0.17	0.24	0.30	0.33	0.28	0.19	0.11	0.04	-0.02
Employees in employment	0.07	0.17	0.24	0.30	0.33	0.28	0.19	0.11	0.04	-0.02
Unemployment rate	-0.02	-0.05	-0.08	-0.11	-0.14	-0.14	-0.12	-0.10	-0.08	-0.06
Household Accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	0.16	0.21	0.24	0.26	0.26	0.12	0.06	0.02	0.00	-0.01
Saving rate	0.11	0.09	0.07	0.05	0.03	-0.09	-0.09	-0.08	-0.06	-0.05

Appendix C: Simulation Results – Charts

Chart C1: Simulation 1: Increase of Government Consumption for Five Years

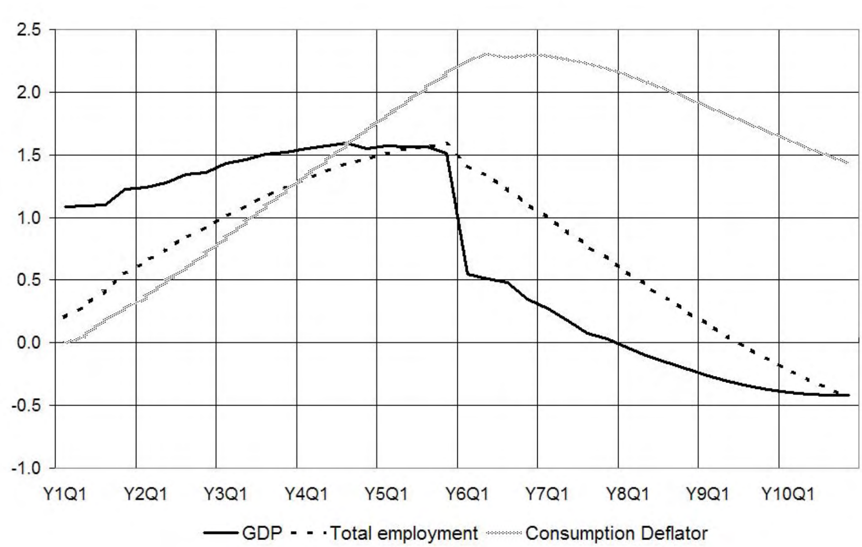


Chart C2: Simulation 2: Increase of Short-term Interest Rates for Two Years

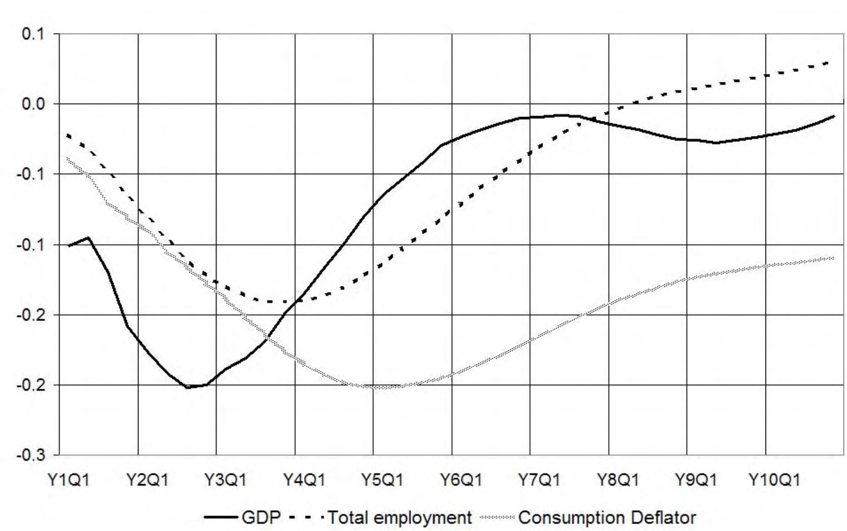
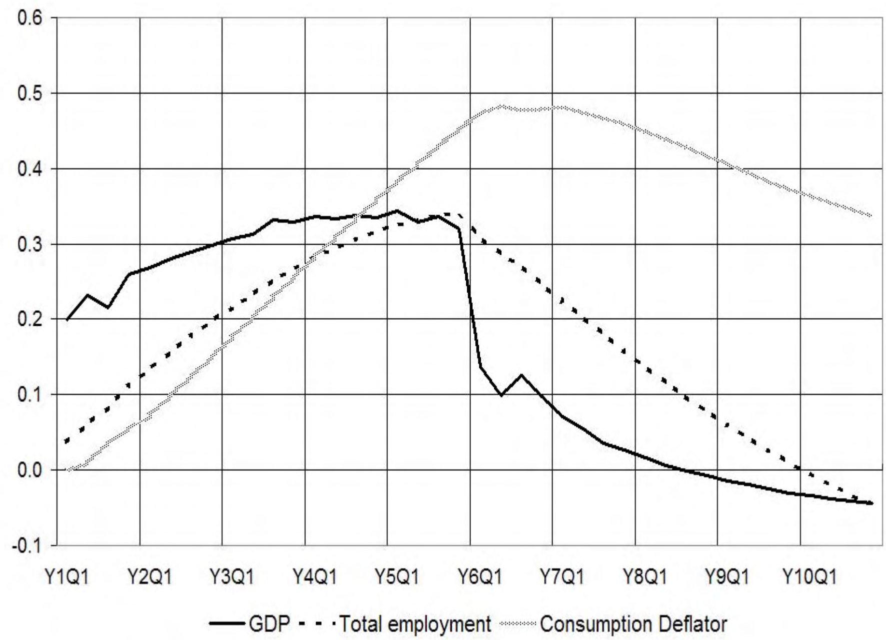


Chart C3: Simulation 3: Increase in World Demand for Five Years



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WIFO-Macromod – An Econometric Model of the Austrian Economy[1]

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1. Introduction

WIFO-Macromod is the annual aggregate macroeconometric model of the Austrian economy developed at the Austrian Institute of Economic Research (WIFO).[2] The model serves a dual purpose: preparing the annual WIFO medium-term economic forecast with a forecast horizon of five years and performing economic policy simulations.[3]

[1] We are grateful to Rudolf Zwiener (DIW, Berlin) and Thomas Warmedinger (ECB, Frankfurt) for their valuable comments and suggestions.

[2] Macroeconometric modelling has a long tradition at WIFO (Schebeck and Thury, 1979, Breuss and Schebeck, 1990). Several other econometric models are currently in use at WIFO: A-LMM is a long-run macroeconomic model developed jointly with the Institute for Advanced Studies, Vienna (IHS). This model is designed to study the long-run consequences of population aging on employment, output growth, and the solvency of the social security system (Baumgartner et al., 2004). In addition, an input-output model (Kratena and Zakarias, 2001) is available, and a multi-regional input output model (Fritz et al., 2004) will soon be available. Furthermore, several specialized models such as the multi-country tourism model (Smeral, 2004) and the PASMA, a disaggregated model of Austria's agricultural sector (Sinabell and Schmid, 2003), are regularly used for forecasting and simulation studies.

[3] The recent medium-term forecast of the Austrian economy is documented in Baumgartner, Kaniovski and Walterskirchen (2004).
Breuss, Kaniovski and Schratzenstaller (2004) study the short and medium run effects of the Tax Reform 2004/2005. Breuss, Kaniovski and Lehner (2004) discuss simulations of the economic consequences of fiscal policy in the years 2000 to 2002. Kaniovski, Kratena and Marterbauer (2003) present simulations of fiscal spending based on several models.

This paper is organised as follows. In section 2, we briefly outline the scope of the model. Then we present its main structural equations and definitions (section 3), and discuss three simulations: public consumption shock, export shock and interest rate shock in section 4. The simulated economic shocks, although conceivable and realistic, do not relate to actual or potential developments but highlight the properties of the model. In *Warmedinger* (2005) and *Zwiener* (2005) WIFO-Macromod is compared with models for the Austrian economy run by the Oesterreichische Nationalbank (Fenz and Spitzer, 2005) and the Institute for Advanced Studies (Hofer and Kunst, 2005).[4]

2. The Scope of the Model

WIFO-Macromod can be described as a demand-driven structural econometric model with supply side elements used for price and wage determination. Focusing on the demand-side of the economy we explicitly model all major components of the use and distribution of the national income accounts. We estimate a trend output with a constant elasticity of substitution production function and use an output gap as a proxy for the aggregate rate of capacity utilisation. Due to the short forecasting horizon of five years and the demand-side focus of the model we treat technical progress as exogenous.

In WIFO-Macromod, Austria is described as a small open economy in the European Economic and Monetary Union (EMU). Thus, the repercussions of economic activity in Austria on the rest of the world are neglected and variables describing the world economic conditions, including those of European economic policy authorities, are set as exogenous. Specifically, we treat the income of Austria’s trading partners, the euro-U.S. dollar exchange rate, short and long-term interest rates and world prices for tradable goods and services as exogenous. We impose that domestic excess savings correspond to the income balance in the current account. The financial relations with the EU budget on both sides (own resources and transfers from the EU) are also modelled as exogenous variables.

The basic structure of the model is shown in chart 1. The model contains 134 endogenous and 64 exogenous variables in 34 behavioural equations and 100 identities. Most behavioural equations are estimated using annual data of the national accounts published by Statistik Austria. These data are currently available for the period 1976 to 2003 and are supplemented by the sector accounts from 1995 onwards. A few structural equations are calibrated involving assumptions that yield more plausible projections. The small size of the available data sample narrows the

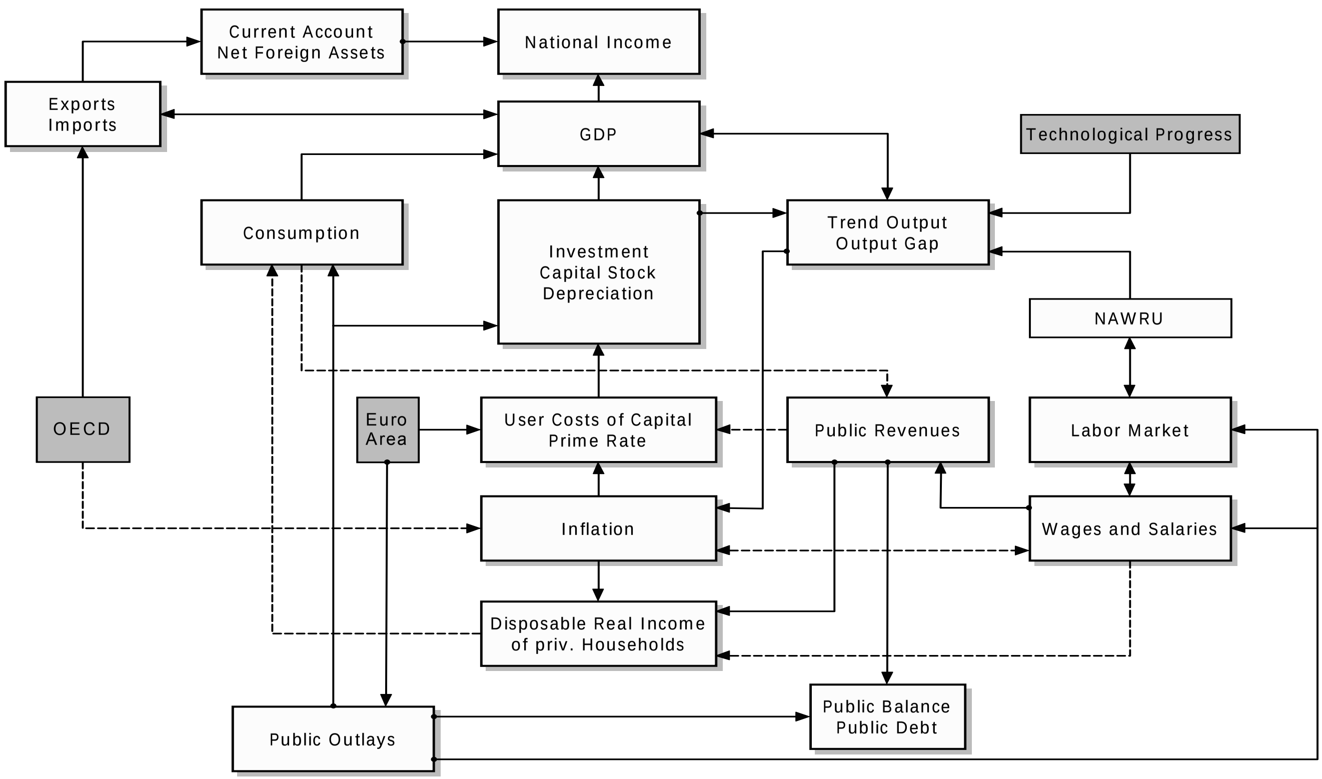
[4] In this paper we present only a brief description of the model. In reaction to the introduction of chaining in the European system of national accounts, the WIFO-Macromod will be completely revised. A comprehensive documentation of the model will then be made available.

choice of econometric techniques that can sensibly be applied. Except for several parameters in the production function, all structural equations were estimated as single equations using ordinary least squares. To satisfy the stationary requirement all equations were estimated using either static or dynamic specifications in first (logarithmic) differences or, in the case of co-integrated series, as error-correction models. All error-correction models were estimated as Sims, Stock and Watson (1990) regressions (henceforth SSW). This method is technically equivalent to estimating the single-equation error-correction model directly by nonlinear least squares, i.e. yields identical coefficients and fit. The principal merit of SSW regression lies in its simplicity and the small-sample properties superior to those of the classic Engle-Granger two-step procedure (Engle and Granger, 1987). Since the standard asymptotic distribution theory applies to all single coefficient tests in SSW, the long-run elasticity between the co-integrated variables can be readily estimated. What cannot be recovered, however, is the complete long-run relationship between the co-integrated variables.

The reason is that the coefficients of all deterministic terms in the long-run relationship, such as a constant or a trend, are not separately estimable using SSW (see the discussion in Davidson and MacKinnon, 1993, p. 723–725).

Although, most of the time we would use the estimated error-correction specification, in some cases only the long-run relationship implied by the error-correction term is used. In this case, we use a relationship in growth rates rather than in the levels, which confers an additional advantage of ensuring a smooth out of sample transition and avoids the indeterminacy in the deterministic part of the long-run relationship.

Chart 1: Structure of WIFO-Macromod



Note: Shading indicates exogenous blocs. Solid and dotted lines are equivalent.

3. The Structure of the Model

3.1 Consumption

In the model we differentiate between consumption outlays of the private and public sector. We estimate an error-correction model for the consumption expenditures of private households as a function of their disposable real income. We do not further differentiate between durable and non-durable consumption goods. Consumption and the value added of the public sector are computed according to their respective ESA definitions and are only partially endogenous.

Like in most other developed economies, the time-series of private household consumption in Austria show high serial correlation and, therefore, a high degree of smoothness. The adjustment of consumption expenditure to shocks in income is sluggish and shows high sensitivity to past incomes. A challenge in the empirical modelling of consumer behaviour has been how to reconcile the empirical implications of the expected permanent life-cycle income hypothesis, i.e. a random walk in consumption expenditure on durable goods (Hall, 1978), with smooth consumption paths. The error-correction approach pioneered in Davidson, Hendry, Srba and Yeo (1978, henceforth DHSY) has been more successful in accounting for these empirical regularities and has become the standard methodology for modelling the consumption of non-durables. We follow the DHSY approach in modelling aggregate consumption expenditure of private households, but use the SSW regression instead of Engle-Granger's two-step method.

The relationship between private consumption expenditure, CP_t, and disposable income, YD_t, of private households at constant 1995 prices is estimated using the SSW regression[12]:

$$\Delta\log(CP_t) = -0.3 + 0.35\Delta\log(YD_t) - 0.212\log(CP_{t-1}) + 0.237\log(YD_{t-1}), \qquad (1)$$

The estimation yields a short-run income-elasticity of consumption of 0.35. Although the estimated coefficient is lower than the average propensity to consume implied by the recent Austrian consumer survey of 0.6, the overall effect is offset by the long-run elasticity of slightly above unity (0.237/0.212 = 1.12). The implied speed of adjustment is such that a permanent income shock of 1% leads to a

[12] In all equations in the text we omit any dummy variables, as those have no effect on out-of-sample projections and simulations.

cumulative increase in consumer expenditures of 0.81 percentage points in the subsequent five years and 1.02 percentage points in ten years.

3.2 Investment, Capital Stock, and Depreciation

Investment is divided into three categories of capital goods: non-residential construction, residential construction or dwellings, and machinery and equipment. The latter category also includes investment in transport equipment, cultivated, and intangible fixed assets such as software. Except for residential construction, we differentiate between private and public investment outlays, for a total of five distinct investment categories. Public residential and non-residential investments as well as investment in dwellings are exogenous. Private non-residential construction and machinery and equipment are determined in the model.

The five investment categories are then used to project the corresponding stocks of capital. Here we do not differentiate between public and private stock of capital. The aggregate capital stock is a factor input in the production function for the determination of the trend output (see section 3.5). We follow Statistik Austria's methodology for computing the capital stock as described in Böhm et al. (2001) and Statistik Austria (2002).[13] We recover the implicit consumption of fixed capital from the perpetual inventory calculation.

Private investment in machinery and equipment, IPM_t, is modelled using an error-correction specification:

$$\Delta \log(IPM_t) = -3.417 + 1.76\Delta \log(YP_t) - 0.46\Delta \log(UCM_t) - 0.226\log(IPM_{t-1} / YP_{t-1}), \qquad (2)$$

where YP_t is the value added of the private sector and UCM_t represents the user costs of capital. The error-correction term, which describes the long-run relationship between value added, investment, and user costs of capital, is motivated by an accelerator model and the neoclassical investment theory. The above equation implies a short-run elasticity of private investment in machinery and equipment with respect to value added of 1.76 and a long-run unit elasticity. The elasticity with respect to user costs of capital of −0.46 is comparable to an estimate for Germany by Harhoff and Ramb (2001) and is lower than an estimate for the U.S.A. at the firm-level by Chirinko, Fazzar and Meyer (1999).

User costs of capital are calculated according to neoclassical investment theory developed in Jorgenson (1963), and Hall and Jorgenson (1967). The exact analytic expression for the user costs of capital depends on the underlying theoretical model

[13] Statistik Austria (2002) uses a variant of the perpetual inventory method that assumes a uniform depreciation of the capital good within any given year. Other key elements of their methodology include age and constant depreciation profiles for different capital goods and their initial stocks.

of investment and the capital stock. Special care must also be taken to ensure the correct representation of the major fiscal instruments of the country's corporate tax code and the relevant national and international subsidy schemes. From a practical point of view, the more fiscal instruments are accounted for, the wider the scope of simulations that can be performed. On the other hand, adding detail to the model adds complexity and, since some variables are not readily observable, it also adds the difficulty of keeping the data up-to-date.

We found the following specification to offer sufficient detail and yet be simple enough. It is based on the derivation of the user costs of capital for Austria presented in Kaniovski (2002):

$$UCM_t = (PI_t / P_t)(RC_t - \Delta\log(PI_t) + RDM_t)RTUCM_t, \qquad (3)$$

where PI_t / P_t is the ratio of investment to the GDP deflator, RC_t the interest rate on business loans, $\Delta\log(PI_t)$ the inflation rate for the capital good, and RDM_t the rate of economic depreciation. The last factor in *(3)* reflects several characteristics of Austria's corporate tax system:

$$RTUCM_t = \frac{1 - Z_t \cdot RTCIT_t}{(1 - RTCIT_t)\sqrt{1 - RDM_t}}. \qquad (4)$$

Here Z_t is the present value of the depreciation tax allowance and $RTCIT_t$ the combined statutory rate of corporate taxation, which currently is identical to the statutory tax rate of the corporation tax (Körperschaftsteuersatz). The factor $\sqrt{1 - RDM_t}$ reflects the assumption that new investment goods depreciate uniformly already in the year of their purchase. The above specification for user costs of capital allows simulations of a change in the corporation tax, the depreciation allowance, or the investment tax allowance.

For the interest rate on business loans we estimate an equation in first differences:

$$\Delta RC_t = 0.00049 + 0.049\Delta RLN_t + 1.114\Delta RSN_t, \qquad (5)$$

where $RSIN_t$ and $RLIN_t$ are the short-run (3 month) and long-run (10 year benchmark) GDP-weighted interest rates for the euro area. Both interest rates are exogenous. Equations (2) to (5) form the main monetary policy transmission channel in the model. Private sector non-residential investment follows a simple error-correction specification based on accelerator theory:

$$\Delta\log(IPC_t) = -5.79 + 1.32\Delta\log(YP_t) - 0.385\log(IPC_{t-1} / YP_{t-1}) + 0.397\log(YP_{t-1}). \qquad (6)$$

The short and long-run elasticities with respect to GDP in the private sector are 1.32 and around 2.0, respectively.

3.3 Foreign Trade and the Current Account

For total exports we estimate a specification which depends on income in OECD countries and the relative price of domestic and foreign goods. This approach is consistent with the Armington assumption of imperfect substitutability between traded goods, as the law of one price is not imposed. For total exports at constant 1995 prices, X_t, we estimate an error-correction model:

$$\Delta\log(X_t) = -3.47 + 1.03\Delta\log(YW_t) - 0.28\Delta\log\left(\frac{PX_t}{PW\$_t US\$_t}\right) - 0.154\log(X_{t-1}) + 0.369\log(YW_{t-1}) \quad (7)$$

In the above export equation, YW_t represents the weighted aggregate GDP of Austria's main exports markets with weights according to the destinations' shares in Austria's exports in the year 2003. The relative price term includes the export deflator, PX_t, and the world price deflator for traded goods in US dollars, $PW\$_t$, from the "World Economic Outlook" of the IMF. The world price is converted into euro using the exchange rate between the euro and US dollar, $US\$_t$. We observe a short run income elasticity of 1.03 and a price elasticity of 0.28. The long-run income elasticity equals 2.4.

In modelling import demand, we differentiate the income effect depending on the use by taking into account different import contents of demand aggregates. Doing so is especially important when simulating the effect of fiscal policy measures. A comparison of import contents of different demand aggregates as shown in table 1 suggests that an increase in government consumption would, other things equal, induce less additional imports and therefore more value added than, say, a comparable increase in private investment in machinery and equipment. We compute a notional imports variable, MIO_t, as the sum of demand components weighted by their respective import contents. As import contents are computed from input/output tables and are not available as time series, we use the 1995 shares since this date coincides with our price basis. Import shares are held constant for the subsequent years.

Table 1: Import Content at Current Prices in Percent

	1995	2000
Demand aggregate		
Private consumption	23	27
Public consumption	9	11
Investment in		
Residential construction	21	22
Non-residential construction	22	22
Machinery and equipment	59	70
Exports	33	39
Total domestic demand	23	27

Source: I/O tables for Austria.

Table 1 shows that the import content of all demand components, with the exception of construction investment, has risen. The difference between M_t and MIO_t can be explained by the decrease in import prices relative to those of domestic goods. However, there may be factors other than prices which influence the import content. The increase in the import share can be partially explained by integration effects due to EU enlargement and deepening. Outsourcing could be another factor contributing to a steady increase in the import content of intermediate goods. Both, price and non-price effects are taken into account by the following specification:

$$\log(M_t / MIO_t) = 0.00446 + 0.232\log(PM_t / P_t) - 0.507\log(PM_{t-1} / P_{t-1}) + 0.856\log(M_{t-1} / MIO_{t-1}) \quad (8)$$

where PM_t and P_t are the import and the GDP deflator, respectively. By definition, the elasticity of MIO_t with respect to the actual imports is unity. A simulation of equation (8) for the time period 1995 to 2005 shows that a 1% increase in public consumption leads to 0.04% increase in total imports, whereas a similar increase in (private) investment in machinery and equipment leads to 0.14% more imports.

The current account balance, CA_t, contains three components: (i) the balance of trade in goods and services, $CAXMN_t$, (ii) the balance of income flows, CAY_t, (iii) and the balance of transfer payments, CAT_t:

$$CA_t = CAXMN_t + CAY_t + CAT_t . \quad (9)$$

The balance of trade at current prices is computed from the exported and imported quantities of goods and services and their respective deflators. The balance of income flows is proportional to the interest earned on the stock of net foreign assets, NFA_{t-1}, accumulated in the past:

$$CAY_t = QCAY\left(NFA_{t-1}RSN_t\right), \tag{10}$$

where $QCAY$ is a constant factor and RSN_t the short-term interest rate.

Domestic savings of the economy, SN_t, is the sum of private household savings, government savings and savings by the business sector:

$$SN_t = (YDN_t - CPN_t) + (GR_t - GE_t) + QSB(IN_t). \tag{11}$$

Business sector saving is determined as a constant ratio, QSB, to investment at current prices. This formulation implies that a constant share of investment is financed out of cash flow. The cash flow financed amount of investment corresponds to business sector savings.

Equating excess saving to the balance of transfer payments closes the savings investment identity for an open economy. For savings and investment to be in equilibrium, excess savings given by the right hand side of the following equation must be equal to the balance of transfer payments, CAT_t:

$$CAT_t = (SN_t - (IN_t - DPN_t) - CAXMN_t - CAY_t)/(1 + QSNDIFFN_t), \tag{12}$$

subject to statistical discrepancy, $QSNDIFFN_t$, in the past. Here $IN_t - DPN_t$ is the difference between investment and depreciation at current prices.

Current account imbalances will cumulatively change the net foreign asset position, where every year the current account balance is added to the previous year stock of assets. Ignoring changes in the valuation of net foreign assets we thus have:

$$\Delta NFA_t = CA_t + CADIFF_t, \tag{13}$$

where $CADIFF_t$ accounts for the past statistical discrepancy.

By disaggregating current account into trade, income and transfer flows, we can distinguish the gross domestic product from the gross national product and derive the disposable income of the economy.

3.4 The Labour Market

Labour demand is derived from the first order conditions for the cost-minimization problem of a CES production function given the prices of factor inputs and the output. The rate of change in employment is explained by the growth in real GDP growth and the change in relative factor prices of labour and capital:

$$\Delta \log(LEA_t) = 0.41\Delta \log(Y_t) - 0.025\Delta \log(WP_{t-1} / UCM_{t-1}) , \tag{14}$$

where LEA_t represent the number of employees, WP_t the average real wage per employee and UCM_t the user costs of capital.

In determining the change in the number of unemployed persons, ΔLU_t, we take both supply and demand factors into account:

$$\Delta LU_t = -0.64\Delta LEA_t + 0.428\Delta POP_t - 0.477\Delta PENPM_t + 18.45\Delta(100 LEAF_t / LEA_t) \tag{15}$$

The change in the number of unemployed persons decrease with the number of jobs created ΔLEA_t and the change in the number of early retirees $\Delta PENPM_t$. It increases with the working age population ΔPOP_t. The last term accounts for the effect of the share of foreign workers in the number of total employees, $LEAF_t / LEA_t$. For example, a rise of the labour demand by 1,000 persons, other things equal, would lead to 640 less unemployed persons. A 1 percentage point increase in the share of foreign labour leads to 18,450 more unemployed.

We define the trend rate of unemployment U_T_t as the moving average of the five most recent actual rates U_{t-j} for $j = 0,...,4$. The corresponding trend employment is used for determining the trend output Y_T_t at constant 1995 prices. We use the cyclical rate of unemployment, defined as the difference between the trend and the actual rates, as a proxy for the tightness of the labour market in the equation for wages.

3.5 Trend Output and the Output Gap

The trend output Y_T_t is defined as a Hodrick-Prescott filtered series of the actual output Y_t, and is projected with a constant elasticity of substitution (CES) production function that combines trend labour and physical capital under constant returns to scale. We assume an exogenous Hicks-neutral technical progress. Input intensities and the elasticity of substitution are derived from a pair of first order conditions to the cost minimization problem and estimated with Full Information Maximum Likelihood. After substituting factor shares and the elasticity of substitution into the production function, the intercept and the rate of change of factor productivity are estimated by OLS. After taking the natural logarithm and the first difference the production function becomes:

$$\Delta \log(Y\_T_t) = 0.017 - (1/0.65)\Delta \log(0.66K_t^{-0.65} + 0.44L\_T_t^{-0.65}) \, , \qquad (16)$$

where L_T_t is the trend number of full-time equivalent employees[14] and K_t is the stock of capital, assuming that the production capacity is always fully utilized. Given the substitution parameter $\rho = -0.65$, the elasticity of substitution between capital and labour is $1/(1-\rho) = 0.61$. The elasticity of substitution is a local measure of technological flexibility. It characterizes alternative combinations of capital and labour which generate the same level of output. Under the assumption of cost minimization on the part of the representative firm, the elasticity of substitution measures the percentage change in the relative factor input as a consequence of a change in the relative factor prices. In our case, factor prices are the real wage per full-time equivalent employee and the user costs of capital. Thus, other things being equal, an increase of 1% of the ratio of real wage to the user costs will lower the ratio of the number of employees to capital by 0.61%. In the baseline, we exogenously set the annual rate of change of the total factor productivity to 1.7%.

The output gap as a measure of the aggregate rate of capacity utilisation is defined as $YGAP_t = Y_t / Y\_T_t - 1$. It is thus positive whenever the actual GDP lies above its trend.

3.6 Wages

Wages per employee in nominal terms are determined for the private sector. For the rate of growth of private sector wages, WPN_t, we estimate the following equation related to the Non-accelerating Wage Rate of Unemployment (NAWRU) concept:

$$\Delta \log(WPN_t) = 0.43\Delta \log(PCP_{t-1}) + 0.29\Delta \log(APLP_{t-1}) - 1.1(U_t - U\_T_t)/100 + 0.3\Delta \log(WPN_{t-1}) \qquad (17)$$

where PCP_t denotes the deflator of private consumption as a proxy for the consumer price index, $APLP_t$ the average labour productivity and $U_t - U\_T_t$ the cyclical unemployment. The above aggregate specification implies a sluggish rate of adjustment of wages to inflation and the productivity of labour. In the long-run, however, the employees are almost fully compensated for an increase in the labour productivity (long-run elasticity of 0.96) and in the case of inflation, are even

[14] Following the ESA 1995 convention, the compensation of the self-employed are included in the gross operating surplus and therefore are not a part of the compensation of employees. We therefore exclude labour input by the self-employed from the production function.

overcompensated (long-run elasticity of 1.43). The employment gap captures the tightness of the labour market against the background of the trend unemployment rate represented by U_T_t. The coefficient implies that a 1 percentage point change increases in the cyclical rate of unemployment leads to a fall by 1.1 percentage points in the nominal wage inflation rate.

We assume that wages in the public sector, WGN_t, adjust to those in the private sector within two periods:

$$\Delta \log(WGN_t) = 0.85\Delta \log(WPN_t) + 0.2\Delta \log(WPN_{t-1}) . \qquad (18)$$

3.7 Prices

The dynamics of the deflator for domestic demand, $PYTD_t$, is central to price determination in the model since several other deflators directly depend on it:

$$PYTD_t = \frac{YTDN_t}{YTD_t} = \frac{YTDN_t \pm (TIND_t - SUB_t)}{YTD_t} = PYTDA_t + \frac{TIND_t - SUB_t}{YDT_t} , \qquad (19)$$

where $YTDN_t$ is the total demand at current prices, $TIND_t$ is the revenue from taxes on production and imports and SUB_t represents subsidies. We estimate an auxiliary equation net of indirect taxes and subsidies:

$$\Delta \log(PYTDA_t) = 0.38\Delta \log(ULC_t) + 0.36\Delta \log(PM_t) + 0.235\Delta(YGAP_t) + 0.329\Delta \log(PYTDA_{t-1}) \qquad (20)$$

Here we differentiate between domestic and foreign cost-push factors represented by the unit labour costs, ULC_t, and the import price deflator, PM_t, respectively, and demand pull factors by a proxy for the overall rate of capacity utilization, the output gap, $YGAP_t$. In addition to the effect of these factors, the actual deflator for domestic demand, $PYTD_t$, also includes the cost-effect of indirect taxes and subsidies as shown in equation (19).

All deflators for the components of final demand, with the exception of total imports and exports, are estimated as dynamic specifications in the rates of inflation. Whereas short-run elasticities may vary, we restrict the long-run elasticity with respect to the deflator for domestic demand to unity. This introduces price homogeneity in the long-run and tends to stabilize the ratios of nominal individual demand components to total demand.

Deflators of total exports, PX_t, and imports, PM_t, are modelled as follows:

$$\Delta \log(PX_t) = 0.23 \Delta \log(ULC_t) + 0.45 \Delta \log(PM_t) ; \qquad (21)$$

$$\Delta \log(PM_t) = 0.23 \Delta \log(PW\$_t US\$_t) + 0.77 \Delta \log(PM_{t-1}) , \qquad (22)$$

with similar specifications estimated for exports and imports of goods omitted here.

3.8 Public Sector

We model public revenues, expenditures, consumption, and value added according to their ESA 1995 definitions. The legal and institutional framework of the Austrian economy is captured in several structural equations and identities. Whereas public revenues are mainly endogenous, most of public expenditures are policy instruments and are exogenous. This improves model forecasts since accurate information concerning future public expenditures is typically available from official sources and can be fed directly to the model. The public wage-bill and the interest payments on public debt are the exceptions and are endogenously determined expenditure items.

Public consumption and value added of the public sector follow their respective ESA definitions. For completeness these definitions require several variables, notably, public sector's gross operating surplus and depreciation. Whereas we exogenously assume the former, the latter is estimated from the past depreciations implied by the perpetual inventory method.

3.8.1 Public Revenues

We estimate the elasticity of the individual public revenue items such as taxes and social contributions with respect to a proxy for their revenue base.[15] The largest five items, their elasticities and base proxies are shown in table 2. All other items such as property income, received current transfers, and other taxes and duties on imports are exogenous. Exogenous is also public output for own final use.

Table 2: Public Revenue Items

Item	Elasticity	Base Proxy at Current Prices
Wage Tax	1.29	Compensation of Employees
Corporation Tax	0.84	see text below
Other Direct Taxes	0.79	GDP
Social Contributions*)	0.94	Compensation of Employees

[15] Clearly this method is only approximate and can generate large forecasting errors due to changes in the institutional setting. Known or plausibly expected institutional changes may prove invaluable, when forecasting public revenues and should not be discarded.

The Value Added Tax	0.76	Private Consumption Outlays
Other Indirect Taxes	0.65	GDP

*) *Except the Unemployment Insurance which is separately modelled.*
Source: Authors' calculations

In modelling corporation tax revenues we take a different approach. Since in Austria corporate income is taxed at a flat rate, we model the dynamics of the tax base and then apply the statutory tax rate to compute the tax revenue. Since corporate profits are not separately available in ESA we use lagged differences between the private sector's gross operating surplus and depreciation as a proxy. The elasticity is obtained by regression of the actual corporate tax base taken from the Corporation Tax Statistics on the tax base proxy variable, and equals 0.84.

3.8.2 Public Expenditures

The expenditure side contains only a few endogenous variables, notably the compensation to employees in the public sector, unemployment benefits and the interest payments on public debt. The dynamics of the average wage per employee in the public sector follows that in the private sector (equation 18). Employment in the public sector is exogenous. Together they determine the compensation per employee and the wage-bill in this sector.

Among the exogenous variables we have the intermediate public consumption, public investment, subsidies including transfers from the European Union, social benefits (except unemployment benefits) and social transfers in kind, as well as other expenditures.

3.8.3 Public Deficit and Debt

Interest payments on gross government debt, GEI_t, are computed as the product of an implicit rate of interest, RGD_t, and the lagged level of debt GD_t:

$$GEI_t = RGD_t GD_{t-1}. \tag{23}$$

GEI_t is an endogenous component of government expenditures and therefore of the balance of the public sector GB_t.

The dynamics of government debt (24) is given by the difference between newly issued debt and amortized debt. Unfortunately, public debt data are readily available for the federal state only.[16] Therefore, we assume a constant ratio

[16] See report on the development of the Austrian federal debt (Bericht über die Finanzschuld des Bundes, Staatsschuldenausschuss, various years).

between the debt of the federal state and the rest of the public sector, and include an adjustment factor, $QGD_t GD_{t-1}$, to balance this gap.

The newly issued debt of the federal state, GCI_t, is almost identical to the difference of the amortized debt of the federal state, $GCRED_t$, and the deficit of the whole public sector GB_t:

$$\Delta GD_t = (GCI_t - GCRED_t) + QGD_t GD_{t-1}; \tag{24}$$

$$\log(GCI_t) = 1.025 + 0.9\log(GCRED_t - GB_t). \tag{25}$$

The implicit rate of interest, RGD_t, is a weighted average of interest rates on outstanding debt, RGD_{t-1}, and on newly issued debt, RIN_t, where $QRGD_t$ is the share of the outstanding debt to total debt (subject to statistical difference $RGDDIFF_t$ in the past). The term structure of the newly issued debt is captured by the share of long-term to total debt, $QRLIN_t$. The interest rate on newly issued debt, RIN_t, is a weighted average of the long-run, $RLIN_t$, and short run, $RSIN_t$, interest rates on public debt, which depend on long-run (26.3) and short-run (26.4) interest rates, respectively:

$$RGD_t = QRGD_t RGD_{t-1} + (1 - QRGD_t)RIN_t + RGDDIFF_t; \tag{26.1}$$

$$RIN_t = QRLIN_t RLIN_t + (1 - QRLIN_t)RSIN_t; \tag{26.2}$$

$$\Delta\log(RLIN_t) = 0.82\Delta\log(RLN_t); \tag{26.3}$$

$$\Delta\log(RSIN_t) = 0.5\Delta\log(RSN_t). \tag{26.4}$$

We compute the primary balance of the general government as the difference between the actual public sector balance and the interest payment on public debt.

4. Simulations

In this section we present three standard simulations to illustrate the main properties of the model:

- fiscal shock over five years

- export shock over five years
- interest rate shock over two years.

Each simulation covers a period of ten years. The shocks are implemented in the year 2004 and are removed after five (or two) years to highlight the adjustment paths. Given the scope of the model we do not consider international spillovers. In particular, the nominal euro-U.S. dollar exchange rate and foreign prices are kept constant in all simulations except for the third. In all three simulations we assume neither fiscal, such as a solvency condition, nor monetary policy rules, such as the Taylor rule. Only the automatic stabilizers that are built into the model are at work.

4.1 Increase of Government Consumption for Five Years

4.1.1 Input

We simulate an increase in intermediate public consumption by 1% of real GDP as of 2004, sustained for five consecutive years. In nominal terms, the absolute size of the shock is EUR 2.4 billion or a 23% increase in intermediate public consumption compared to the baseline. The magnitude of the shock remains constant over the five years and, hence, decreases relative to nominal GDP. After five years, public intermediate consumption returns to the baseline level.

4.1.2 Results

Table 3 shows the effect of the public expenditure shock. As a result, public consumption increases by 6%, of which over 90% are due to the increase in intermediate public consumption; the remaining effect is attributed to endogenous variables such as the public wage bill. A direct shock of a GDP component has an immediate effect on GDP. We observe a dynamic fiscal multiplier of 1.17 in the first year, which reaches its maximum of 1.31 in the third year. Private consumption increases by 0.43 percentage points in the third year. The private household's short-term propensity to consume of 0.35 leads to a substantial increase in the savings ratio of around 0.3% in the first year. The average labour productivity, computed as the ratio of real GDP to the number of employees rises by 0.8 percentage points. This is attributed to an adjustment of nominal average compensation per employee to an increase in consumer price inflation. In the absence of a fiscal policy rule linking expenditures to revenues, the assumed increase in public expenditures leads to an increase in public deficit of 0.7% of GDP in the first and 0.5% in the third year. In the first year the public debt increases by 1.1% relative to the baseline. Since the output at current prices increase by 1.2%, the negative net effect on the public debt ratio to GDP is very small initially.

After the fifth year we have a negative fiscal shock in relation to the year before. We observe a strong investment cycle, with 1.5% less private investment spending in the last year of the simulation. This decrease is partially explained by the rise in the user costs of capital due to the rise in the real interest rate. Total imports continue to rise even after the subsequent decrease in GDP. The model shows sluggish price and wage adjustment. Despite the return to the baseline spending level after five years, the model predicts a steady accumulation of the public debt up to 3.6% of GDP in ten years. Since the term-structure of interest rate is exogenous in the model, a fiscal shock does not crowd-out private investment.

Table 3: Increase of Government Consumption for Five Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	Levels, percentage deviations from baseline									
HICP	0.02	0.15	0.32	0.46	0.57	0.60	0.49	0.31	0.10	−0.08
Consumption deflator	0.05	0.18	0.34	0.49	0.60	0.58	0.49	0.32	0.13	−0.05
GDP Deflator	0.02	0.21	0.43	0.64	0.81	0.85	0.71	0.48	0.21	−0.05
Investment deflator	0.01	0.15	0.33	0.54	0.72	0.81	0.75	0.57	0.33	0.08
Unit Labour costs	−0.43	0.02	0.35	0.61	0.78	1.24	0.89	0.56	0.24	−0.04
Compensation per employee	0.27	0.78	1.17	1.42	1.52	1.27	0.71	0.20	−0.25	−0.57
Productivity	0.69	0.75	0.80	0.80	0.73	0.04	−0.17	−0.35	−0.48	−0.53
Export deflator	−0.10	0.01	0.08	0.14	0.18	0.28	0.20	0.13	0.05	−0.01
Import deflator	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00	±0.00
GDP and components	*Levels, percentage deviations from baseline*									
GDP	1.17	1.26	1.31	1.27	1.14	−0.02	−0.33	−0.59	−0.76	−0.83
Consumption	0.20	0.32	0.43	0.50	0.54	0.36	0.22	0.07	−0.06	−0.18
Investment	1.56	1.82	1.91	1.78	1.48	−0.25	−0.85	−1.28	−1.50	−1.51
Of which: construction	0.99	1.26	1.42	1.47	1.40	0.41	−0.04	−0.44	−0.75	−0.95
Government consumption	5.87	6.06	6.15	6.19	6.16	0.66	0.28	−0.06	−0.32	−0.48
Exports	0.03	−0.01	−0.03	−0.04	−0.04	−0.07	−0.03	−0.01	0.01	0.03
Imports	0.67	0.70	0.75	0.78	0.81	0.33	0.37	0.40	0.41	0.38
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic demand	1.52	1.66	1.77	1.78	1.70	0.25	−0.05	−0.30	−0.49	−0.58
Trade balance	−0.35	−0.40	−0.46	−0.52	−0.57	−0.27	−0.28	−0.29	−0.27	−0.24
Labour market	Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline									
Total employment	0.46	0.49	0.48	0.45	0.40	−0.06	−0.16	−0.23	−0.28	−0.29
Employees in employment	0.48	0.51	0.50	0.47	0.41	−0.06	−0.16	−0.24	−0.29	−0.30
Unemployment rate	−0.31	−0.33	−0.33	−0.31	−0.27	0.04	0.11	0.16	0.19	0.20
Household accounts	Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline									
Disposable income	0.56	0.65	0.72	0.71	0.62	0.03	−0.17	−0.35	−0.46	−0.50
Saving rate	0.33	0.29	0.26	0.18	0.07	−0.31	−0.36	−0.39	−0.36	−0.30
Public sector	*Percentage of GDP, absolute deviations from baseline*									
Public balance	−0.74	−0.57	−0.51	−0.47	−0.48	0.15	−0.05	−0.20	−0.33	−0.42
Public debt	−0.06	0.30	0.61	0.93	1.35	1.88	2.18	2.63	3.13	3.58

Source: Authors' calculations.

4.2 Increase in World Demand for Five Years

4.2.1 Input

Here we assume an exogenous increase in Austria's real exports of goods and services by 1%, sustained over five years. Contrary to the previous simulation, the magnitude of the export shock relative to baseline is constant over time. In absolute values at constant 1995 prices, total exports increase by EUR 1.2 billion in 2004. To implement this shock we skip the otherwise endogenous export equations. Thus, we ignore the endogenous repercussions on the volume of exports via domestic price effects.

4.2.2 Results

Dynamics of adjustment after the export shock are similar to that discussed in the fiscal spending simulation. However, since the size of the shock relative to GDP is slightly above one half of that in the previous simulation, the magnitude of the resulting effects is smaller (table 4).[17] The 1% increase in the level of real exports generates 0.6% more real GDP after five years. The contribution of domestic demand is responsible for two thirds of the GDP effect; the rest is attributed to an improvement in the trade balance. The change in inflation is moderate and amounts to 0.3 percentage points in the medium term. Due to the delayed price response, the change in inflation peaks two years after that of the GDP. These sluggish price dynamics are attributed, in part, to the sluggish adjustment of nominal wages to the consumer price inflation. The increase in public revenues of 0.7%s relative to the baseline leads, given constant spending, to an improvement in public balances of the order of 0.3 percentage points relative to GDP. The ratio of public debt to the nominal GDP is reduced by 1 percentage point after ten years.

[17] When the shocks are standardised, the magnitudes of the effects are quite similar with the exception of total imports and public sector balance.

Table 4: Increase in World Demand for Five Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
HICP	– 0.00	0.04	0.11	0.17	0.22	0.26	0.23	0.17	0.10	0.03
Consumption deflator	– 0.00	0.04	0.10	0.16	0.21	0.25	0.23	0.18	0.11	0.04
GDP deflator	– 0.05	0.01	0.08	0.16	0.23	0.35	0.33	0.26	0.16	0.06
Investment deflator	– 0.03	– 0.01	0.05	0.12	0.19	0.30	0.32	0.28	0.20	0.11
Unit labour costs	– 0.15	– 0.00	0.11	0.22	0.30	0.52	0.40	0.29	0.18	0.07
Compensation per employee	0.09	0.28	0.45	0.58	0.67	0.61	0.42	0.22	0.04	– 0.11
Productivity	0.24	0.28	0.33	0.36	0.37	0.09	0.02	– 0.07	– 0.14	– 0.18
Export deflator	– 0.03	– 0.00	0.03	0.05	0.07	0.12	0.09	0.07	0.04	0.02
Import deflator	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
GDP and components	*Levels, percentage deviations from baseline*									
GDP	0.41	0.49	0.55	0.58	0.59	0.12	– 0.01	– 0.13	– 0.23	– 0.28
Consumption	0.06	0.13	0.20	0.24	0.28	0.23	0.16	0.09	0.02	– 0.04
Investment	0.49	0.68	0.79	0.83	0.79	0.18	– 0.14	– 0.36	– 0.51	– 0.57
Of which: construction	0.34	0.48	0.58	0.65	0.69	0.31	0.13	– 0.04	– 0.18	– 0.29
Government consumption	0.06	0.19	0.29	0.36	0.39	0.33	0.19	0.06	– 0.05	– 0.13
Exports	1.00	1.00	1.00	1.00	1.00	± 0.00	± 0.00	± 0.00	± 0.00	± 0.00
Imports	0.60	0.65	0.68	0.71	0.74	0.13	0.13	0.14	0.15	0.14
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic demand	0.16	0.26	0.33	0.38	0.40	0.21	0.08	– 0.03	– 0.12	– 0.18
Trade balance	0.24	0.23	0.21	0.20	0.19	– 0.09	– 0.09	– 0.10	– 0.10	– 0.10
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	0.16	0.19	0.21	0.21	0.21	0.03	– 0.03	– 0.06	– 0.09	– 0.10
Employees in employment	0.17	0.20	0.21	0.22	0.22	0.03	– 0.03	– 0.06	– 0.09	– 0.10
Unemployment rate	– 0.11	– 0.13	– 0.14	– 0.15	– 0.14	– 0.02	0.02	0.04	0.06	0.07
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	0.19	0.25	0.30	0.32	0.32	0.11	0.02	– 0.06	– 0.12	– 0.15
Saving rate	0.11	0.12	0.11	0.10	0.07	– 0.08	– 0.12	– 0.14	– 0.14	– 0.13
Public sector	*Percentage of GDP, absolute deviations from baseline*									
Public balance	0.10	0.17	0.22	0.26	0.30	0.21	0.14	0.08	0.03	– 0.02
Public debt	– 0.32	– 0.56	– 0.83	– 1.14	– 1.47	– 1.44	– 1.45	– 1.37	– 1.22	– 1.04

Source: Authors' calculations.

4.3 Increase of Short-term Interest Rates for Two Years

The model includes six interest rates, two of which, the GDP-weighted short-term (3 month) and long-term (10 year benchmark) euro area rates are exogenous. As the short-term interest rate for the euro area closely follows the European Central Bank rate on the main refinancing operations, which provide the bulk of liquidity to the euro area banking system, we implement a monetary policy shock via a change in the short-term interest rate. The interest rate on business loans and the implicit rates of interest on public debt of short and long-term maturities, and a weighted average of the two rates, are determined in the model (see Section 3.8.3).

4.3.1 Input

We assume a 1 percentage point increase in the nominal short-term interest rate sustained over two years. To capture the effect of the term-structure of interest rates, we raise the long-term interest rate by 0.163 percentage points in the first year, followed by an increase of 0.063 in the second year. As the euro-U.S. dollar exchange rate is exogenous, we make a simple uncovered interest parity assumption that leads to an appreciation of the euro–U.S. dollar by 0.163% in the first and 0.063% in the second year. The input for this simulation includes all three assumptions, for the short and long-term interest rates, and the exchange rate, taking effect in the first two years. In the third and the subsequent years these variables return to their baseline levels.

4.3.2 Results

The interest rate shock has an immediate impact on the interest rate on business loans of 1.1 percentage points in both years. This transmits into an increase in the user costs of capital between 1.2 to 1.3 percentage points. As the user costs of capital are a determinant of private investment in machinery and equipment only and the long-term interest rate change is small in the second year the impact on total investment is the largest in the first year and diminishes afterwards. The resulting small GDP effect of around 0.1 percentage point mirrors the fact that construction and private consumption of durables are independent of the interest rates. After accounting for the last two effects, we would expect a larger negative impact on GDP in the medium term. The change in relative factor prices leads to substitution from capital to labour. Therefore, employment rises by up to 0.15% in the second and third year after the shock. The change in the short-term interest rate has almost no impact on public finances.

5. Conclusions

WIFO-Mocromod was used to simulate three macroeconomic shocks. First, we analyse the effect of a fiscal expansion by 1% of nominal GDP as of 2004 sustained for five years. We observe a dynamic fiscal multiplier of 1.3 after three years. The second simulation studies an exogenous shock of 1% of total export demand at constant prices, which amounts to 0.6% of real GDP in Austria, sustained for five years. The dynamic export multiplier is 0.7 at the onset and increases to 0.9 in the fourth year. In the third simulation we evaluate a monetary policy shock. The simulation inputs include an increase in the short (1 percentage point) and long-term interest rates coupled with euro devaluation according to the uncovered interest rate parity hypothesis, over a period of two years. As a result, real GDP declines in the short-term by 0.1% compared to baseline.

Table 5: Increase of Short-term Interest Rates for Two Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
HICP	0.02	0.08	0.11	0.10	0.09	0.07	0.05	0.02	0.00	–0.02
Consumption deflator	0.02	0.07	0.10	0.10	0.09	0.07	0.05	0.03	0.00	–0.01
GDP deflator	–0.01	0.07	0.13	0.11	0.11	0.09	0.06	0.03	–0.00	–0.03
Investment deflator	–0.00	0.05	0.10	0.11	0.11	0.10	0.07	0.04	0.01	–0.01
Unit labour costs	0.04	0.25	0.23	0.12	0.15	0.11	0.07	0.03	0.00	–0.02
Compensation per employee	–0.02	0.04	0.11	0.13	0.15	0.09	0.02	–0.02	–0.06	–0.08
Productivity	–0.06	–0.21	–0.13	0.01	–0.01	–0.02	–0.04	–0.05	–0.06	–0.05
Export deflator	0.03	0.08	0.07	0.04	0.04	0.03	0.02	0.01	0.00	–0.00
Import deflator	0.04	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01
GDP and components	*Levels, percentage deviations from baseline*									
GDP	–0.10	–0.07	0.03	0.01	–0.01	–0.04	–0.07	–0.08	–0.09	–0.08
Consumption	–0.04	–0.04	–0.02	–0.01	–0.01	–0.01	–0.03	–0.04	–0.04	–0.05
Investment	–1.45	–0.97	0.65	0.42	0.29	0.16	0.06	0.00	–0.03	–0.03
Of which: construction	–0.09	–0.08	0.00	–0.01	–0.02	–0.05	–0.08	–0.10	–0.11	–0.11
Government consumption	–0.03	–0.04	–0.02	0.01	0.03	0.01	–0.02	–0.04	–0.05	–0.06
Exports	0.04	–0.01	–0.02	–0.01	–0.01	–0.01	–0.00	0.00	0.00	0.00
Imports	–0.44	–0.34	0.16	0.13	0.11	0.10	0.09	0.08	0.08	0.06
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic demand	–0.36	–0.26	0.14	0.09	0.07	0.03	–0.00	–0.03	–0.04	–0.04
Trade balance	0.26	0.18	–0.11	–0.09	–0.08	–0.07	–0.06	–0.06	–0.05	–0.04
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	–0.04	0.13	0.15	–0.01	–0.01	–0.02	–0.03	–0.03	–0.03	–0.03
Employees in employment	–0.04	0.14	0.16	–0.01	–0.01	–0.02	–0.03	–0.03	–0.03	–0.03
Unemployment rate	0.03	–0.09	–0.10	0.00	0.00	0.01	0.02	0.02	0.02	0.02
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	–0.13	–0.06	0.04	–0.01	–0.01	–0.03	–0.05	–0.05	–0.05	–0.05
Saving rate	–0.08	–0.02	0.04	0.01	0.01	–0.01	–0.02	–0.02	–0.01	–0.01
Public sector	*Percentage of GDP, absolute deviations from baseline*									
Public balance	–0.05	0.02	0.05	0.00	0.01	–0.01	–0.03	–0.04	–0.05	–0.05
Public debt	0.12	0.03	–0.12	–0.10	–0.09	–0.05	0.01	0.08	0.14	0.19

Source: Authors' calculations.

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The Macroeconometric Model LIMA

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1. The LIMA Forecasting Model of the Institute for Advanced Studies Vienna

The LIMA model has grown out of the LINK project that aims at joining worldwide economic forecasting models into a common framework. Because many of the variables are only available at an annual frequency, the LIMA model also operates at this annual frequency. This can be troublesome for short-run prediction, as unofficial provisional data on main accounts aggregates come in on a quarterly basis. Therefore, LIMA is rarely run in its original form with zero residuals, and add factors play a key role. The model is routinely used for medium-term forecasting at horizons of one to five years. It is less often utilized for conditional forecasting and policy simulations. For these purposes, the LIMA model is occasionally augmented with additional reaction equations.

The LIMA model is a traditional macroeconometric prediction model with an emphasis on the economy's demand side. Thus, the model may be called a 'Keynesian' model. It has 78 equations, which implies 78 endogenous variables. As in most macroeconometric models, most equations are mere identities. Only 21 equations are 'behavioral' and contain estimated coefficients. With 78 endogenous variables and 21 structural equations, the LIMA model is a comparatively small macroeconometric model. LIMA's model structure is updated frequently when new data become available and suggest that an equation is no more adequate, or in order to adopt the most recent developments in econometrics.

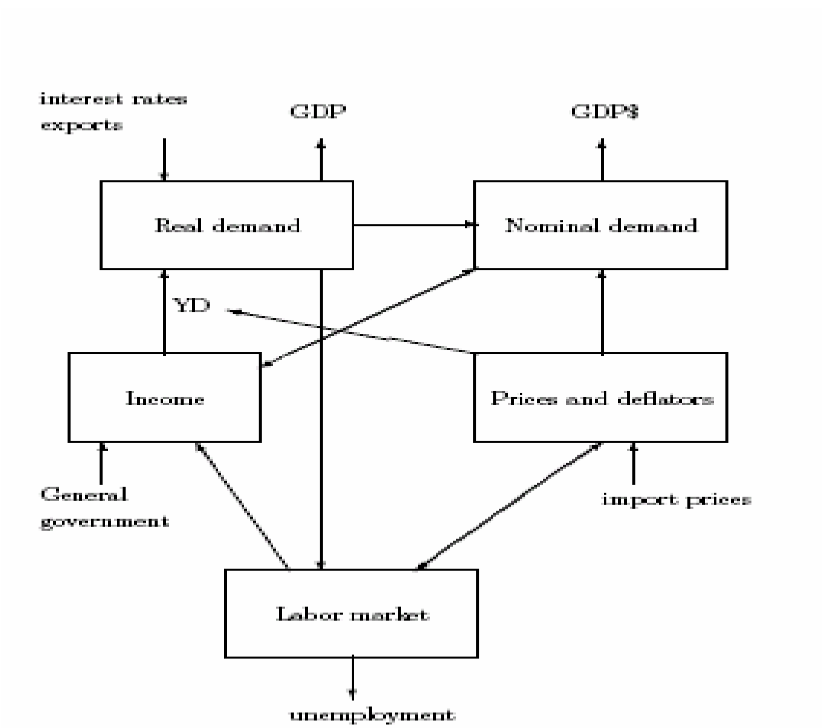
Parameter estimates are updated once a year, when the official provisional data for the previous year become available. 1976 is the earliest year, for which national accounts data are available that correspond to the ESA standard. All equations are estimated by ordinary least squares (OLS). Indications of mis-specification due to autocorrelation are adjusted by dynamic modeling rather than by GLS–type corrections. Thus, most behavioral equations are dynamic.

The model's center piece is the *domestic demand sector*. Demand aggregates are modeled in real terms, i.e. at constant prices, and sum up to real gross domestic product (GDP). Additional equations are used to determine *prices and deflators*.

By multiplying those deflators into the real aggregates, nominal variables and eventually nominal gross domestic product (GDP in U.S. dollar) are calculated.

This adding-up to obtain GDP requires export and import variables. The treatment of exports and imports is asymmetric. *Imports* are fully endogenous and respond to demand categories, such as consumer durables and equipment investment. By contrast, exports are mainly exogenous. Older LIMA versions considered modeling exports as depending on world demand but, unfortunately, data on world demand become available with a considerable time lag only, which excludes its usage for the practical purpose of forecasting. For export and import prices, the approach is reversed. Import prices are exogenous, as it is assumed that Austrians have to accept the world market's price level, while export prices are endogenous.

Chart 1: Structure of the Forecasting Model LIMA



Another component of GDP is public consumption. In the current version, public consumption is exogenous. In contrast to spending, several components of government revenues are modeled as endogenous variables, such as direct taxes or contributions to social security. From this *government sector*, balancing items such as the budget deficit can also be calculated.

The real and government sectors also interact with the *labor market sector*, which yields variables such as employment, the labor force, and wages. Other variables, such as the working-age population, are exogenous. In the *income sector*, wage income and certain nominal variables from the government sector, such as social insurance, add to form nominal disposable household income, which, after expressing it in constant prices, becomes the main determinant of private consumption. This important link is indicated by the letters YD in the diagram. The LIMA model does not include a *financial sector*. Financial variables that are influential for the goods market, such as exchange rates and interest rates, are supplied by specialists on the financial sector who use separate models.

2. Domestic Demand

2.1 Private Consumption

Consumer demand consists of three categories: consumer durables, consumption of other goods, and consumer services. Almost 50% of household expenditures are spent on services. The share of services in household consumption appears to be increasing in the longer run. Before 1980, it used to be below 45%.

As a general rule, demand equations use logarithmic growth rates as dependent variables. Logarithmic growth rates are fairly constant in the longer run, hence they come closer to fulfilling the assumption of stationarity than, for example, first differences. On the other hand, percentage growth rates are far less convenient to handle from an econometric model builder's viewpoint.

In all consumption equations, the principal explanatory variable is the growth rate of household disposable income YD. The real variable YD is obtained from deflating nominal household income by the consumption deflator. Therefore, the price index of total consumption deflates income, while a special price index for consumer services deflates the dependent variable. It is tempting to explain the demand for services by a relative price, reflecting the idea that services and goods are partial substitutes. However, such attempts fail to yield significant explanation.

Another potential source of explanation comes from error-correction relationships. While economic theory and plausibility dictate that the long-run elasticity of consumption with respect to income should be one, this is not so for consumer sub-aggregates. For example, a co-integrating regression of log *consumer services* on log income

$$cs_t = b_0 + b_1 yd_t + u_t$$

yields $\hat{b}_1 = 1.117$, slightly in excess of unity. Here and in the following, we use small letters to denote logarithms of variables in capitals, for example

$cs = \log(CS)$. In theory, unit elasticity for total consumption should be imposed on the model. This is technically difficult, however, due to the implied non-linear restriction structures. Therefore, this important long-run restriction is ignored in estimation. The co-integrating regression is estimated by least squares, and the resulting error-correction variable $cs - \hat{b}_1 yd$ is then used as an additional regressor.

Table 1: Behavioral Equation for Consumer Services

regressor	coefficient	t–value
constant	–0.239	–2.720
$\log(CS_{t-1}) - 1.117 * \log(YD_{t-1})$	–0.186	–2.984
$\log(YD_t / YD_{t-1})$	0.291	3.217

$R^2 = 0.441$, DW=1.916

Note: Estimation Time Range is 1978–2002. Dependent Variable is $\log(CS_t / CS_{t-1})$.

The estimation results are acceptable. All regressors are significant, and the (here, not very reliable) Durbin-Watson statistic does not indicate any serious specification error. Neither interest rates at any lags nor lags of the dependent variable yield a significant explanatory contribution.

For *consumer non-durables*, the analogous long-run equation is

$$cnd_t = b_0 + b_1 yd_t + u_t,$$

which yields $\hat{b}_1 = 0.701$, less than unity, indicating that the share of non-durables will decrease in the longer run. The short-run equation is estimated in analogy with services.

Table 2: Behavioral Equation for Consumer Non-durables

regressor	coefficient	t –value
constant	0.100	2.292
$\log(CND_{t-1}) - 0.701 * \log(YD_{t-1})$	–0.308	–2.147
$\log(YD_t / YD_{t-1})$	0.452	3.943

$R^2 = 0.449$, DW=1.844

Note: Estimation time range is 1977–2002. Dependent variable is $\log(CND_t / CND_{t-1})$.

Similarly as in the case of services, additional regressors do not appear to have any explanatory power. The R^2 is almost identical to the services equation.

For *consumer durables*, the long-run equation

$$cd_t = b_0 + b_1 yd_t + u_t$$

yields $\hat{b}_1 = 1.541$, the largest elasticity among all sub-components. The short-run equation for consumer durables reflects the influence of the interest rate.

Table 3: Behavioral Equation for Consumer Durables

regressor	coefficient	t –value
constant	–3.009	–3.358
$log(YD_t / YD_{t-1})$	1.846	3.285
$log(CD_{t-1}) - 1.541 * \log(YD_{t-1})$	–0.659	–3.388
INT1_t	–0.034	–2.118

$R^2 = 0.536$, DW=1.862

Note: Estimation time range is 1977–2002. Dependent variable is $\log(CD_t / CD_{t-1})$.

In contrast to the other consumption sub-aggregates, consumer reaction to interest rates plays a role in the durables segment. The real interest rate $INT1$ is constructed as a ten-year bond rate deflated by the consumption deflator:

$$INT1 = SMR10J - 100 \frac{\Delta(PC)}{PC}.$$

The significance of demand reaction in this sector may be due to the fact that consumer durables usually require larger single amounts of spent money, such that consumers are more willing to weigh the costs and benefits of purchases. Also, consumer durables, by their very nature, are utilized over a longer time span. In some cases, a purchase can be weighed against the alternative of renting equipment, such as cars and carpet cleaners. Therefore, an economic theory similar to that of fixed investment may apply. We also note that R^2 attains the highest value for this sub-aggregate.

Compared with the consumption of households, the consumption by non-profit institutions is small. The reaction of this aggregate is specified by a simple linear dependence on household consumption of the form

$$\Delta cnp_t = a + b\Delta c_t + u_t,$$
$$C_t = CND_t + CD_t + CS_t,$$

where we use the notation $c = \log C$. Additionally, a local dummy was inserted for an exceptional year. The empirical results show that the hypothesis $(a,b) = (0,1)$ cannot be rejected. We nevertheless use the unrestricted form in the LIMA model.

Table 4: Behavioral Equation for Consumption by Non-profit Institutions Serving Households

regressor	coefficient	t–value
constant	0.002	0.371
$log(C_t/C_{t-1})$	0.973	4.976
$d97$	–0.128	–8.103

$R^2 = 0.804$, DW=2.107

Note: Estimation time range is 1977–2002. Dependent variable is $\log(CNP_t/CNP_{t-1})$.

2.2 Investment Demand

Besides consumption, investment or 'gross fixed capital formation' is another important component of aggregate demand. While the ESA system disaggregates investment into a larger number of subcomponents, LIMA only considers equipment investment, which includes machinery and transportation equipment, and construction investment, which includes business as well as residential construction. *Equipment investment* is the slightly smaller part but its equation is more important than the construction investment counterpart, as construction may be influenced strongly by public funding and policy.

While the basic idea for consumption modeling is dynamic error correction, investment demand equations often rely on factor demand specifications that are derived from specific forms of production functions. In all concepts, a primary determinant of investment is current output growth, which is interpreted as indicating the short-run tendency in demand that should be satisfied by production, which in turn requires investment. The current investment function specifications in LIMA are more data-driven and they focus on error correction, in analogy to consumption functions.

The long-run elasticity of equipment investment with respect to GDP is estimated as 1.3919 from a co-integrating regression. The implied equilibrium relation

$$ife - 1.3919 gdp$$

is preferred to the more traditional log share in output. Using the logged share of equipment investment in total output as a regressor would assume that the share of equipment investment in total output is fairly constant in the longer run. This is not necessarily true and is not really backed by theory. Economic theory yields a constant share of *total* investment in output only.

Economic theory suggests a negative influence from real interest rates on investment demand. Unfortunately, such an influence is not backed by empirical evidence. The current specification $INT2$ is a 10–year bond rate that was deflated by the investment deflator. While this 'real interest rate' fails to become significant, it still shows the strongest influence among diverse alternative specifications for real and nominal rates.

Table 5: Behavioral Equation for Equipment Investment

regressor	coefficient	t–value
$\log(IFE_{t-1}) - 1.3919 * \log(GDP_{t-1})$	–0.451	–3.179
$\log(GDP_t/GDP_{t-1})$	2.607	4.218
$INT2_t$	–0.005	–1.372
$d8283$	–0.088	–3.373
$R^2 = 0.662$, DW=1.496		

Note: Estimation time range is 1980–2002. Dependent variable is $\log(IFE_t/IFE_{t-1})$.

A sizeable aberration requires the usage of a dummy variable for two years in the early 1980's. Clearly, the introduction of such dummy variables should be restricted to occasions where they are absolutely necessary.

There is also an analogous equation for *construction investment*. Here, an additional lag term becomes significant, while real interest fails to do and is kept for theoretical reasons only. The long-run elasticity of construction is set at 0.7918, according to a preliminary co-integrating regression. This implies that the share of construction in total investment is declining. Dummy variables have not been found necessary. It appears that the dynamic behavior of construction investment has been subjected to what looks like structural breaks and shifts in the recent past. However, trends or sophisticated dummy constructions may prove to be detrimental in longer-run forecasting, while they just improve in-sample fit. Therefore we abstained from artificially increasing R^2 using such methods.

Table 6: Behavioral Equation for Construction Investment

Regressor	coefficient	t–value
constant	–0.187	–2.363
$\log(IFC_{t-1}) - 0.7918 * \log(GDP_{t-1})$	–0.181	–2.144
$\log(GDP_t / GDP_{t-1})$	1.245	3.315
$\log(IFC_{t-1}/IFC_{t-2})$	0.339	2.148
$INT2_t$	–0.002	–0.429

$R^2 = 0.484$, DW=2.146

Note: Estimation time range is 1978–2002. Dependent variable is $\log(IFC_t/IFC_{t-1})$.

Adding the exogenous real changes in inventories II to fixed investment yields total investment or gross capital formation I via

$$I = IFE + IFC + II. \tag{1}$$

3. Imports and Exports

As can be seen from chart 1, LIMA treats imports as endogenous, as import demand depends on domestic demand, where imports partly satisfy the needs for intermediate input and partly are utilized directly in consumption and investment. In contrast, exports are exogenous, as export demand depends on activities on the world market, as domestic goods and services are used by non-resident producers and consumers. For special simulation purposes, effects of changing relative prices on export demand must be calibrated into assumptions on future exports behavior.

3.1 Import Demand

According to economic theory, import demand reacts to domestic demand and to relative prices. Empirically, there is a longer-run tendency for the import quota to rise, although it is difficult to determine the eventual limiting behavior of this tendency. There is also a sizeable reaction to export demand. Import demand varies across the components of GDP. Equipment investment and consumer durables have the highest import contents. Particularly for longer-run projections, import equations have a certain tendency to cause instabilities, as it is not easy to accommodate theoretical, econometric, and purely observational issues simultaneously.

We chose the way to define a variable WMD, which is defined as weighted import demand from domestic demand according to

$$WMD = 0.245 * C + 0.060 * (CP + CNP) + 0.174 * IFC$$

$$+0.638 * IFE + 0.374 * II + 0.480 * X. \tag{2}$$

The weights have been determined from Austrian input-output tables. The elasticity of import demand with regard to WMD turns out to be larger than one. The import demand system is estimated in two stages. In the first stage, the long-run reaction is determined by a co-integrating regression. In the second stage, the error-correction term is introduced as a regressor in a short-run import-demand equation.

The co-integrating regression is shown in table 7. It displays the typical features of co-integrating regressions. All t–values are extremely large, R^2 is high, and the Durbin-Watson statistic points to serious autocorrelation.

Table 7: Long-run Equilibrium for Real Goods Imports

regressor	coefficient	t–value
constant	0.794	19.536
$\log(WMD_t) + \log\{(M_t/GDP_t)/(M_{02}/GDP_{02})\}$	0.766	70.042

$R^2 = 0.994$, DW=0.594

Note: Estimation time** range **is 1976–2002. Dependent variable is** $\log(MG_t)$**.

The equation for *goods imports* in table 8 satisfies the criterion of stability within the LIMA model as well as statistical criteria. The sum of coefficients with regard to WMD is 1.35, which is a medium-run elasticity. The relative import content of domestically produced goods and services, which include exports, increases due to stronger international integration. However, the error-correction term serves as a break and tends to avoid over-reaction to demand expansion. Reaction to terms of trade is less pronounced but also significant.

Table 8: Behavioral Equation for Real Goods Imports

regressor	coefficient	t–value
constant	–0.247	–1.764
$\log(WMD_t/WMD_{t-1})$	1.173	10.790
$\log(MG_{t-1})$-0.68*$\log(VD_{t-1})$–0.49*$\log(XG_{t-1})$	–0.167	–1.777
$\Delta\log(PMG_{t-1}/PXG_{t-1})$	–0.423	–2.205
$\log\left(WMD_{t-1}/WMD_{t-2}\right)$	0.180	1.723
$d93-d94$	–0.041	–3.959

$R^2 = 0.931$, DW=1.964

Note: Estimation time range is 1978–2002. Dependent variable is $\log(MG_t/MG_{t-1})$.

A separate equation describes the behavior of *imports of tourist services*. Tourist imports depend on relative prices, on total household consumption, and on a long-run equilibrium condition. The long-run equilibrium condition shows an elasticity of 1.34 with respect to household consumption. Traveling abroad becomes increasingly attractive, as income levels rise. The short-run elasticity is almost identical. Interestingly, immediate reaction to increased relative prices is stronger (–1.99) than longer-run reaction (–0.78). Expensive holiday resorts deter Austrian tourists for one season only.

The two remaining categories of imports, *other service imports* MSO and *adjustment for imports than cannot be separated into goods and services* $MADJ$, are exogenous in LIMA. Therefore, total imports M evolve from their components as

$$M = MG + MSO + MST + MADJ. \tag{3}$$

Table 9: Behavioral Equation for Real Service Imports in Tourism

regressor	coefficient	t–value
constant	–1.860	–3.107
$\log(MST_{t-1}) - 1.34 * \log(CR_{t-1})$	–0.461	–3.062
$\log(C_t/C_{t-1})$	1.393	3.165
$\log(PMST_{t-1}/PC_{t-1})$	–1.987	–5.709
$\log(PMST_{t-2}/PC_{t-2})$	1.208	3.098
$d87$	0.153	5.195
$d94$	0.089	2.387
$R^2 = 0.843$, DW=2.402		

Note: Estimation time range is 1978–2002. Dependent variable is $\log(MG_t/MG_{t-1})$.

3.2 Export Demand

While usually exports are exogenous variables in the LIMA model, for the purpose of certain simulations an export reaction equation is added. In this equation, *goods exports* are determined by the demand on Austrian export markets and also by terms of trade.

Table 10: Behavioral Equation for Real Goods Exports

regressor	coefficient	t–value
constant	0.016	1.652
$\log(XMKT_t/XMKT_{t-1})$	1.115	6.620
$\Delta\log(PXG_t/PMG_t)$	–0.238	–0.789
$R^2 = 0.657$, DW=2.459		

Note: Estimation time range is 1977–2002. Dependent variable is $\log(XG_t/XG_{t-1})$.

The elasticity coefficient of 1.11 expresses a longer-run tendency of Austrian exporters to increase their presence on foreign markets. In contrast, price reaction is small and statistically not significant. One might presume that Austrian exporting firms target competition by quality rather than competition by prices.

In any LIMA variant, total exports evolve as the sum of four sub-aggregates, in analogy to total imports in 3 as

$$X = XG + XSO + XST + XADJ.$$

4. Aggregate Output

The main output variable GDP, i.e. gross domestic product, evolves as the sum of all demand aggregates, just as in the SNA account zero, by way of

$$GDP = C + CNP + CP + I + DIF + X - M \tag{4}$$

A part of this is also *domestic demand* VD, which is obtained in an analogous way as

$$VD = CR + CNP + CP + I + DIF. \tag{5}$$

The discrepancy between demand and production accounting DIF is set exogenously. Analogous equations are used for the nominal quantities $GDP\$$ and $VD\$$:

$$GDP\$ = C\$ + CNP\$ + CP\$ + I\$ + DIF\$ + X\$ - M\$, \tag{6}$$

$$VD\$ = C\$ + CNP\$ + CP\$ + I\$ + DIF\$. \tag{7}$$

These equations finally yield price deflators for the total output aggregates

$$PGDP = \frac{GDP\$}{GDP} * 100, \tag{8}$$

$$PVD = \frac{VD\$}{VD} * 100. \tag{9}$$

5. Prices

5.1 Consumption Prices

For each demand aggregate, two behavioral equations must be specified: an equation for real demand and an equation for the price deflator. In the case of private consumption, the corresponding price deflator is named PC, for 'prices of *c*onsumption'. The consumption deflator PC is usually taken as the most significant price variable, as it represents the average price level as it is seen by consuming households. In a sense, PC is still the Paasche counterpart to the Laspeyres cost-of-living indexes. This interpretation, however is subject to an imminent modification, as the new SNA chaining concept will be put into practice. The institute's regression equation lets PC depend on labor costs and on import prices.

Table 11: Behavioral Equation for the Deflator of Private Consumption

regressor	coefficient	t–value
constant	0.009	3.597
$\log(ULC_t/ULC_{t-1})$	0.279	4.181
$\log(ULC_{t-1}/ULC_{t-2})$	0.190	3.014
$\log(PM_t/PM_{t-1})$	0.312	5.344
$D83$	0.018	2.350
$\log(GDP_t/GDPTS\_HP_t)$	0.115	1.031

$R^2 = 0.845$, DW=1.693

Note: Estimation time range is 1978–2002. Dependent variable is $\log(PC_t/PC_{t-1})$.

Consumer prices react with a proportionality factor of around 0.5 to labor costs and with a factor of around 0.3 to imported inflation. The lag distribution with regard to wage inflation reflects the mechanism of wage rounds. In the absence of shocks, inflation tends to stabilize, as the sum of coefficients is less than one. A reaction to a measure for the output gap has been built into the equation for theoretical reasons. It fails to achieve statistical significance.

Table 12: Behavioral Equation for the Deflator of NPIsH Consumption

regressor	coefficient	t–value
$\log(PC_t/PC_{t-1})$	0.396	3.289
$\log(YWGLEA_t/YWGLEA_{t-1})$	0.562	6.653
$d93$	0.029	4.807

$R^2 = 0.906$, DW=1.685

Note: Estimation time range is 1977–2002. Dependent variable is $\log(PCNP_t/PCNP_{t-1})$.

Price indexes for consumer sub-aggregates are not modeled in LIMA: There is an equation for NPIsH consumption prices, however, which expresses inflation in $PCNP$ as a function of inflation in the main price index PC and in wages, as the largest part of NPIsH consumption concerns services. The equation is estimated without a constant, reflecting statistical insignificance of the intercept as well as the observation that an autonomous source for $PCNP$ inflation does not exist.
The popular Laspeyres-type consumer price index PLC is linked to the consumption deflator by a reaction function.

Table 13: Behavioral Equation for the Consumer Price Index

regressor	coefficient	t–value
constant	0.003	1.916
$\log(PC_t/PC_{t-1})$	0.939	21.186

$R^2 = 0.949$, DW=2.335

Note: Estimation time range is 1977–2002. Dependent variable is $\log(PLC_t/PLC_{t-1})$.

The consumer price segment of LIMA is completed by an equation for the deflator of public services PCP. PCP inflation depends on general PC inflation, on wage inflation (salaries of public employees), and on a dynamic time lag expressing persistence in inflation.

Table 14: Behavioral Equation for the Deflator of Government Consumption

regressor	coefficient	t–value
constant	–0.006	–2.059
$\log(PC_t/PC_{t-1})$	0.258	2.297
$\log(YWGLEA_t/YWGLEA_{t-1})$	0.583	4.804
$\log(PCP_{t-1}/PCP_{t-2})$	0.268	2.605

$R^2 = 0.933$, DW=1.433

Note: Estimation time range is 1981–2002. Dependent variable is $\log(PCP_t/PCP_{t-1})$.

Note that the Durbin-Watson statistic indicates serious problems of autocorrelation. Unfortunately, the search for further explanatory variables in order to isolate the effects of that correlation proved unsuccessful.

Price deflators allow defining nominal demand aggregates. While nominal consumer sub-aggregates are not modeled, nominal private consumption is defined by

$$C\$ = C * PC/100, \tag{10}$$

and similar definitions yield $CNP\$$ and $CP\$$:

$$CNP\$ = CNP * PCNP/100, \tag{11}$$

$$CP\$ = CP * PCP/100. \tag{12}$$

5.2 Investment Prices

A large part of equipment investment demand is satisfied by imported goods, therefore the price deflator should be influenced directly by import prices. Another explanatory variable is ULC, unit labor costs, which stems from the labor market sector of the LIMA model. Substantial autocorrelation in the deflator also requires the insertion of lags. Thus, the $PIFE$ equation is a severely dynamic regression equation. As a general rule, dynamic equations support the stability of the model, while static equations may result in unstable behavior. Finally, the output gap, which is determined as the difference of realized GDP and a Hodrick-Prescott filtered GDP in lieu of potential output, may exert some pressure on prices. While this variable remains insignificant statistically, its influence is kept in the equation for theoretical reasons.

Table 15: Behavioral Equation for the Deflator of Equipment Investment

regressor	coefficient	t–value
$\log(PIFE_{t-1}/PIFE_{t-2})$	0.321	1.837
$\log(ULC_{t-1}/ULC_{t-2})$	0.247	2.447
$\log(PMG_{t}/PMG_{t-1})$	0.148	2.021
$\log(PMG_{t-1}/PMG_{t-2})$	0.097	1.210
$\log(GDP_{t}/GDPTS\_HP_{t})$	0.105	0.680
$R^2 = 0.685$, DW=2.537		

Note: Estimation time range is 1978–2002. Dependent variable is $\log(PIFE_t/PIFE_{t-1})$.

In line with most price equations, the $PIFE$ equation does not have a constant term. This implies that individual demand aggregates do not have an inflationary core of their own but that they just pick up price developments of their inputs.

For construction investment, imports play a far lesser role. Therefore, construction prices $PIFC$ are modeled as depending on domestic influences only. The coefficient of lagged $PIFC$ inflation reflects the high degree of dynamic persistence in the prices of this sector. While the output gap appears to be more important for $PIFC$ than for $PIFE$, it again fails to attain statistical significance.

Table 16: Behavioral Equation for the Deflator of Construction Investment

regressor	coefficient	t–value
$\log(PIFC_{t-1}/PIFC_{t-2})$	0.727	8.773
$\log(ULC_{t}/ULC_{t-1})$	0.279	3.094
$d8384$	–0.013	–1.771
$d89$	0.030	3.097
$\log(GDP_{t}/GDPTS\_HP_{t})$	0.213	1.465
$R^2 = 0.817$, DW=2.122		

Note: Estimation time range is 1978–2002. Dependent variable is $\log(PIFC_t/PIFC_{t-1})$.

Just as for consumption, nominal investment demand is constructed from the real variables and the price deflators, i.e.

$$IFE\$ = IFE * PIFE/100, \tag{13}$$

$$IFC\$ = IFC * PIFC/100, \tag{14}$$

$$II\$ = II * PII/100. \tag{15}$$

Finally, total nominal investment evolves from adding up its components

$$I\$ = IFE\$ + IFC\$ + II\$. \tag{16}$$

From the real and nominal total investment aggregates, the investment price deflator PIF is calculated as

$$PIF = I\$/I * 100. \tag{17}$$

Note that it really is the price deflator for total investment and not just for fixed investment. However, the II part is small, therefore the difference can be ignored. Another related and completely exogenous price deflator is the one for the statistical discrepancy DIF

$$PDIF = DIF\$/DIF * 100. \tag{18}$$

5.3 Export Prices

While import prices are assumed exogenous and a similar assumption is adopted for goods export prices, which are mainly determined on the world market, a simple regression equation ties the *deflator of exports in tourist services* to the consumption deflator.

Table 17: Behavioral Equation for the Deflator of Service Exports in Tourism

regressor	coefficient	t–value
$d8283$	–0.013	–2.876
$\log(PC_t/PC_{t-1})$	1.059	28.090

$R^2 = 0.879$, DW=2.478

Note: Estimation time range is 1978–2001. Dependent variable is $\log(PXST_t/PXST_{t-1})$.

In the end, export and import deflators for the total categories are then determined indirectly according to the following pattern. Firstly, nominal exports within the sub-aggregates (goods, services in tourism, other services, adjustment for items that cannot be separated into goods and services) are determined by multiplying deflators into the real quantities

$$XG\$ = XG * PXG/100, \tag{19}$$

$$XST\$ = XST * PXST/100, \tag{20}$$

$$XSO\$ = XSO * PXSO/100, \tag{21}$$

$$XADJ\$ = XADJ * PXADJ/100. \tag{22}$$

Then, the total nominal aggregate is formed as

$$X\$ = XG\$ + XSO\$ + XST\$ + XADJ\$. \tag{23}$$

Finally, the total exports deflator is determined from

$$PX = \frac{X\$}{X} * 100. \tag{24}$$

An analogous system of equations is used for imports and import deflators:

$$MG\$ = MG * PMG/100, \tag{25}$$

$$MST\$ = MST * PMST/100, \tag{26}$$

$$MSO\$ = MSO * PMSO/100, \tag{27}$$

$$MADJ\$ = MADJ * PMADJ/100. \tag{28}$$

$$M\$ = MG\$ + MSO\$ + MST\$ + MADJ\$. \tag{29}$$

$$PM = \frac{M\$}{M} * 100. \tag{30}$$

6. The Labor Market

6.1 Employment

The LIMA employment equation specification uses error correction and relative factor prices. The main determinant of employment, however, is real output growth. The coefficient on real output growth shows the effects that are otherwise known as Okun's Law.

Table 18: Behavioral Equation for Employment Excluding Self-employment

regressor	coefficient	t–value
constant	0.325	2.561
d83	–0.021	–3.387
$\log(GDP_t/GDP_{t-1})$	0.435	4.274
$\log(LEA_{t-1}/GDP_{t-1})$	0.228	2.670
$\log(YWGLEA_{t-1}/PGDP_{t-1})$	–0.273	–2.697
$R^2 = 0.683$, DW=1.997		

Note: Estimation time range is 1981–2002. Dependent variable is $\log(LEA_t/LEA_{t-1})$.

All regressors are significant and have the expected signs. Unfortunately, the inclusion of a dummy variable was necessary. Fortunately, it is located in the earlier years and may have only small effects on forecasting.

The short-run Okun-type coefficient has the plausible value of around 0.4. Note that it is not exactly the same as in Okun's law, due to some non-linear transformations and due to the omission of the labor-supply effects that are also captured in the original Okun coefficient. Error correction has a sizeable impact, which implies that the long-run unit elasticity shows its effects after fey years already. In other words, a sudden recession has only small effects on employment, while the full negative effects are felt if the recession does not end soon.

The negative effects of real wages, i.e. the relative price of the production factor labor, are also quite strong. The variable $YWGLEA$ is the *per capita* gross wage. Technically, it counteracts the tendency of employment to grow proportional to output, which would imply an absence of technological progress. However, the long-run growth of real wage puts a brake on unlimited employment expansion. Thus, the employment equation is a stabilizing component in the LIMA model.

In order to construct an unemployment rate, we first determine *total labor force* TLF as a fraction of the exogenous working-age population $POPWAT$ by

$$TLF = \frac{TLFPR}{100} * POPWAT. \tag{31}$$

The factor $TLFPR$ is an endogenous and important variable. Its behavioral equation is shown in table 19. It is modeled using the logit transformation.

Table 19: Behavioral Equation for Participation Rate

regressor	coefficient	t–value
constant	0.205	2.338
d98	0.032	2.606
$\log\{TLFPR_{t-1}/(100-TLFPR_{t-1})\}$	0.871	19.816
$\log(LEA_{t-1}/TLF_{t-1})$	0.490	1.379
$\log(DLFFOR_t/DLFFOR_{t-1})$	0.198	6.151
$\log\left(LENACT_t/LENACT_{t-1}\right)$	0.049	2.115

$R^2 = 0.963$, DW=1.060

Note: The domestic Estimation time range is 1977–2002. Dependent variable is $\log(\frac{TLFPR}{100-TLFPR})$.

The domestic labor force $TLFNAT$ is obtained by subtracting the labor force provided by foreigners $DLFFOR$

$$TLFNAT = TLF - DLFFOR, \tag{32}$$

while the so-called *dependent labor force* DLF evolves as

$$DLF = TLF - SEG, \tag{33}$$

i.e. by subtracting the self-employed. The *unemployed* among the dependent labor force are determined as

$$UN = TLF - SEG - LEA - LENACT, \tag{34}$$

i.e. after an additional adjustment for the non-active employees $LENACT$.
From UN, the *unemployment rate* UR is calculated as

$$UR = \frac{UN}{LEA + LENACT + UN} * 100.$$

This calculation yields the traditional unemployment rate according to the domestic definition, which may differ from the international rate, which is published within the framework of the ESA/SNA accounts.

Another interesting variable from this part of the LIMA model is *labor productivity*, which evolves as

$$PRLEA = \frac{GDP}{LEA} * 100. \tag{35}$$

6.2 Wages

The main wage variable $YWGLEA$ is modeled to parallel prices on its long-run expansion path. In the short run, however, price elasticity may differ from unity and actually does so in the estimated equation, although not strongly. There is a slight Phillips-type pressure from tightness in the labor market.

6.3 Nominal Income

From the *per capita* wages $YWGLEA$ and employment LEA, a wage sum $YWGG\$$ is calculated as

$$YWGG\$ = \frac{YWGLEA * LEA}{1000}.$$

Table 20: Behavioral Equation for per Capita Nominal Wages

regressor	coefficient	t–value
constant	0.013	6.025
$1/UR_t$	0.017	1.406
$\log(PGDP_t/PGDP_{t-1})$	0.969	9.808
$\log(YWGLEA_{t-1}) + 2.623 - \log(PGDP_{t-1})$	–0.286	–3.399
$d84$	–0.020	–3.565
$d01$	–0.021	–4.136

$R^2 = 0.947$, DW=1.561

Note: Estimation time range is 1977–2002. Dependent variable is $\log(YWGLEA_t/YWGLEA_{t-1})$.

This wage sum, in turn, appears as the main component in determining *net national income* (NNI)

$$Y\$ = YWGG\$ + BUSE + PASUB + YF\$ - DEP\$. \quad (36)$$

The remaining components are: gross operating surplus $BUSE$, net production taxes $PASUB$, border-crossing primary income $YF\$$, and depreciation $DEP\$$. Subtracting depreciation results in a net income. While the generation of $YWGG\$$ has already been described, we now turn to the remaining components.

The operating surplus $BUSE$ is obtained as the balancing item from the primary income account, just as in national accounting

$$BUSE = GDP\$ - YWGG\$ - PASUB. \quad (37)$$

Net production taxes $PASUB$ is an endogenous variable. A simple regression equation models it as evolving in parallel to GDP.

Table 21: Behavioral Equation for Production Taxes Minus Subsidies

regressor	coefficient	t–value
$\log(GDP\$_t / GDP\$_{t-1})$	0.967	11.007
$dd9495$	0.035	1.934
$dd9798$	0.041	2.279

$R^2 = 0.499$, DW=2.270

Note: Estimation Time Range is 1977–2002. Dependent variable is $\log(PASUB_t / PADUB_{t-1})$.

Border-crossing primary income $YF\$$ is an exogenous variable.

Depreciation or *consumption of fixed capital* is determined as a fraction of the capital stock CST, which is priced at the current investment price deflator PIF, i.e.

$$DEP\$ = \frac{FDEP * CST * PIF}{100}. \tag{38}$$

The exogenous factor $FDEP$ is exogenous. Currently, it has been set at 4.14% annually.

If $Y\$$ is adjusted for border-crossing secondary incomes—i.e. transfers—the *net national disposable income* is obtained as

$$NE\$ = Y\$ + YT\$. \tag{39}$$

Another set of bookkeeping equations is required to determine the *household disposable income*, which is an important explanatory variable for consumer demand in the real sector. Firstly, primary household income is the sum of wage and other income. While all wage income is distributed to households, only a fraction of 'profits' becomes effective in this regard, while the remainder is used for firms' saving. The quota $FBUSE$ is an exogenous variable in

$$YHH\$ = YWGG\$ + FBUSE * BUSE. \tag{40}$$

When primary household income is adjusted for transfers, disposable household income is obtained as

$$YD\$ = YHH\$ + TRANSV - TDHV - SVB. \tag{41}$$

Note that the negative transfers $TDHV$ and SVB are calculated in the public sector part of LIMA, while positive transfers $TRANSV$ are exogenous. From disposable income $YD\$$ and consumption, a *household saving rate* can be constructed via

$$SQ = \frac{YD\$ + PP\$ - C\$ - CNP\$}{YD\$ + PP\$} * 100. \tag{42}$$

The variable $YWGG\$$ is also used to determine *unit labor costs* ULC, which are an important input to the price module of LIMA

$$ULC = YWGG\$ / GDP. \tag{43}$$

7. External Balances

These pure accounting equations serve to derive entities for the current accounts position of the balance of payments. Firstly,

$$BPG = XG\$ - MG\$ + BPGA \tag{44}$$

determines the trade balance for goods. Then,

$$BPST = XST\$ - MST\$ + BPTSA, \tag{45}$$

$$BPSO = XSO\$ + XADJ\$ - MSO\$ + MADJ\$ + BPSOA, \tag{46}$$

yield the trade balance for services. Each of these equations contains an exogenous adjustment term. The sum of the trade positions and the net positions for primary and secondary income yields the current accounts balance

$$BPC = BPG + BPST + BPSO + BPOP + BPTR. \tag{47}$$

8. Public Sector

This part of the LIMA model yields aggregate direct taxes—i.e. taxes on income—and aggregate social insurance contributions. These variables $TDHV$ and SVB

are then used in the income sector. If the government budget is to be predicted, this module is augmented by a more refined set of behavioral and definitional equations. For the purpose at hand, it is more restricted.

Table 22: Behavioral Equation for Social Insurance Contributions

regressor	coefficient	t–value
constant	–0.005	–1.355
$\log\left(YWGG\$_t / YWGG\$_{t-1}\right)$	0.981	13.838
$\log(SVBSA_t / SVBSA_{t-1})$	0.813	7.109
$\log(HVBG_t / HVBG_{t-1})$	0.287	3.274

$R^2 = 0.951$, DW=2.191

Note: Estimation time range is 1982–2002. Dependent variable is $\log(SVB_t/SVB_{t-1})$.

While the behavioral equation for social insurance contributions SVB shown in Table 22 has a rather straight forward structure, aggregate taxes are obtained via a sophisticated functional form. The average tax rate depends on time-dependent indicators of the tariff structure and on taxable income per capita.

Table 23: Behavioral Equation for Aggregate Taxes on Income

regressor	coefficient	t–value
ΔTYB_t	5.126	5.876
$\Delta(TYA_t + TYB_t * \log(YWGG\$_t + TRANSV_t) - \log(LEA_t))$	0.342	5.602

$R^2 = 0.570$, DW=1.660

Note: Estimation time range is 1977–2002. Dependent variable is $\Delta \frac{TDHV - GST + GSTKG}{YWGG\$ + TRANSV}$.

9. Simulations

In this section simulation results are presented to illustrate the most important transmission mechanisms in the model and to allow comparisons with the OeNB and the WIFO-model. First, we consider two demand shocks (public consumption and exports), then a monetary shock (interest rate) is simulated. In the first two simulations the demand shocks last for five years, in the last simulation the interest rates fall back to their baseline level after two years. Simulations cover ten years. The results are presented either as percentage or percentage point deviations from the baseline. Tables 1–3 in the appendix show the result of our simulations.

9.1 Increase of Government Consumption for Five Years

In the first five years public consumption is increased by one percent of (initial) real GDP. Because the purpose of these simulations is to show the direct effects of a positive demand shock, no financing of the increase in public consumption is considered. Nominal interest rates are assumed to remain constant at their baseline levels over the whole simulation period. Real transfers and the ratio of taxes paid by households to GDP are kept constant.

Higher public consumption leads to an increase in output. The impact multiplier is greater than 1. Crucial for this result is our specification of the import equation, which takes into consideration that the share of public consumption imported from abroad is very low compared to the other demand components. Real investment activity is boosted by the accelerator effect. The increase in disposable income leads to higher private consumption, partly offset by a rise in the savings rate in the first year. Due to higher domestic demand imports expand, implying a deterioration of the trade balance. Demand side pressures lead to pick up in inflation with a lag of one year. After five years the unemployment rate is half of a percentage point below the baseline value and real wages increase in line with productivity. The fall-back of government consumption after five years to the baseline reverse most of the results. GDP returns to the baseline value immediately. Because of a fall in the savings rate consumption expenditures remain above the baseline values, this effect is offset by higher imports. The prices are sticky and inflation is significantly above the baseline values at the end of the simulation period.

9.2 Increase in World Demand for Five Years

This simulation investigates the effects of a demand shock due to external growth of world demand. We incorporate this shock in our model by an exogenous increase in exports by 1 percentage point of (initial) GDP for five years. This positive demand shock leads to an increase in output and in all demand components. In contrast to simulation 1 the interim multiplier is below one. This is caused by the higher import content of exports. The initial impact of net exports amounts to 0.35 percentage of GDP. Due to higher employment consumption expenditures increase, the acceleration effect leads to higher investment demand. Demand side pressure implies higher inflation. The unemployment rate declines by 1/3 of a percentage point. Real wages grow in line with productivity. After five years world demand falls back to its baseline level. This negative demand shock triggers reverse adjustment processes. GDP returns to the baseline level immediately. The accelerator effect implies a reduction in investment expenditures. Consumption drops only marginally and remains above the baseline values for the whole simulation period. This effect is offset by higher import expenditures. Due to higher unit labor costs inflation is above the baseline value until the end of the simulation period.

9.3 Increase of Short-term Interest Rates for Two Years

In this simulation the impact of a monetary shock is investigated. Nominal short-term interest rates are increased by 100 basis points for a two years period. According to the common assumptions the effect on long-term interest rates is very small. In the first (second) year the interest rate is 16.3 (6.3) basis points above the baseline value. The exchange rate appreciates according to the uncovered interest rate parity. The appreciation amounts to 0.16 and 0.063 percentage points, respectively.

The small monetary shock has almost no macroeconomic effect in our model. GDP is reduced by 0.05 percentage points in the first two years. The increase in the real interest rate causes a small fall in consumption expenditures (–0.07) and a slightly stronger effect for investment demand (–0.15 percentage points). A critical assumption is here that consumption and investment depend mainly on real long-term interest rates in our model. A stronger transmission of the rise in the short-term interest rates would imply a larger effect. The appreciation of the exchange rate leads to a small improvement in the terms-of-trade. However, the appreciation is so small that the trade balance is not significantly affected.

Appendix

Table A1: Increase of Government Consumption for Five Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
VPI	-0.04	0.17	0.68	1.19	1.69	2.18	2.42	2.38	2.32	2.26
Consumption deflator	-0.05	0.18	0.72	1.27	1.80	2.32	2.58	2.53	2.47	2.41
GDP deflator	0.05	0.37	0.98	1.64	2.32	2.88	3.23	3.31	3.33	3.34
Investment deflator	0.07	0.43	1.10	1.96	2.92	3.91	4.63	5.07	5.33	5.49
Unit labour costs	-0.78	-0.06	0.72	1.52	2.25	3.62	3.60	3.53	3.42	3.35
Compensation per employee	0.08	0.61	1.32	2.04	2.73	3.27	3.41	3.37	3.31	3.28
Productivity	0.86	0.66	0.60	0.52	0.47	-0.34	-0.19	-0.16	-0.10	-0.07
Export deflator	0.00	0.02	0.07	0.12	0.17	0.22	0.25	0.24	0.24	0.24
Import deflator	-0.01	-0.01	0.00	0.03	0.05	0.08	0.10	0.11	0.10	0.11
GDP and components	*Levels, percentage deviations from baseline*									
GDP	1.53	1.52	1.56	1.49	1.42	-0.02	-0.07	-0.18	-0.17	-0.14
Consumption	0.54	0.79	1.09	1.25	1.37	0.94	0.80	0.60	0.54	0.55
Investment	2.87	2.79	2.77	2.56	2.40	-0.34	-0.34	-0.41	-0.29	-0.17
Of which: construction investment	1.91	2.43	2.49	2.30	2.08	0.18	-0.41	-0.57	-0.47	-0.31
Government consumption	5.85	5.82	5.79	5.71	5.62	0.00	0.00	0.00	0.00	0.00
Exports	0.00	-0.01	-0.02	-0.04	-0.04	-0.06	-0.09	-0.12	-0.14	-0.16
Imports	0.76	0.91	1.04	1.14	1.24	0.64	0.56	0.49	0.45	0.43
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic demand	1.99	2.08	2.22	2.23	2.23	0.43	0.35	0.22	0.22	0.25
Inventories										
Trade balance	-0.46	-0.56	-0.66	-0.74	-0.81	-0.45	-0.42	-0.40	-0.39	-0.40
Labour market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	0.57	0.73	0.82	0.83	0.82	0.27	0.10	-0.02	-0.06	-0.07
Employees in employment	0.66	0.85	0.95	0.97	0.95	0.32	0.12	-0.02	-0.07	-0.08
Unemployment rate	-0.60	-0.67	-0.68	-0.61	-0.53	0.07	0.21	0.27	0.24	0.20
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	1.10	1.04	0.64	0.17	-0.28	-1.68	-1.98	-1.96	-1.86	-1.76
Saving rate	0.46	0.39	0.23	0.14	0.11	-0.32	-0.25	-0.09	0.00	0.04

Source: Authors' calculations.

Table A2: Increase in World Demand for Five Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
VPI	-0.07	0.02	0.27	0.53	0.79	1.12	1.31	1.36	1.40	1.44
Consumption deflator	-0.07	0.02	0.29	0.56	0.84	1.19	1.40	1.44	1.49	1.53
GDP deflator	-0.12	0.02	0.31	0.64	0.98	1.47	1.72	1.85	1.96	2.06
Investment deflator	0.02	0.18	0.51	0.95	1.46	2.02	2.48	2.83	3.10	3.33
Unit labor costs	-0.58	-0.18	0.16	0.54	0.91	1.82	1.85	1.94	1.99	2.06
Compensation per employee	-0.10	0.15	0.50	0.85	1.22	1.69	1.85	1.93	2.00	2.09
Productivity	0.49	0.33	0.34	0.31	0.30	-0.12	0.00	-0.01	0.01	0.02
Export deflator	-0.06	-0.05	-0.02	0.00	0.03	0.11	0.13	0.14	0.14	0.15
Import deflator	-0.03	-0.03	-0.02	-0.01	0.00	0.04	0.06	0.06	0.06	0.07
GDP and components	*Levels, percentage deviations from baseline*									
GDP	0.86	0.78	0.85	0.86	0.87	0.12	0.18	0.10	0.10	0.10
Consumption	0.24	0.34	0.52	0.62	0.69	0.56	0.54	0.45	0.44	0.45
Investment	1.60	1.42	1.50	1.47	1.45	0.03	0.20	0.13	0.17	0.22
Of which: construction investment	1.08	1.27	1.34	1.30	1.25	0.27	0.07	-0.01	0.03	0.10
Government consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	1.58	1.50	1.42	1.38	1.34	0.00	0.00	0.00	0.00	0.00
Imports	1.09	1.18	1.20	1.21	1.23	0.31	0.25	0.26	0.28	0.30
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic demand	0.52	0.53	0.64	0.69	0.72	0.31	0.34	0.27	0.28	0.30
Inventories										
Trade balance	0.35	0.25	0.21	0.18	0.14	-0.19	-0.16	-0.17	-0.18	-0.19
Labor market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	0.32	0.38	0.44	0.47	0.48	0.21	0.15	0.10	0.08	0.07
Employees in employment	0.38	0.45	0.52	0.55	0.56	0.24	0.18	0.11	0.09	0.08
Unemployment rate	-0.34	-0.35	-0.37	-0.35	-0.33	-0.01	0.02	0.06	0.05	0.04
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	0.59	0.54	0.36	0.15	-0.07	-0.78	-0.96	-1.00	-1.01	-1.02
Saving rate	0.25	0.19	0.11	0.08	0.06	-0.16	-0.11	-0.03	0.01	0.03

Source: Authors' calculations.

Table A3: Increase of Short-term Interest Rates for Two Years

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Prices	*Levels, percentage deviations from baseline*									
VPI	-0.01	-0.01	-0.01	-0.04	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06
Consumption deflator	-0.01	-0.01	-0.01	-0.04	-0.05	-0.06	-0.06	-0.06	-0.06	-0.06
GDP deflator	0.04	0.04	-0.01	-0.05	-0.06	-0.07	-0.08	-0.08	-0.08	-0.08
Investment deflator	0.00	-0.01	-0.03	-0.06	-0.08	-0.10	-0.11	-0.12	-0.13	-0.13
Unit labor costs	0.07	0.06	-0.01	-0.06	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
Compensation per employee	0.04	0.03	-0.02	-0.06	-0.07	-0.08	-0.08	-0.08	-0.08	-0.08
Productivity	-0.03	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Export deflator	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Import deflator	-0.08	-0.07	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GDP and components	*Levels, percentage deviations from baseline*									
GDP	-0.05	-0.07	-0.05	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00
Consumption	-0.08	-0.06	-0.04	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
Investment	-0.13	-0.17	-0.11	-0.05	-0.02	-0.01	0.00	0.00	0.00	-0.01
Of which: construction investment	-0.06	-0.13	-0.12	-0.07	-0.03	-0.01	0.00	0.00	0.00	0.00
Government consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Imports	-0.06	-0.03	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
Contributions to shock	*Percentage of GDP, absolute deviations from baseline*									
Domestic demand	-0.08	-0.07	-0.05	-0.03	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01
Inventories										
Trade balance	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Labor market	*Levels, percentage deviations from baseline, except unemployment: percentage points, absolute deviations from baseline*									
Total employment	-0.02	-0.03	-0.03	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00
Employees in employment	-0.02	-0.04	-0.03	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00
Unemployment rate	0.02	0.03	0.02	0.01	0.00	0.00	-0.01	-0.01	0.00	0.00
Household accounts	*Levels, percentage deviations from baseline, except the savings rate: percentage points, absolute deviations from baseline*									
Disposable income	0.02	-0.01	-0.02	0.02	0.04	0.05	0.05	0.05	0.04	0.04
Saving rate	0.08	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00

Source: Authors' calculations.

1st Comment on "The Austrian Quarterly Model of the OeNB, WIFO-Macromod and Macroeconometric Model LIMA (IHS)"

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1. Forecasts with Macro-econometric Models

Models can only be evaluated if you do know the questions they are supposed to answer. These questions determine the theoretical foundation, size, disaggregation, data, specification, strategy for tests. The forecasting quality of the three models of OeNB, WIFO and (HIS) cannot be evaluated here, because the necessary statistics about the forecasting errors of the models are not available.

2. Characteristics of the Three Models

All three models are national structural macro-econometric models.

- *AQM* is a quarterly model with a neoclassical long-term solution. It estimates error correction models (ECM) and is used for forecasts and economic policy simulations. It is part of the ESCB-model.
- *WIFO-Macromod* is an annual model. The demand side is important. It follows the ECM framework and is used for forecasts and economic policy simulations.
- *LIMA* is an annual model, in which the demand side is important. Using the ECM methodology, its main purpose are forecasts. It is part of the LINK-project.

3. Simulation Results

- Common characteristics of the three models: High elasticities of public expenditures and external demand and low negative elasticities of interest rate changes. On the other hand a very strong impact of wages and prices, but a very low impact of international competitiveness on exports.

- Differences*:* AQM-model does not have induced productivity effects in the medium term and there are no differences in the elasticity of public expenditures and exports on growth.
- Special features of all three models are very high price and wage effects, but a very low impact of changes in international competitiveness.

4. Expected Wage and Price Effects in a Monetary Union

Preconditions*:* A common short-term interest rate in the European Monetary Union (EMU) and no nominal exchange rate changes in the EMU anymore. The economy of Austria is small and open with low wage and price increases.
Expected simulation result of higher public expenditures (1% of GDP):

- Induced growth impact should be smaller or equal to unity
- Wages should increase only slightly
- Prices in Austria are mainly determined by external factors and should not change a lot
- Induced employment effect should be much smaller than unity because of expected changes in productivity
- Exports should decline (relative to baseline) because of the impact of a lower international competitiveness

5. Macroeconomic Effects (after 5 Years) of Higher Public Expenditures (1% of GDP)

- OeNB-AQM:
- GDP: +1,6%, Wages: +1,9%, Prices: +2%, Employment: +1,6%, Exports: –0,3%
- WIFO-Macromod:
- GDP: +1,1%, Wages: +1,5%, Prices: +0,6%, Employment: +0,4%, Exports: –0%
- IHS-LIMA:
- GDP: +1,4%, Wages: +2,7%, Prices: +1,8%, Employment: +0,8%, Exports: –0%

6. Summary

Induced medium term growth effects of higher public expenditures seem to be very high in the models of OeNB and IHS. In both models wages and prices increase a lot after public expenditures have been lifted. The prices increase by around 2% and the wages between 2% and 3%. In the OeNB model the employment reaction is as large as the GDP reaction. There are no medium term productivity effects in this case. All models do not show a considerable impact of changes in competitiveness on exports. This is surprising because Austria is a small and open economy. Strong price effects do reduce the real interest rates and do have a positive growth impact on the one side. But on the other side the impact of a reduced international competitiveness should reduce economic growth.

2nd Comment on “The Austrian Quarterly Model of the OeNB, WIFO-Macromod and Macroeconometric Model-Lima (IHS)”

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This block entailed presentations of three large structural econometric models, produced and used by the OENB, the IHS and the WIFO. The objective of this session was to illustrate the forecast properties of the three models by means of three representative shocks (fiscal, monetary and external demand shocks). Although an assessment of the forecast performance of any model would require additional information (such as e.g. recent residual paths), it is nevertheless fair to say that such a model comparison exercise through shock evaluation gives also important information about the forecast performance of the models. First of all, this is because the starting point of a forecast is never that of an equilibrium, and the exogenous assumptions underlying the forecast have sometimes the nature of economic shocks.

This part of the discussion aims to highlight the main model features that are key for the transmission of the shock. Although not comprehensive, we identified four main channel categories. These will be discussed in more detail below. Summary tables provide an overview regarding the simulation properties of the three models.

1. Imports

Imports represent a key crowding-out mechanism for any given shock. All three models include standard import equations which model imports as a function of domestic demand and price competitiveness. A positive feature of all three models is that they use weights derived from Input / Output tables for a weighted import demand indicator. This is important, as this specification allows imports to react differently to changes in the individual final demand components. However, even though all three models have used the 1995 I/O table for the calculation of the weights, the export weights differ (IHS: 0.48, OENB: 0.54, WIFO: 0.33), so that some differences in the import crowding-out effects can be attributed to the different weights. Another important issue in this respect is the elasticity of imports with respect to activity, i.e. with respect to the weighted import demand indicator.

Theory or steady-state consistency implies unit elasticity, but data suggests an elasticity of significantly higher than one. This is an effect of globalisation and trade integration in the course of the last decades. However, this exogenous process can also be incorporated by means of a deterministic trend. Although, seemingly similar for describing the data in-sample, out-of-sample forecast or policy simulation implies hugely different multipliers for the two alternative specifications. The IHS model displays a medium-run elasticity which is larger than one. The OENB model incorporates a unit restriction and includes a deterministic trend, which accounts for exogenous import growth of 0.5% p.a. The WIFO model also uses unit elasticity but without including a trend, which implies presumably a compromise in terms of fitting the data.

2. Consumption

Consumption plays a role for the speed of transmission of a shock, as it tends to be the most sticky GDP component, reflecting a tendency for consumption smoothing. The quarterly OENB model has a coefficient on the lagged endogenous variable of 0.26, whereas the two annual models of the IHS and the WIFO do not include the lagged endogenous variable. The difference between the annual and the quarterly model also plays a role for the interpretation of the coefficient on the error correction term. The quarterly error correction in the OENB model is 0.1, which is in annual terms higher than the 0.2 displayed in the two annual models. The speed of adjustment also depends on the coefficient on contemporaneous income, which appears to be relatively small in all three models. Both features above imply that any shock would initially have a relatively strong impact on the savings ratio.

Long-run homogeneity is in the OENB imposed with respect to the sum of income and wealth. The WIFO model displays a long-run elasticity of 1.1, where it may not be possible to reject homogeneity statistically. The IHS model has no restriction across the three sub-components of consumption, but the individual elasticities suggest the homogeneity may also fit the data.

3. Investment

Contrary to the cushioning role of consumption, investment is normally expected to work as an accelerator. The size of this accelerating effect depends largely on the short-run coefficient on activity. Both, the IHS and the WIFO model entail a disaggregation of investment. The individual components in the IHS model exhibit elasticities between 1.3 and 2.6, and in the WIFO model between 1.3 and 1.8. The short-run elasticity in the OENB model is relatively small (1.1). The long-run accelerator effects also differ significantly. The OENB model entails a theory-consistent unit elasticity, the IHS model displays elasticities for the investment components which range also around unity, whereas the WIFO model shows a long-run elasticity of 2.

The role of the interest rate and user cost of capital is very small or even insignificant in the IHS model, whereas the other two models enter the long-run capital accumulation specification in a theory-consistent way.

4. Labour Market

The labour market channel is important first in view of the adjustment of labour demand to output shocks. The elasticities in the short-run labour demand equations are quite similar in the IHS and the WIFO model (about 0.4), whereas the OeNB model entails are more sluggish response in the short run (0.2).

The second important labour market channel is the Phillips curve effect. The short-run adjustments are modelled in different ways, the OeNB model is the only one which assumes explicitly a long-run vertical Phillips curve.

Table 1 below summarises the main differences across the three models in the context of the four channels outlined above. Table 2 summarises the differences between the three models regarding their responses to three representative shocks. Table 3 is an overall summary with general comments for all three models.

Table 1: Main Transmission Channels

Main Channel Category	Sub-category	IHS	OENB	WIFO
Imports	Activity variable (role of exports?)	I/O weighted import demand (export weight 0.48)	I/O weighted import demand (export weight 0.54)	I/O weighted import demand (export weight 0.33)
	Elasticity w.r.t. activity	1.35 (medium-run?)	SR: 0.8, LR: 1	1
	Deterministic trend	–	0.5% p.a.	–
Consumption	Lagged endogenous	0	0.26	0
	Contemporaneous income	0.291 (CS), 0.452 (CND), 1.846 (CD)	0.19	0.35
	Long-run income effect	Not restricted across 3 sub-components, probably about one.	0.93, homogeneity w.r.t. income plus wealth	1.12
	ECT coefficient	–0.186	–0.09	–0.21
	Other variables	Interest rate in equation for consumer durables.	Long-term interest rate in long-run Relationship (coefficient -0.6). Wealth effect (small)	–
Investment	Accelerator	SR 2.61(IFE)/1.25(IFC), LR 1.39 (IFE) / 0.792(IC)	SR coefficient 1.11, long-run supply-side determined (implicit elasticity is 1)	SR 1.76 (IPM) / 1.32 (IPC), LR 2.0(IPM / IPC)
	Role of Interest rate	Very small (insignificant) coefficient	User cost of capital in long-run (equilibrium) relationship, not SR	User cost of capital in long-run (equilibrium) relationship
	User cost of capital specification	–	Function of nominal interest rate, 1:1 relationship prices to real interest rates	Function of nominal interest rate, 1:1 relationship prices to real interest rates
Labour market	Elasticity of Employment w.r.t. GDP	SR: 0.435, LR: 1	SR: 0.20, long-run supply-side determined (implicit elasticity is 1)	SR: 0.41 (no LR)
	Wages – Phillips curve effect (productivity/unemployment rate)	Through unemployment rate, no unit labour cost effect exacerbates output effect	Through employment gap in the short-run, long-run vertical Phillips curve	Productivity 0.29 (dynamic LR 0.41), long-run effect from prices smaller than unity

Table 2: Comparison of Representative Shocks

	IHS	OENB	WIFO
Fiscal Shock	➢ Almost full multiplier effect in Y1 (1.5%), rising to 1.6% in Y3. ➢ High and lasting price effect from wages ➢ Not clear where negative effect on income comes from (with positive real wage and employment effect) ➢ Why is consumption staying high?	➢ 1.1% in Y1, rising to 1.6% in Y4 ➢ Usual caveat of real interest rate effect on investment ➢ Price effect seems on the high side, coming from ULC, as employment reacts strongly (1:1 to GDP) ➢ Import crowding out relatively strong, which is surprising given (i) a lower elasticity w.r.t. GDP and (ii) a rise in the import deflator.	➢ Almost full multiplier effect in Y1 (1.2%), rising to 1.3% in Y3 ➢ Strong investment cycle leads to relatively strong negative GDP effect towards the end of the simulation horizon ➢ Lasting investment effect seems also at odds with real interest rate effect ➢ Strong and continuing decline in the savings ratio after Y5 ➢ Price effect comparatively small, but reasonable
Monetary Shock	➢ Price/wage effect permanent (although small)? ➢ Not clear where positive income effect comes from (with negative real wage and employment effect) ➢ Instantaneous negative impact on consumption in spite of higher real income	➢ Investment down through user cost of capital ➢ Consumption is taking over as main negative contributor to the fall in GDP from Y2/Y3. Why is there no favourable effect on disposable income from lower prices? ➢ Negative income effect from employment, why is there no favourable impact from the supply side (relative factor costs)?	➢ Bumpy GDP profile, possibly from strong factor substitution (capital/employment?) ➢ Price effect not in line with central bankers views (and hopes). ➢ Positive investment effect from Y3 onwards
Foreign Shock	➢ Size of shock not clear (exports up by ~1.5%) ➢ High and lasting price effect from wages ➢ Why is consumption departing substantially from the income path? ➢ Not clear where negative income effect (after Y5) comes from (with positive real wage and employment effect)	➢ Why is there such a comparatively low contribution from the trade balance? ➢ Size of employment effect equal to GDP effect, i.e. no productivity effect	➢ Exports exogenously shocked (not foreign demand), which seems better in view of high elasticity of exports w.r.t. foreign demand ➢ Strong investment cycle leads to relatively strong negative GDP effect towards the end of the simulation horizon

Table 3: General Comments on Simulation Properties

	IHS	OENB	WIFO
General Comments	➢ Effects instantaneous, richer dynamics would be more reasonable, especially when used for forecasting ➢ Income effect not corresponding to wage / employment developments ➢ Consumption departing from income path ➢ Output has strong impact on wages ➢ No steady-state consistency, e.g. no long-run homogeneity or unit elasticities where necessary ➢ Non-unit elasticities lead sometimes to permanent effects of shocks ➢ Productivity doesn't enter wage equation?	➢ Strong employment reaction seems to be entirely demand-driven. The supply-side effect through wages / ULC seems to be weak ➢ Employment reaction also distorts picture of price effects through ULC	➢ Why are imports not following the GDP path? ➢ How does import equation fit data with unit elasticity and no inclusion of a trend?

The Economic Indicator of the OeNB: Methods and Forecasting Performance

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Abstract

The Oesterreichische Nationalbank (OeNB) has been publishing a quarterly short-term forecast of real GDP since April 2003 (OeNB's Economic Indicator, OEI). Its aim is to forecast growth of real GDP in Austria in the current and the consecutive quarter. It is based on a combination of the forecasts of an unobserved component model and a dynamic factor model, supplemented by judgement. Out-of-sample-simulations have shown that the OEI performs significantly better than naive benchmark models. Although the record in real-time forecasting is very short, the available results indicate that the OEI seems to be a valuable tool for forecasting short-term economic developments in Austria.

1. Introduction

Obtaining timely information about the current state and future prospects of the economy is of crucial importance for policy making. Quarterly National Accounts data provide a comprehensive overview about the economy. However, they are available only with a considerable delay. This raises the need for short-term forecasts not only for forthcoming quarters, but also to fill the gap until the first release of the data.

This was the motivation for the Oesterreichische Nationalbank (OeNB) to produce its own quantitative assessment of the conjunctural situation in Austria on a quarterly base. The *OeNB's Economic Indicator (OEI)* is published since the second quarter of 2003. Its objective is to forecast growth of real GDP in Austria in the current and the consecutive quarter.

Whereas medium- and long-term forecasts are usually based on structural macroeconometric models, short-term forecasts are produced utilizing non-structural time series models. The battery of available methods range from single regression equations and simple time series models (ARIMA, VAR, BVAR) over trend extrapolation methods (smoothing methods) to more complex methods. The *OEI* is based on the forecasts stemming from two up-to-date econometric methods, a dynamic factor model and an unobserved component model.

There are many reasons why combining forecasts from different models may be a fruitful approach. Since the seminal work of Bates and Granger (1969) it is well known that the combination of different forecasts often improves forecasting performance. In theory it is possible to build a model that encompasses all rivalling models, i.e. it pools all relevant information used in these models and hence performs best in forecasting. Although pooling of information is preferable to pooling of forecasts from a theoretical perspective (Diebold and Lopez, 1996), it is often hard to find an encompassing model in practice[1]. This clearly indicates that all models are miss-specified, which is an important rationale for forecast combination. Besides miss-specification, substantial gains from combination can be expected in the case of structural breaks and non-stationarities (see Hendry and Clements 2002 for a detailed discussion). Combining usually reduces the variance of the forecast. Forecasts can be combined in different ways. The simplest possibility is to assign equal weights to all forecasts. Using the median forecast instead of the mean makes the combined forecast less sensitive to outliers. Forecasts can also be combined with methods that assign the weights based on a ranking of the forecasts. More elaborated methods include the variance-covariance method and the regression-based method (Diebold and Lopez, 1996). Although the literature suggests that no specific combination method performs best in all situations, simple methods such as an averaging often perform as well as more statistically sophisticated methods (Clemen, 1989).

The combination method utilized in the OEI is to assign equal weights to both forecasts. In addition, judgement is added wherever deemed appropriate. The use of judgement is widely-used in short- and medium-term forecasting. The Bank of Canada and the Reserve Bank of New Zealand use judgement in their short-term projections, just to mention two of the numerous examples (Drew and Frith, 1998, Coletti and Murchison, 2002). The reasons for including judgement are manifold. First, every model is a simplification of reality and does not capture all information which may be relevant. Especially qualitative information is used to complement the model forecasts. Second, expected persistence of forecast errors may justify the use of judgement. If, for example, an unpredicted weakness of GDP growth is likely to continue, a negative add-factor might be added. Third, data quality plays a role. Each model that exploits statistical relationships is only as good as the data it

[1] Forecast combination is closely related to the concept of forecast encompassing. The latter concept would suggest incorporating superior features of rivalling models until combining the forecasts brings no gains. So testing for forecast encompassing is exactly the same as testing if there are gains from combination.

uses. Finally, discretionary policy measures have to be included in the form of judgement.

The OeNB uses currently two models in the OEI: an unobserved components model and dynamic factor model. Both models refer in their nature to the problem of optimal filtering but from a different perspective. The unobserved components model uses the Kalman filter technique to estimate the unobserved state of a system based on 'noisy' observations of a small number of time series. At the contrary, the dynamic factor model uses a very large number of time series and utilizes a filtering technique in the frequency domain aiming to extract the factors of the data set which explain the major part of the frequency spectrum. Thus, the two models can be seen as providing natural complements in the construction of a short-term indicator.

The structure of the paper is as follows. section 2 presents the unobserved components model. In section 3, the dynamic factor model is described. In section 4, the forecasting performance of the OEI is assessed. Emphasis is laid on a simulated out-of-sample forecasting experiment. In addition, the currently available forecasting record (which consists of seven forecasts) is subject to a first assessment. Section 5 concludes.

2. The Unobserved Components Model

The main challenge consists in finding an efficient econometric framework to use monthly conjunctural indicators to predict quarterly National Account GDP figures. A straightforward solution would be the aggregation of monthly to quarterly data. But this method is associated with a considerable loss of information as the dynamics within a quarter are no longer explicit. Furthermore, it does not solve the problem how the latest information from monthly indicators can be used if observations are available only until the first or second month within a quarter. Finally, the method should allow for a quick update of the forecast in case new monthly information becomes available.

State space models represent an efficient way of dealing with these kinds of problems. Based on a Kalman filter technique exogenous monthly indicators are used as explanatory variables to estimate a monthly GDP series as an unobserved component. A special feature of the model is the aggregation procedure to derive quarterly GDP growth rates from monthly GDP growth rates. The aggregation procedure makes clear that quarterly growth rates are not independent from the dynamics within the previous quarter.[2] This phenomenon is closely associated with the well known carry-over effect in macroeconomic forecast exercises.

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[2] Given that the mean value theorem holds, one third of a quarterly growth rate is determined by the monthly dynamics within the previous quarter. If the observation-frequency within a quarter tends towards infinity the ratio approaches one half. In the

The basic idea of state space models is that an observable time series (Y_t) under study can be explained by a vector of unobserved components (α_t). The unobserved components are linked to the observed variable via a measurement equation, i.e. from the observed variable conclusions on the unobserved components can be drawn. A typical example from economics is the decomposition of GDP in a trend, a seasonal and an irregular component. In the present paper the aim is to extract unobservable monthly GDP growth rates from the quarterly GDP ESA95 series. The estimation of the unobserved component, i.e. monthly GDP growth, is based on an autoregressive term and exogenous monthly conjunctural indicators. This relation is formulated in the so called transition equation. The evaluation of this estimation takes place in the measurement equation. Each third month, at the end of a quarter, the quarterly GDP growth rate is calculated as a weighted sum of past and current monthly GDP growth rates and can be compared to the actual outcomes.

2.1 The Model

In general a state space model consists of an observation (measurement) and a transition equation.[3] In the present model the observation equation which compares the actual and the estimated quarterly GDP growth rates takes the simple form:

$$\Delta \ln y_\tau^Q = \Delta \ln y_\tau^{Qe} \quad \tau = 1 \ldots T/3; \quad t = 1,2,3 \ldots T \quad \textit{(Observation equation)} \qquad (U.1)$$

where $\Delta ln\, y_\tau^Q$ denotes the actual growth rate of real GDP, $\Delta ln\, y_\tau^{Qe}$ the estimated growth rate of real GDP and t and τ the index of months and the index of quarters, respectively. The estimated growth rate of real GDP is a weighted sum of the present and the past four estimated monthly growth rates of real GDP where the weights are given by $(1/3 \quad 2/3 \quad 1 \quad 2/3 \quad 1/3)$.[4] Thus, the estimated growth rate of real GDP is given by:

$$\Delta ln\, y_\tau^{Qe} = \tfrac{1}{3}\Delta ln\, y_t^m + \tfrac{2}{3}\Delta ln\, y_{t-1}^m + \Delta ln\, y_{t-2}^m + \tfrac{2}{3}\Delta ln\, y_{t-3}^m + \tfrac{1}{3}\Delta ln\, y_{t-4}^m \qquad (U.2)$$

$$\tau = 1 \ldots T/3; \quad t = 1,2,3 \ldots T$$

case of quarterly and annual observations the ratio equals 3/8. (see Fenz and Spitzer, 2003).

[3] For a complete set up of the state space model see Fenz and Spitzer (2003).

[4] For a derivation of the weights see Fenz and Spitzer (2003).

where $\Delta ln\, y_t^m$ denotes the unobserved monthly GDP growth rates.

The transition equation describes the path of the unobserved component, i.e. monthly GDP growth rate. As is generally the case in state space models the unobserved component is assumed to follow a first order Markov process. Monthly GDP growth additionally depends on a number of stationary exogenous variables (i.e. explanatory monthly indicators) denoted by $x_{n,t}^m$, where $n = 1 \ldots N$.

$$\Delta ln\, y_t^m = \zeta \cdot \Delta ln\, y_{t-1}^m + \beta_1 \cdot x_{1,t}^m + \ldots + \beta_N \cdot x_{N,t}^m + e_t \quad \text{(Transition equation) (U.3)}$$

Equations (1) to (3) describe how monthly indicators can be combined with quarterly GDP growth rates for forecasting purposes. Once the parameters of the model are estimated using the Kalman filter, observations of the monthly indicators can be used to derive forecasts of quarterly GDP growth rates. Depending on the leading indicator properties of each single indicator and the time lags of data releases, the available observations of monthly indicators may not be sufficiently long to cover the whole forecasting horizon. In this case of missing observations monthly indicators are forecast using ARIMA models.

2.2 Estimation Results

The forecasting performance of more than 300 variables from various sectors and markets was analysed and compared. Variables tested cover the labour market, external trade, confidence indicators, prices, financial variables, whole and retail sales, industrial production and exchange rates. The selection of explanatory variables is based on the following principles: (a) leading indicator properties; (b) estimation properties; (c) forecasting performance; (d) time lag of data releases; (e) probability of data revisions; (f) coverage of different sectors.

According to these criterions the following six monthly indicators were selected as explanatory variables in the transition equation of the state space form to estimate monthly GDP growth rates: Ifo-index (*ifo*), outstanding loans to the domestic non financial sector (*loans*), number of vacancies (*vac*), real exchange rate index (*exrate*), number of employees (*empl*) and new car registrations (*cars*). All explanatory variables are in logarithm and enter the equation system in first differences with the exception of the number of employees where we used second differences.

$$\begin{aligned}\Delta \ln y_t^m = \zeta \cdot \Delta \ln y_t^m + \beta_1 \Delta \ln ifo_{t-1} + \beta_2 \Delta \ln loans_{t-4} + \beta_3 \Delta \ln vac_t + \beta_4 \Delta \ln exrate_{t-3} \\ + \beta_5 \Delta\Delta \ln empl_{t-1} + \beta_6 \Delta \ln cars_{t-2} + e_t \end{aligned} \quad \text{(U.4)}$$

The error term e_t follows an AR(1) process. The inclusion of the parameter σ^2 is due to computational convenience. u_t represents the innovations of the equation system which are calculated each third month via the measurement equation.

$$e_t = \rho_1 \cdot e_{t'-1} + \sigma^2 u_{t-1} \tag{U.5}$$

Table1: Estimation Results for Monthly GDP Growth Rates

	Δln / ΔΔln	**Lag**	**Coefficient**	**t-value**
Ifo-index business climate for West Germany	Δln	1	0.17	2.34
Outstanding credits to domestic non financial sector, current prices	Δln	4	0.17	2.25
Number of vacancies	Δln	0	0.13	2.29
Real exchange rate	Δln	3	–0.19	–2.63
Number of employees	ΔΔln	1	0.45	2.65
New car registrations	Δln	2	0.61	3.26
Dummy94_4			–3.87	–5.02
Dummy95_1			3.18	4.13
Dummy97_1			–2.09	–2.77
ζ			–0.40	–2.36
ρ_1			–0.63	–3.04

Note: All variables are standardized.
Δln / ΔΔln indicate first and second differences, respectively.
Lag: number of lags of the exogenous variable – indicates leading indicator properties.
Source: Authors' calculations.

The ifo-index is a good indicator of business confidence in Austria and additionally mirrors the latest developments on Austria's most important export market. Outstanding loans to the domestic non financial sector capture financing conditions and credit standards in the banking sector. The number of vacancies is a well known early indicator for the labour market. The real exchange rate index affects the price competitiveness of Austrian exports. Second differences in the number of employees indicate new labour market developments relatively early. Finally, new car registrations are known to react sensitive to economic fluctuations. Furthermore, three dummies were introduced to control for outliers in the GDP time series in 1994Q4, 1995Q1 and 1997Q1.

The in sample one step ahead performance of the UOC model is shown in chart 1. The estimated quarter-on-quarter GDP growth rates tend to be less volatile than the original series as is typically the case in forecasting exercises.

3. The Generalized Dynamic Factor Model

During the last two years, factor models became increasingly popular as tools to forecast macroeconomic variables (see e.g., Stock and Watson, 1998, Gosselin and Tkacz 2001, Artis, Banerjee and Marcellino, 2002). These models promise to offer a tool to summarize the information available in a large data set by a small number of factors. The basic idea that stands behind a factor model is that the movement of a time series can be characterized as the sum of two mutually orthogonal components: The common component which should explain the main part of the variance of the time series as a linear combination of the common factors. The second component, the idiosyncratic component, contains the remaining variable specific information and is only weakly correlated across the panel.

The approach utilized in this paper is the frequency domain analysis as proposed by Forni and Reichlin (1998), Forni and Lippi (1999) and Forni, Hallin, Lippi and Reichlin (2000) (referred to as 'FHLR' thereafter). It has been increasingly used for business cycle analysis and forecasting (e.g. 'EuroCoin', Altissimo et al., 2001 or Cristadoro et al., 2001). The main difference of the FHLR approach to the widely-used approach of Stock and Watson (1998) is that it allows richer dynamics, since both contemporaneous and lagged correlations between variables are incorporated.

3.1 The Model

In our approximate dynamic factor model, each variable x_{it} for $i=1,...,N$ and $t=1,...,T$ of the panel is assumed to be a realization of a zero mean, wide-sense stationary process $\{x_{it}, t \in \mathbb{Z}\}$. Each process of the panel is thought of as an element from an infinite sequence, indexed by $i \in \mathbb{N}$. All processes are co-stationary, i.e. stationarity holds for any of the n-dimensional vector processes $\{x_{nt} = (x_{1t} \ldots x_{nt})'; t \in \mathbb{Z}, n \in \mathbb{N}\}$. Each series is decomposed into two components

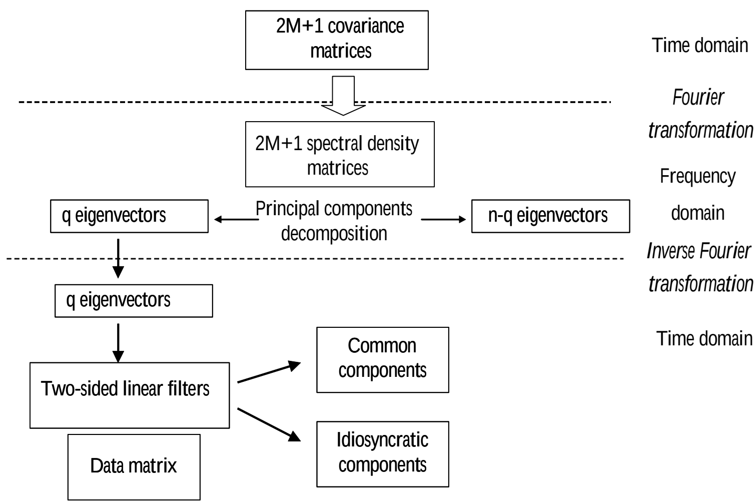
$$x_{it} = \chi_{it} + \xi_{it} = \lambda_i(L)F_t + \xi_{it} \tag{F.1}$$

where χ_{it} is the common component, ξ_{it} the idiosyncratic component and $\lambda_i(L) = \lambda_{i1}(L),...,\lambda_{ik}(L)$ is a $1\times(k+1)$ vector of finite lag polynomials of factor loadings of order k. $F_t = (f_{1t},...,f_{qt})'$ is a $1\times q$ vector of q common factors. Each series is therefore expressed as the sum of moving averages of the factors plus an idiosyncratic component. There is a limited amount of cross-correlation between the idiosyncratic components allowed.

3.2 Estimating the Common Component

Forni, Hallin, Lippi and Reichlin (2000, 2001 and 2003) proposed an estimation method for model (1). The method relies on a *dynamic principal components* analysis. This approach exploits the dynamic covariance structure of the data, i.e. the relation between different variables at different points in time. This information is contained in $k=2m+1$ covariance matrices, where m denotes the number of leads and lags.

Chart 1: The Dynamic Factor Model: Estimation of the Common and Idiosyncratic Components



These covariance matrices are transformed from the time domain into the frequency domain by Fourier transformations. Each of the resulting spectral density matrices is decomposed by applying principal components. The resulting first q eigenvectors and eigenvalues are summed up over frequencies and are then transformed back to the time domain by an inverse Fourier transformation resulting in a two-sided linear filter. Applying these filters to the data matrix gives the common and the idiosyncratic component for each variable in the data set.

3.3 Forecasting the Common Component

The common and the idiosyncratic component of a variable are mutually orthogonal. Thus, forecasting a variable in a dynamic factor model can be split into two separate forecasting problems, forecasting the common component and forecasting the idiosyncratic component. Since the idiosyncratic components are mutually orthogonal or only weakly correlated, they can be forecast easily using standard univariate or low-dimensional multivariate methods like ARIMA of VAR models. The remainder of the subsection concentrates on the task of forecasting the common component.

The forecasting strategy used in the FHLR approach exploits the information contained in the lagged covariances between the variables to construct the factor space. The dynamic principal components which can be obtained by decomposing the spectral density matrix are based on two-sided filters of the data matrix. This is a major drawback for forecasting, since these filters cannot be used directly to construct a forecast. The basic idea to overcome that problem is to use the covariance matrices of the common and the idiosyncratic component obtained by the dynamic principal component analysis to construct a static factor space which may be a better approximation for the factor space than usual static principal components (Forni, Hallin, Lippi and Reichlin, 2003). The factors are given by

$$F_n^t = X_n^{t'} Z_n^T \tag{F.2}$$

Forni, Hallin, Lippi and Reichlin (2003) show that Z_{nl}^T can be obtained as the solution of the following generalized eigenvalue problem:

$$Z_{nl}^T \equiv \arg\max a\Gamma_{n0}^{\chi T}\tilde{a} \tag{F.3}$$

subject to $a\Gamma_{n0}^{\chi T}\tilde{a} = 1$,

$$a\Gamma_{n0}^{\xi T}\tilde{Z}_{nm}^T = 0\ for\ 1 \le m < l, l \le l \le n$$

a denotes the eigenvalues resulting from the solution of the generalized eigenvalue problem and $\Gamma_{n0}^{\chi T}$ and $\Gamma_{n0}^{\xi T}$ denote the variance-covariance matrices of the common and the idiosyncratic components, respectively. The intuition behind this approach is that the solution of the generalized eigenvalue problem gives us weights Z_{nl}^T that maximize the ratio between the variance of the common and the idiosyncratic component in the resulting aggregates. In other words, the two variance-covariance matrices can help to construct averages of the data matrix which put a larger weight on variables that have a larger 'commonality' (Forni, Hallin, Lippi and Reichlin, 2003).

The *h*-step ahead forecast for the common component $\chi_{it} (= \phi^{n,t}_{i,T+h|T})$ can be obtained by projecting the future value, $\chi_{it,T+h}$ onto the approximate factor space

$$\phi_{i,T+h|T} \equiv proj(\chi_{i,T+h} \mid G(F_{nq})) = F_t (F_t{}' F_t)^{-1} F_t{}' F_t{}' x_{nT} \quad \text{(F.4)}$$

The factor space $G(F_{nq}))$ is spanned by the static principal components $F_t = (f_{1t}, ..., f_{nt})'$. As $n \to \infty$ the approximate factor space, i.e. the space spanned by the first q principal components, denoted by $G(F_{nq},t)$ converges to the factor space $G(Fq,t)$[5].

Inserting equation (F.2) into equation (F.4) and rearranging gives us the proposed projection formula

$$\phi_{i,T+h|T} = \Gamma^{\chi T}_{nh} Z^{T}_{n} (Z^{'T}_{n} \Gamma^{xT}_{n0} Z^{T}_{n\,t})^{-1} Z^{'T}_{n} x_{nT} \quad \text{(F.5)}$$

As the sample size increases, the estimate $\phi_{i,T+h|T}$ converges in probability to χ_{it}. A more detailed explanation of the estimation and the forecasting procedure can be found in Schneider and Spitzer (2004).

3.3 Estimation Results

The data set includes 105 variables of monthly or quarterly frequency. Some variables have been included in the model in levels as well as in differences. So the total number of series included in the factor model is 143. The quarterly data set ranges from the first quarter of 1988 until the second quarter of 2003, i.e. it contains 62 observations.

Missing monthly observations within the last quarter are forecast by a monthly factor model. These monthly series are aggregated to quarters and are then concatenated to the quarterly data to build the final data set.

Extensive simulations (Schneider and Spitzer, 2004) have shown that the forecasting performance of the dynamic factor models can be increased considerably when it is based on a handful of carefully selected series instead of the full data set of 143 series. The best performance can be obtained with small models with 11 variables (forecast of the current quarter) respectively 13 variables (forecast of the consecutive quarter). Table 2 lists the variables of these two

[5] For a proof see Forni, Hallin, Lippi and Reichlin (2003), Lemma 3.

models, which have been selected in order to minimise the root mean squared error (RMSE).

Table 2: Variables Used in the Dynamic Factor Model

Forecast of the current quarter	**Forecast of the consecutive quarter**
GDP, real	GDP, real
Exports of commodities into the EU	Vacancies
Production expectations in industry	Dax-Index
Imports – SITC 7 (machines and transport equipment)	M1
M2	Exports of commodities into the U.S.A.
Unemployment rate (national definition)	USD/EUR exchange rate
Dax-Index	Yield spread
Secondary market yield (maturity 9–10 years)	HICP energy
Changes in inventories	Assessment of the present business situation – construction
Dow Jones Index	Wholesale prices for consumer goods
Direct credits to private firms	GDP deflator
	Total exports
	HICP commodities

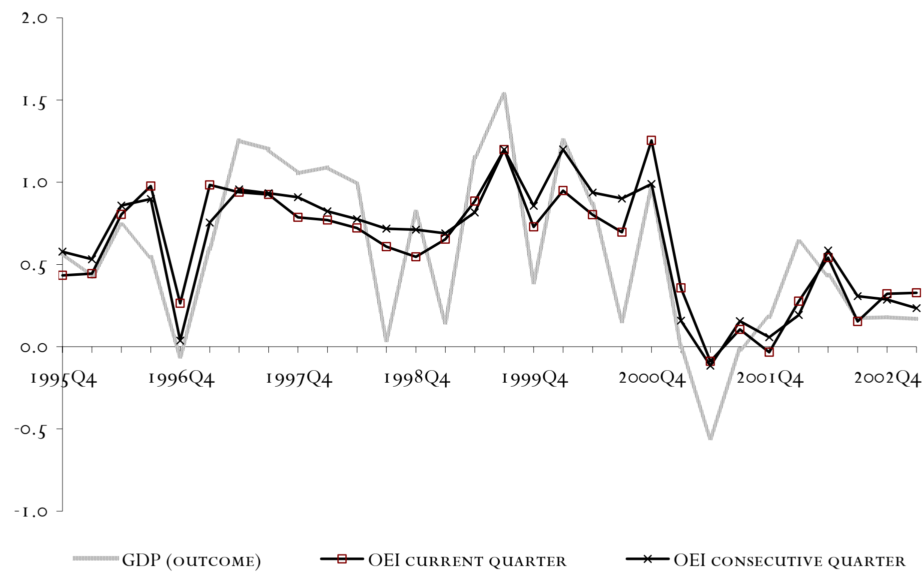
4. Assessing the Forecasting Performance

This section assesses the forecasting performance of the OEI. In the first subsection, a simulated out-of-sample forecasting exercise evaluates the forecasting performance of the OEI and its two models relative to two simple benchmark models. This out-of-sample exercise is purely model-based. In the second subsection, efforts are made to provide a first provisional assessment of the seven publications of the OEI (which also include judgement).

4.1 A Simulated Out-of-Sample Forecasting Exercise

We have conducted a simulated out-of-sample forecasting exercise to assess the forecasting performance of the OEI and its two sub models. The forecasting performance for each model was obtained by performing out-of-sample forecasts for 30 rolling windows. The first window contained data until the second quarter of 1995. The last two observations were used for evaluating the out-of-sample forecasts. After computing the one and the two-steps-ahead forecasts, one new observation of the data set was added, the model was reestimated and new forecasts were computed. This procedure was repeated for all remaining windows until the second quarter of 2002. Chart 1 gives a visual impression of the forecasting performance of the OEI. It shows that the OEI predicts most of the turning points correctly (even two-steps ahead). Even the steep slow down of economic activity in the first two quarters of 2001 was predicted (although not to its full extent).

Chart 2: Simulated Out-of-Sample Forecasts of the OEI for the Current and the Consecutive Quarter



Note: Change in % to previous quarter, GDP corrected for outliers.
Source: OeNB's Economic Indicator.

A couple of different tests have been utilized to quantify the forecast performance. The results can be found in table A-1 to A-4 in the appendix. First, it has to be assessed whether the forecasts $\hat{y}_t$ have the same mean as the realizations $y_t (= \mu)$. This can be done by testing the null hypothesis $\hat{y}_t - y_t = \mu + u_t$ using a simple t-test. The results (table A-1) show that there is no significant deviation of the mean of forecasted series to the realizations. Hence, the forecasts are unbiased. In order to asses the forecasting performance of our two models relative to some simple benchmark models, we have compared them with a ‘naive’ (no-change) and an ARIMA forecast. Both OEI models perform remarkably better then the benchmark forecasts (table A-2). The combination of the two model forecast (OEI) performs slightly better than the model with the lower RMSE[6]. The average RMSE of the

[6] A direct comparison of the forecasting performance of these two models is critical since the dynamic factor model was optimized in order to minimise the forecasting error over

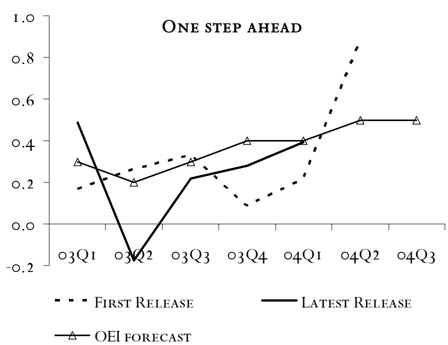
OEI for the forecasts of the current and the consecutive quarter (0.63) lies well below the naive forecast (1.24) and the ARIMA forecast (1.03). A crucial question is whether these differences are statistically significant. This has been tested by the Diebold and Mariano (1995) test for equal forecasting accuracy. It tests the null hypothesis of equal forecasting accuracy of two rivalling forecasts. Table A-4 presents the results. It can be seen that the gains of the OEI against the two benchmark forecasts ('naive' forecast and ARIMA forecast) are highly significant. Table A-4 give the results of the Harvey test for model encompassing (see Harvey, Leybourne and Newborn, 1998). It tests the null that forecast A encompasses forecast B, i.e. forecast B adds no predictive power to forecast A. The null can be rejected for all forecast combinations with the exception of one.

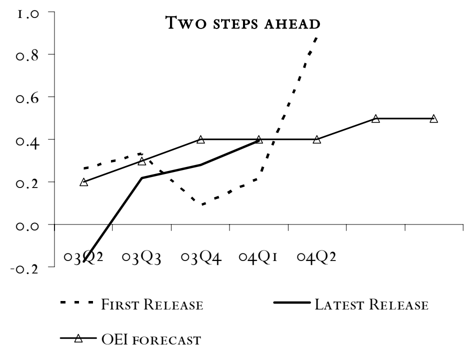
4.2 Forecasting Record

Till now the *OEI* has been published seven times. Consequently, there are six observations available for an assessment of the forecasting performance of the current quarter and five observations for the consecutive quarter. Given the small number of observations the assessment can not be done with the same accuracy as in the simulated out-of-sample experiment with 30 observations. Instead, only tentative conclusions from descriptive analyses may be drawn.

30 quarters (which are used in the exercise), whereas the unobserved components model was optimized for 10 quarters only (due to less degrees of freedom). Hence, the direct comparison between the two models should not be taken literally.

Chart 3: Performance of the First Data Release and the OEI Relative to the Latest Data Release





Note: Change in % to previous quarter.
Source: Authors' calculations, WIFO.

An assessment of the forecasting performance is hampered by the fact that all forecasts published fall into an exceptional phase. Compared to past downswings the slowdown lasted considerably longer. The high degree of uncertainty surrounding this period is also reflected in the pronounced revisions of first releases of GDP growth figures. Chart 2 shows that according to first data releases the cyclical trough was reached in the fourth quarter of 2003, whereas the latest release suggests that the trough already took place in the second quarter. Chart 2 also shows the typical result that forecasts are less volatile than actual outcomes. Table 5 quantifies the forecasting performance of the OEI in terms of the RMSE (root mean squared error). The OEI (including judgement) and the pure model results (without judgement) are compared with the first and the latest data releases. In addition, the first data release is compared relative to the latest release. For both the forecast of the current and the consecutive quarter, the second quarter of 2004 (which is already available) has been omitted since only the first data release exists for it.

Table 5: Performance of the First Data Release and the OEI Relative to the Latest Data Release

Series to be compared	Relative to	Period: 03Q1–04Q1	Period: 03Q2–04Q1
		Forecast of the current quarter	Forecast of the consecutive quarter
OEI	First data release	0.176	0.185
OEI	Latest data release	0.198	0.200
Pure model results	First data release	0.235	0.279
Pure model results	Latest data release	0.258	0.188
First data release	Latest data release	0.273	0.260

Note: Root mean squared error.
Source: Authors' calculations.

Four main results can be mentioned. First, there are gains from adding judgement to the pure model results. The forecasting errors of the OEI are about 20 to 30% lower then the pure model results (with one exception). Second, the RMSE of the OEI is smaller than the RMSE of the first release (both with respect to the final release of GDP growth figures). This result holds both for the forecast of the current and of the consecutive quarter. Third, there is only a negligible difference when comparing the OEI with the first and the latest data release. Fourth, the forecasting performance of the current and the consecutive quarter are roughly equal. As the number of observations is too small to conduct statistical tests, this conclusion is very tentative.

5. Summary

The aim of this paper was to present the framework developed at the Oesterreichische Nationalbank for short-term forecasting of real GDP in Austria. Out-of-sample-simulations have shown that the OEI performs significantly better than naive benchmark models. Up to now, the *OeNB's Economic Indicator (OEI)* has been published seven times. Although the number of observations is by far too small to make well-founded statements about the forecasting accuracy, the results suggest that it predicts the latest data release with accuracy comparable to the first data release. The OEI seems to be a valuable tool for forecasting short-term economic developments in Austria.

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Appendix

Table A1: Test on Unbiasedness

	Realisation	Current quarter (h=1)	Consecutive quarter (h=2)
Mean	0.61	0.59	0.64
p-value	-	0.42	0.23

Source: Authors' calculations.

Table A2: Simulated Out-of-Sample Forecasting Performance

	Current quarter (h=1)	Consecutive quarter (h=2)	Mean
'Naive' forecast	1.18	1.30	1.24
ARIMA	1.01	1.05	1.03
Dynamic factor model	0.65	0.65	0.65
Unobserved components model	0.77	0.76	0.76
OeNB's economic indicator	**0.63**	**0.63**	**0.63**

Note: Root mean squared error, computed for 30 windows.
Source: Authors' calculations.

Table A3: Results of the Diebold-Mariano Test for Equal Forecasting Accuracy

	Current quarter (h=1)		Consecutive quarter (h=2)	
Unobserved components model	*p-values*		*p-values*	
'Naive' forecast	0.003	***	0.005	***
ARIMA	0.037	**	0.081	*
Dynamic factor model				
'Naive' forecast	0.000	***	0.000	***
ARIMA	0.000	***	0.009	***
OeNB's economic indicator				
'Naive' forecast	0.000	***	0.000	***
ARIMA	0.001	***	0.013	**

Source: Authors' calculations.

Table A4: Results of the Harvey Test for Model Encompassing

Null hypothesis	**p-value**
Forecast of the current quarter	
H0: Factor model encompasses unobserved components model	0.148
H0: Unobserved components model encompasses factor model	0.000
Forecast of the consecutive quarter	
H0: Factor model encompasses unobserved components model	0.039
H0: Unobserved components model encompasses factor model	0.000

Source: Authors' calculations.

Comment on “The Economic Indicator of the OeNB: Methods and Forecasting Performance”

Robert M. Kunst
University of Vienna

Fenz, Schneider and Spitzer use the *general dynamic-factor model* in order to construct economic indicators. This model, which is a variant of the dynamic principal-components approach, rests on the idea of condensing data information. For certain reasons, for example for a summary representation of the dynamic properties of a multivariate data set, it can be more convenient to consider *one* series instead of many. With regard to the targeted use of the approach, the main question is whether it helps in improving forecasts.

In the notation of Forni and Reichlin (1998), the basic model can be written as

$$x_{it} = \chi_{it} + \xi_{it},$$

with χ *common* and ξ *idiosyncratic*. Instead of forecasting $x_t = (x_{1t}, \ldots, x_{nt})'$ using an n–dimensional VAR, one may extrapolate idiosyncratic ξ_i and a basis for the common components χ. Does this make the task of predicting a special x_j with j fixed easier? Here, x_j appears to be fixed—the GDP. One may be less interested in forecasting the χ basis, i.e. the *coincident indicator*.

This coincident indicator χ itself deserves some consideration. Apart from the motivation that it may serve as an intermediate stage in GDP prediction, and that its construction may be required for institutional reasons, some economic researchers may also focus on such an indicator out of economic interest. Firstly, the coincident indicator serves as a provider of summary information on the current situation of the business cycle. Secondly, it may even be a more adequate target than GDP in tuning economic policy. Thirdly, the indicator may be easier to predict than GDP. These points could be the basis for future research with a genuine macroeconomic emphasis, beyond the current aim of improving on short-run GDP prediction.

Another interesting aspect of the paper is the authors' quest for checking significance in improvements in forecasting accuracy. In concordance with some of the forecasting literature, which follows the seminal work of Diebold and Mariano (1995), the authors state: "A crucial question is whether differences [in average RMSE among the prediction methods] are statistically significant." I am a bit hesitant to accept that this question is so crucial, at least without any further discussion.

My problems with this testing approach are summarized in Kunst (2003). Which method should be applied if differences are *insignificant*? Should one use the worse method, as the better one achieves an insignificant improvement only? Why? For simplicity? Has not the concern for simplicity been satisfied already, as an overly complex model fails in prediction?

Just to emphasize that other researchers point to similar problems with the accuracy testing approach, let me quote from Chatfield (2001): "The question arises as to whether there is a significant difference between the methods. This is a rather hard question to answer as it is not immediately obvious what is meant by significance in this context. In asking if the differences between forecasting methods can be attributed to sampling variability, it is not clear what sampling mechanism is appropriate. I would be reluctant to rely on [such tests]." Chatfield continues by stating that "The real test of a method lies in its ability to produce out-of-sample forecasts." In saying so, he comes close to the argument given in Kunst (2003) that the ranking in an out-of-sample forecast comparison is in itself comparable to the decision obtained by a hypothesis test with automatically determined significance level, just as it is used in comparing information criteria.

Testing *on top* of a forecast comparison could make sense if there are excessive costs involved in compiling a sophisticated forecast and gauging that forecast against a simple benchmark forecast. In this case, the significance level can be adjusted to correspond to the forecaster's costs. Indeed, in the application of Fenz, Schneider and Spitzer such a situation could be present, as was argued by the authors during the meeting.

A last aspect of the work by Fenz, Schneider and Spitzer is the application of pooling techniques and of judgment. With regard to the benefits of these two features, there is no unanimous agreement in the literature. One might presume that judgment is beneficial to forecasting whenever there is information available that cannot be quantified and therefore cannot be integrated into the data base. On the other hand, pooling may be beneficial if a set of forecasts is based on several models, each of which captures certain aspects of economic reality while none of them covers all aspects. It was outlined in the literature that mis-specification of the forecasting models is not sufficient for an outperforming of simple forecasts by the pooled forecast.

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Dating Turning Points for Austria: A Suggestion

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Abstract

The present paper proposes to use the information contained in a large panel data set, and to group those series together that display similar time series and business cycle properties, whereby the groups are also part of the estimation and not set a priori. Based on a dynamical structure which identifies a group of leading and a group of coincident series, we are able to date historical turning points and to make probabilistic forecasts on future ones. The results are consistent with common expectations, in particular the group of leading series includes Austrian confidence and sentiment indicators, German survey indicators, exports to G7 and to U.S. and interestingly, the Austrian and the German stock market indices.

1. Introduction

In this paper, I suggest to estimate business cycle turning points for Austria by using the information contained in a large set of economic, real and financial, variables. The information about the cyclical stance is extracted by estimating groups of series that display similar dynamics over time. To capture the fact that some groups of series usually lead the cycle, two groups of series are linked by an additional dynamical structure. That is, we explicitly allow for a group that leads another one in the cyclical dynamics. As the leading/coincident properties of series are not known with certainty (except perhaps for GDP and its components), we also estimate which groups may be linked by the dynamical structure. Obviously, not all series can be classified into one of both the coincident and the leading group of variables. Therefore, the remaining group, which collects all the series not following the coincident and the leading group of series, is moving "independently" from the other two groups.

The methodological approach pursued in the paper is based on the idea of model-based clustering of multiple time series (Frühwirth-Schnatter and Kaufmann, 2004a). An extension is introduced here in the sense that an additional dynamical structure links two groups in the panel. How to form the groups and which groups are linked by the dynamic structure is subject to estimation. Moreover, as the series are demeaned before the analysis, the estimation yields an inference on growth cycles. The growth cycle itself is modeled by a process which identifies periods of above-average and below-average growth. As these periods usually cannot a priori be identified with certainty, I will assume that an unobservable first-order Markov process is driving the economy.

Recently, research on the euro area business cycle has intensified. The areas which numerous papers deal with are dating business cycle turning points, assessing the current stance of the business cycle, forecasting the cycle itself as well as the probability of turning points. The model of the present paper is related to Benoechea and Pérez-Quirós (2004) who estimate a bivariate Markov switching model for the industrial production index and the industrial confidence indicator. With the so-called filter probabilities of the state indicator, which reflect the state probability in period t given the information up to period t, they assess the current state of the euro area business cycle and form a forecast on the probability of a turning point. While they apply the Markov switching framework to two aggregate variables, namely industrial production and the industrial confidence indicator, here the cyclical stance is extracted from the information contained in a large cross-section of economic series. Moreover, while they are modeling the state indicators of each series as switching independently or jointly, here, one group is explicitly defined as leading another, the coincident, group.

Forni et al. (2000) suggest using dynamic principal components to extract the coincident and the leading index of economic activity. From a large cross-section, they choose a set of core variables usually considered to be the most relevant to describe the business cycle stance, and include additional variables that are most correlated with this core and have only minor idiosyncratic dynamics. The common component extracted from these series allows to compute a coincident indicator for the euro area as a whole and for each individual country as well. The Austrian series included in the core are GDP, investment, consumption and industrial production. Austrian orders is the only series additionally taken into consideration in the final estimation. Generally, all financial and monetary variables are not sufficiently correlated to the core to be included in the final estimation, and neither are the price series and the share prices. Not surprisingly, orders turn out to be strongly correlated to the common component of the core series. Finally, the country-specific comparison of turning points with the euro area aggregate reveals that Germany, and also Austria, are not leading the euro area coincident indicator.

These results are of interest as the ones reported in the present paper point into the same direction. Financial variables do not pertain to the set of core variables, i.e. they do not fall into the leading group of variables and neither into the coincident group of variables. On the other hand, asset prices (the Austrian ATX and the German DAX stock market indices) fall into the leading group of series. Orders, confidence and economic sentiment indicators as well, fall into the leading group of variables.

Another possibility to predict turning points is suggested in Canova and Ciccarelli (2004). Based on the estimation of a Bayesian panel VAR for the G7 countries, forecasts in the growth rates of GNP are used to predict turning points and the probability of turning points. In principle, one could use the approach for a single country and form several VARs for related series in the panel, like business surveys, labor market series, trade series etc. Nevertheless, panel VARs appear most attractive to capture cross-country or country-specific inter-industry interdependencies. Our data set does not include many foreign variables, nor are the included series very disaggregate. Therefore, I will use the "basic" panel approach described in the following section.

Finally, a very specific approach is described in Bruno and Lupi (2004). Using early released reliable indicators, specifically a business survey series on future production prospects and the quantity of goods transported by railways, the authors specify a parsimonious forecasting model to produce a forecast of actual industrial production which then is used in an unobserved components model to assess the actual stance of the business cycle. In the present paper, however, we want to exploit the information of many series, of which many are also timely released, to form an expectation about turning points. Missing data on actual industrial production or other national account series can be handled as missing values and replaced by an estimate given the information we have on other timely released series (see also Frühwirth-Schnatter and Kaufmann, 2004b).

The paper is organized as follows. Section 2 introduces the model, section 3 outlines the estimation procedure. The data and the results are summarized in section 4.

2. The Econometric Model

Let y_{it} represent the (demeaned) growth rate at date t of a time series i in a large panel of economic variables, all assumed to be important for assessing the business cycle stance. The time series are assumed to follow the process:

$$y_{it} = \mu^i_{I_{it}} + \phi^i_1 y_{i,t-1} + \ldots + \phi^i_p y_{i,t-p} + \varepsilon_{it}, \qquad (1)$$

with $\varepsilon_{it} \sim iid\ N(0, \sigma^2 / \lambda_i)$, $t = 1, \ldots, T$. For a single time series, the model comes close to the one estimated in Hamilton (1989) for US GNP. We assume that the growth rate $\mu_{I_{it}}^{i}$ depends on a latent state variable I_{it}, which takes one of $J = 2$ values, i.e. either 1 or 2:

$$\mu_{I_{it}}^{i} = \begin{cases} \mu_1^i & \text{if} \quad I_{it} = 1 \\ \mu_2^i & \text{if} \quad I_{it} = 2 \end{cases}. \tag{2}$$

The latent specification of I_{it} takes into account the fact that the state prevailing in each period t is usually not observable with certainty. Moreover, as periods of higher growth might have a different duration than periods of lower growth, we specify I_{it} to follow a Markov switching process of order one, $P(I_{it} = l \mid I_{i,t-1} = j) = \xi_{jl}^{i}$, with the restriction $\sum_{l=1}^{2} \xi_{jl}^{i} = 1$, $j = 1,2$.

The superscript i is used here to denote that each time series, in principle, can follow an independent process (if the observation period is long enough). However, if time series are evolving similarly over time, efficiency gains might be exploited by pooling the information in the respective series (see e.g. Hoogstrate et al., 2000, and Frühwirth-Schnatter and Kaufmann, 2004a). The difficulty in following this procedure is to form the appropriate grouping of series. If we do not have a priori certain information about it, we might wish to draw an inference on the appropriate grouping characterizing the series included in the panel. To this aim, an additional latent group-indicator S_i, $i = 1,\ldots,N$, is defined that relates to group-specific parameters, whereby S_i can take one out of K different values, $S_i = k$, $k = 1,\ldots,K$, if we assume to have K distinct groups of countries in the panel. Therefore, the model for $\mu_{I_{it}}^{i}$ given in (2) may be extended to:

$$\mu_{I_{it}}^{S_i} = \begin{cases} \mu_1^k & \text{if} \quad S_i = k \text{and} I_{kt} = 1 \\ \mu_2^k & \text{if} \quad S_i = k \text{and} I_{kt} = 2 \end{cases}, \quad k = 1,\ldots,K, \tag{3}$$

whereby the probabilities $P(S_i = k)$ are given by η^k, $k = 1,\ldots,K$ with the restriction $\sum_{k=1}^{K} \eta^k = 1$.

In model (1), the autoregressive parameters are also thought to be group-specific, i.e. $(\phi_1^{S_i},\ldots,\phi_p^{S_i}) = (\phi_1^k,\ldots,\phi_p^k)$ if $S_i = k$. In principle, these coefficients can also be modeled as state-dependent. This would capture the fact that business cycle downturns are steeper than business cycle upturns, which would be reflected in higher autoregressive coefficients in the latter case. However, a preliminary investigation revealed that the autoregressive parameters are not state-dependent. Therefore, also for expositional convenience, the general specification is dropped.

We further assume group-specific state indicators (see the specification in (3)). This specification is appropriate to early detect or predict turning points. We expect that some series of the panel are leading the cycle, while some other series will be coincident with the cyclical dynamics of GDP. To capture this dynamic stylized fact, we put an additional structure on two of all of the group-specific state indicators.

Assume that the second group of series is the leading group while the coincident series are classified into the first group. We may parameterize this additional structure by designing an encompassing state indicator with restricted transition probability matrix (see also Phillips, 1991).

Note that each state indicator I_{kt} is assumed to have its own transition matrix $\xi^k = (\xi^k_{11}, \xi^k_{12}, \xi^k_{21}, \xi^k_{22})$. Define the encompassing state variable I^*_t which captures all $J^* = 4$ possible constellations of both state indicators 1 and 2 in period t:

$$
\begin{aligned}
I^*_t &= 1 := (I_{1t} = 1, I_{2t} = 1) \\
I^*_t &= 2 := (I_{1t} = 1, I_{2t} = 2) \\
I^*_t &= 3 := (I_{1t} = 2, I_{2t} = 1) \\
I^*_t &= 4 := (I_{1t} = 2, I_{2t} = 2).
\end{aligned}
$$

If the state indicator of group 2 is assumed to lead the state indicator of group 1,[1] eight of the 16 elements of the transition distribution of I^*_t will in fact be restricted to zero:

$$
\xi^* = \begin{bmatrix} \xi^*_{11} & \xi^*_{12} & 0 & 0 \\ 0 & \xi^*_{22} & 0 & \xi^*_{24} \\ \xi^*_{31} & 0 & \xi^*_{33} & 0 \\ 0 & 0 & \xi^*_{43} & \xi^*_{44} \end{bmatrix} = \begin{bmatrix} \xi^1_{11}\xi^2_{11} & \xi^1_{11}\xi^2_{12} & 0 & 0 \\ 0 & \xi^1_{11}\xi^2_{22} & 0 & \xi^1_{12}\xi^2_{22} \\ \xi^1_{21}\xi^2_{11} & 0 & \xi^1_{22}\xi^2_{11} & 0 \\ 0 & 0 & \xi^1_{22}\xi^2_{21} & \xi^1_{22}\xi^2_{22} \end{bmatrix}, \qquad (4)
$$

whereby ξ^*_{12}, ξ^*_{24}, ξ^*_{31}, ξ^*_{43} are equal to $1-\xi^*_{11}$, $1-\xi^*_{22}$, $1-\xi^*_{33}$, $1-\xi^*_{44}$, respectively.

[1]The leading behavior of state 2 is modeled in a strict form in the sense that a switch in the state indicator of group 2 will be followed by a switch in the state indicator of group 1 before the state indicator of group 2 may switch back to the initial state.

Finally, if state 1 is assumed to be the below-average state, $1/(1-\xi_{22}^{*})$ will be the expected lead of the second group out of a trough, and, correspondingly, $1/(1-\xi_{33}^{*})$ the expected lead of the second group in reaching a peak.

For expositional convenience I assumed so far that group 2 is leading group 1, while the remaining $K-2$ groups would behave independently over time. An additional difficulty arises, if there is uncertainty about which group is leading and which group is coincident. Therefore, we define a variable, say ρ^{*}, which characterizes the dynamical structure of the groups by taking one realization ρ_l of the $L=K(K-1)$ possible permutations of $\{1,2,0_{K-2}\}$.[2] The element in ρ^{*} which takes the value 1 refers to the group of coincident series, the element which takes the value 2 refers to the leading group, and all other elements refer to the groups that behave independently. If we have no a priori knowledge on the dynamic structure between groups, each permutation is given a priori equal weight $\eta_\rho = 1/(K(K-1))$.

3. MCMC Estimation

The following notation is adopted to describe the estimation in a convenient way. While y_{it} denotes observation t for time series i, y_i^t gathers all observations of time series i up to period t, $y_i^t = \{y_{it}, y_{i,t-1}, \dots, y_{i1}\}$, $i=1,\dots,N$. The variables Y_t and Y^t will denote accordingly all time series observations in and up to period t, respectively, $Y_t = \{y_{1t}, y_{2,t}, \dots, y_{Nt}\}$ and $Y^t = \{Y_t, Y_{t-1}, \dots, Y_1\}$. Likewise, the vectors $S^N = (S_1, \dots, S_N)$ and $I^T = (I_1^T, \dots, I_K^T)$, where $I_k^T = (I_{kT}, I_{k,T-1}, \dots, I_{k1})$, $k=1,\dots,K$, collect the group and the state indicators, respectively. Moreover, θ will denote all model parameters[3] and $\psi = (\theta, S^N, I^T, \lambda^N, \rho^{*})$ will be the augmented parameter vector which includes additionally the two latent indicators, the series-specific weights and the structure variable.

The model is estimated within the Bayesian framework using Markov chain Monte Carlo simulation methods. Starting point is Bayes' theorem

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[2]The vector 0_{K-2} denotes a vector of $K-2$ zeros.

[3]That is: $\theta = (\mu_1^1, \mu_2^1, \dots, \mu_1^K, \mu_2^K, \phi_1^1, \dots, \phi_p^1, \dots, \phi_p^K, \sigma^2, \xi^1, \dots, \xi^K, \eta^1, \dots, \eta^K)$, where $\xi^k = (\xi_{11}^k, \xi_{12}^k, \xi_{21}^k, \xi_{22}^k)$, $k=1,\dots,K$.

$$\pi(\psi \mid Y^T) \propto L(Y^T \mid \psi)\pi(\psi), \tag{5}$$

where an inference on the posterior distribution $\pi(\psi \mid Y^T)$ is obtained by updating prior information on the augmented parameter vector characterized by the distribution $\pi(\psi)$ with the information given in the data, which is given by the likelihood $L(Y^T \mid \psi)$.

For known values of S^N, I^T and ρ^*, the likelihood $L(Y^T \mid \psi)$ can be factorized in

$$L(Y^T \mid \psi) = \prod_{t=p+1}^{T} \prod_{i=1}^{N} f(y_{it} \mid y_i^{t-1}, \mu_{I_{S_i t}}^{S_i}, \phi_1^{S_i}, \ldots, \phi_p^{S_i}, \sigma^2, \lambda_i), \tag{6}$$

where $f(y_{it} \mid \cdot)$ denotes the density of the normal distribution:

$$f(y_{it} \mid y_i^{t-1}, \mu_{I_{S_i t}}^{S_i}, \phi_1^{S_i}, \ldots, \phi_p^{S_i}, \sigma^2, \lambda_i) = \frac{1}{\sqrt{2\pi\sigma^2/\lambda_i}} \exp\left\{ -\frac{1}{2\sigma^2/\lambda_i} \left(y_{it} - \mu_{I_{S_i t}}^{S_i} - \sum_{j=1}^{p} \phi_j^{S_i} y_{i,t-j} \right)^2 \right\}. \tag{7}$$

The prior on the augmented parameter vector is specified in a way which assumes that the group-specific state indicators I^T, the group indicator S^N, the weights λ^N, are independent of each other and independent of the model parameters θ:

$$\pi(\psi) = \pi(I^T \mid \rho^*, \xi)\pi(S^N \mid \eta)\pi(\lambda^N)\pi(\rho^*)\pi(\theta), \tag{8}$$

with know densities for $\pi(I^T \mid \rho^*, \xi)$ and $\pi(S^N \mid \eta)$, respectively.

The prior distribution for ρ^* is discrete, and each permutation ρ_l, $l = 1, \ldots, L$, out of the $L = K(K-1)$ possible ones from $\{1, 2, 0_{K-2}\}$ is given a prior probability of $\eta_\rho = 1/(K(K-1))$. The weights λ^N are distributed independently, $\pi(\lambda^N) = \prod_{i=1}^{N} \pi(\lambda_i)$, assuming a Gamma prior distribution for each λ_i, $\pi(\lambda_i) = G(\nu/2, \nu/2)$, with degrees of freedom $\nu = 8$.

The Bayesian model setup is completed with the specification of the prior distribution for the model parameter θ, $\pi(\theta)$, which, for the sake of brevity, is not described in detail here. Basically, the parameter vector is further broken down into appropriate blocks of parameters for which we can specify well-known conjugate prior distributions.

The inference on the joint posterior distribution $\pi(\theta, S^N, I^T, \lambda^N, \rho^* \mid Y^T)$ is then obtained by successively simulating out of the following conditional posterior distributions:

(i) $\pi(S^N \mid Y^T, I^T, \lambda^N, \theta)$,

(ii) $\pi(\rho^* \mid Y^T, S^N, \lambda^N, \theta)$,

(iii) $\pi(I^T \mid Y^T, S^N, \lambda^N, \rho^*, \theta)$,

(iv) $\pi(\lambda^N \mid Y^T, S^N, I^T, \theta)$,

(v) $\pi(\theta \mid Y^T, S^N, I^T, \lambda^N)$.

The Markov chain simulation proves to be handy in the present case as all distributions in (i)-(v) can be derived and sampled from quite easily (see e.g. the appendix in Kaufmann, 2004). For given (sensible) starting values for θ, λ^N and I^T, iterating several thousand times over the sampling steps (i)-(v), thereby replacing at each step the conditioning parameters by their actual simulated values, yields a sample out of the joint posterior distribution $\pi(\theta, S^N, I^T, \lambda^N, \rho^* \mid Y^T)$. The simulated values may then be post-processed to estimate the properties of the posterior distribution, e.g. the mean and standard error may be inferred by computing the mean and the standard deviation of the simulated values. For practical implementation, step (v) involves a further break-down of the parameter vector θ into appropriate sub-vectors (corresponding to the prior specification) for which the conditional posterior distributions can fully be derived and simulated straightforwardly.

4. Results

4.1. Data

The analysis is done with a large cross-section of Austrian quarterly time series covering the period of the first quarter of 1988 through the fourth quarter of 2003. The data include GDP, its components and industrial production, economic confidence and sentiment indicators for Austria, Germany and the US, the consumer price index, the harmonized consumer price index as well as its components, wholesale prices, wages and labor market series, trade series and exchange rates, and, finally, financial variables also containing besides the ATX, the DAX index the Dow Jones index. The complete set is available in table form from the author upon request. Before the estimation, the data are transformed to stationary series by taking first differences or first differences of the logarithmic level multiplied by 100. All series are additionally demeaned to remove long-run trends.

Some basic data properties are displayed in table 1. To save space, only those series are reported for which the contemporaneous correlation with GDP (YER) is significant. We see that all series have distinct mean above-average and below-average growth rates, which justifies the two-states specification (this is also the case for the series not reported). The contemporaneous correlations of the series with GDP (in the column labeled "GDP") give a first hint about the series that might be moving contemporaneously with the business cycle. Obviously, the components of GDP (PCR, ITR, GCR, MTR, XTR) and industrial production (INDPROD) are correlated with GDP. Some confidence and economic sentiment indicators (QTPR to EBAUSE), in particular the German IFO indices (IFOERW, IFOKL, IFOGL), some trade series (EXPG to IMP-DE) and labor market series (ALQN to STANDR) are also significantly correlated with GDP, whereby the unemployment rates are so negatively. We do not find significant correlation for the price series except for the aggregate wholesale prices (GHPIG) and the wholesale prices without seasonal goods (GHPIOS). Among the financial variables, we find the 3-months interest rate (STI), the government bond yield (SEKMRE) and some credit aggregates (DCR-HH, DEBT, DCR) which are positively correlated with GDP.

4.2. The Classification of Series

To receive an impression of the usefulness of the proposed method, the model is estimated for three groups, $K = 3$, and the lag length is set to $p = 4$. Two groups will be linked by a dynamic structure such that one group will lead the other one in the switching process, while the third will collect all other series. This is a very restrictive, and almost surely a miss-specification, because the third group is a mix of series that differ from the first two in terms of the group-specific parameters or in terms of the switching state indicators. On the other hand, if we focus on finding the "core" series reflecting the stance of the business cycle and the series leading the cycle, then this "minimum" specification may capture the most relevant information contained in the data set.

To estimate the model, we iterate 8,000 times over the sampling steps (i)-(v) described in section 3. The first 2,000 iterations are discarded to remove dependence on starting conditions.

Chart 1 depicts the posterior state probabilities $P(I_k^T = 0 \mid Y^T)$ of the coincident ($S_i = 2$) and of the leading group ($S_i = 3$) of series. They are obtained by averaging over the M simulated values $I^{T,(m)}$, $m = 1,...,M$. The inference is quite clear as nearly all posterior probabilities are either one or zero. What is also recognizable at first view is that the lead into recession is slightly shorter than the lead into recovery. This is confirmed if we compute the transition matrix of I^{*T}, see equation (10) below. The leading group is usually between two and three quarters in the below-average growth state before the contemporaneous group follows. On the other hand, when the leading group switches back to the above-average growth state, the contemporaneous group follows after slightly more than 3 quarters.

Chart 2 depicts the posterior group probabilities $P(S_i = k \mid Y^N)$ for each series. First of all, most classifications emerge again quite clearly. From the picture, we observe that with some exceptions, variables of the same kind fall into the same group. Table 2 explicitly lists the variables falling into the coincident and the leading group of series. As already mentioned, GDP and its components (YER to XTR), except for government consumption, obviously belong to the coincident group of variables. Trade data (EXP6 to IMP-DE) and industrial production (INDPROD) do so likewise. Some financial variables like terms of trade (TOT), energy (HICP-E) and wholesale prices (GHPIG to GHPIKONG) move also contemporaneously. The retail sales sentiment indicator (EHANSE) falls also into the group of contemporaneously moving time series.

The series which are traditionally relied upon to assess and to forecast the cyclical prospects of the economy fall into the group of leading variables. The actual situation and the expectations in industrial production and the construction sector (QTAUF to QTBAGL) fall into this group, the economic sentiment and the confidence indicators of the industry and the construction sector (KTPROL to EBAUSE) as well. As the Austrian economy heavily relies on exports, it does not surprise that also the German IFO economic indicators (IFOERW, IFOKL, IFOGL), the US purchasing index (PMI), and exports in machinery and automobiles (EXP7) and exports to the US (EXP-US) are leading the GDP cycle. Finally, it is interesting to note that the ATX and the DAX index are classified as leading the business cycle.

Based on figure 1, we may now decide how to date turning points for Austria. With the present model specification, we identify growth cycles, i.e. $I_{kt} = 0$ relates to periods of below-average growth. Therefore, the turning point in the series will effectively have occurred before falling into this state. Hence, I choose to identify turning points on the basis of the posterior state probabilities of the leading group of variables. Period t will be identified as a peak if $P(I_{k,t-2} = 1, I_{k,t-1} = 1, I_{k,t} = 1 \mid Y^T) < 0.5$ and $P(I_{k,t+1} = 1, I_{k,t+2} = 1 \mid Y^T) > 0.5$; likewise, period t will be identified as a trough, if

$P(I_{k,t-2}=1, I_{k,t-1}=1, I_{k,t}=1 \mid Y^T) > 0.5$ and $P(I_{k,t+1}=1, I_{k,t+2}=1 \mid Y^T) < 0.5$, where k refers to the group of the leading variables, in our case group 3.

The turning points identified with this rule are found in table 4, on the line labeled "MS leading group". As no official dates are available for Austria, we compare the dates with those reported by the Economic Cycle Research Institute (ECRI, www.businesscycle.com). The two chronologies are in close accordance to each other. There is only some ambiguity with respect to the two most recent downturns. Using the posterior probabilities of the leading group, we identify a shorter downturn from the second quarter of 2000 through the end of 2001, while ECRI dates the peak nine months earlier. We can also identify a period of below-average growth in the second half year of 2002, which has not been dated by the ECRI.

Finally, it is interesting to note that the turning points identified for the coincident group of series, in particular for GDP, are also in accordance with the major turning points identified with the OeNB's Economic Indicator (OEI), see Fenz et al. (2004).

4.3. The Probability of a Turning Point in 2004

At the end of 2003, it is highly probable that both the leading and the coincident groups are in a state of above-average growth. Given that both groups of series are in state 2, or in other words in state 4 of I_T^*, what is the probability of reaching a turning point in the first half year of 2004? We may compute a forecast:

$$\pi(I_{T+h}^* \mid Y^T) = \xi^{*h} \cdot \pi(I_T^* \mid Y^T), \tag{9}$$

which would yield, if $h=2$, a 46% probability of reaching a turning point ($I_{T+2}^*=3$) and a 13% probability of reaching a below-average state ($I_{T+2}^*=1$) in both groups of series. These forecasts are obtained when we substitute $\hat{\xi}^*$ for ξ^* in (9), the mean posterior transition distribution for ξ^* obtained from the MCMC output (see also table 3 for each group-specific state persistence):

$$\hat{\xi}^* = \begin{bmatrix} \hat{\xi}_{11}^* & \hat{\xi}_{12}^* & 0 & 0 \\ 0 & \hat{\xi}_{22}^* & 0 & \hat{\xi}_{24}^* \\ \hat{\xi}_{31}^* & 0 & \hat{\xi}_{33}^* & 0 \\ 0 & 0 & \hat{\xi}_{43}^* & \hat{\xi}_{44}^* \end{bmatrix} = \begin{bmatrix} 0.68 & 0.32 & 0 & 0 \\ 0 & 0.67 & 0 & 0.33 \\ 0.35 & 0 & 0.65 & 0 \\ 0 & 0 & 0.36 & 0.64 \end{bmatrix}. \tag{10}$$

Another formulation would be that the expected duration of the above-average state at the end of 2003 is $1/(1-\hat{\xi}^{*}_{44}) = 2.78$ periods, i.e. between half a year and 3 quarters of a year. Comparing with the economic performance during the first half of 2004, we see that indeed, after a subdued first quarter, GDP experienced a pick-up in the second quarter. Chart 3 draws GDP growth along with the posterior below-average state probabilities. We can observe that GDP picks up during the first half year of 2004 (the dark shaded periods in the graph).

5. Conclusion and Further Issues

In the present paper I propose to use the information contained in a large panel of quarterly economic and financial variables to estimate business cycle turning points for Austria. The econometric model is based on the idea of model-based clustering of multiple time series, which suggests pooling those series together which display similar time series and business cycle dynamics, whereby the appropriate classification of series is also part of the estimation method. To account for the fact that some series are leading the business cycle, I explicitly link two groups by a dynamical structure, defining one of them as the group of series which is leading another group of series. We may expect the latter one to be the series moving contemporaneously with the business cycle. As I demean all series prior to estimation, the method identifies growth cycles.

The results for a system assuming three groups are broadly consistent with expectations. GDP and its main components (except for government consumption), industrial production and some trade series, energy and whole sale prices as well, fall into the group of contemporaneous series. The group of leading series consists of Austrian confidence and sentiment indicators in the industrial and the construction sectors, of German survey indicators (IFO-business cycle indicator), exports to G7 and to US in particular, and, interestingly, the Austrian and the German stock market indices.

Because the method identifies growth cycles, the chronology of turning points is constructed based on the results for the leading group of series. The dates closely correspond to those identified by the Economic Cycle Research Institute. The turning points of the group of coincident series, which includes GDP, are also consistent with those identified by the OeNB's Economic Indicator.

The model estimate allows forming a forecast about the probability of a turning point conditional on the economic stance at the end of the sample. Given that at the end of the year 2003, both groups of series were in an above-average growth state, the probability of reaching a turning point in the first half year of 2004 was 46% and the probability of reaching a below-average state for both groups was quite lower (13%). Actually, GDP experienced a pick-up in the first half year of 2004.

Although these results are quite promising, there are some issues which remain to be settled. The present investigation assumes that three groups are present in the panel data set. While two groups are linked by the dynamical structure, the third is behaving independently from the other two. This third group collects all series which do not fit into the other two in terms of the group-specific parameters or in terms of the business cycle dynamics. A further investigation of these series, in particular whether they could further be split up in more than one group, would certainly improve the general fit of the data. Eventually, one might even extend the dynamical structure to specify a group of series which is lagging the business cycle.

Another unresolved question is the handling and the identification of counter-cyclical variables. Some obvious series like unemployment and the unemployment rate are negatively correlated with GDP. Actually, these series fall into the third group of series, presumably because their parameters are of opposite sign in each business cycle state. The model may be extended to explicitly allow for series that are behaving contemporaneously, but counter-cyclically to the business cycle. The sampler needs then to be adjusted to identify counter-cyclically behaving series.

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Appendix A: Tables[4]

Table 1: Data Properties

Series	Mean	Mean above average	Mean below average	Standard deviation	GDP	P-value
YER	0.58	0.48	–0.46	0.58	1.00	1.00
PCR	0.60	0.40	–0.43	0.61	0.44	0.00
ITR	0.64	1.71	–2.06	2.29	0.48	0.00
GCR	0.38	0.42	–0.54	0.73	0.37	0.00
MTR	1.43	1.84	–1.84	2.64	0.30	0.02
XTR	1.46	1.89	–1.78	2.31	0.54	0.00
QTPR	–0.02	3.75	–3.75	4.67	0.30	0.02
QTPRO	0.07	3.27	–3.07	4.20	0.29	0.02
QTBAGL	0.18	4.27	–4.27	5.59	0.28	0.02
INDSEN	–0.03	2.96	–3.57	3.99	0.25	0.04
KTPROL	0.07	5.12	–5.45	6.47	0.25	0.04
KTAUF	–0.15	4.78	–5.09	5.98	0.25	0.05
KTAUSL	–0.13	4.81	–5.12	5.83	0.26	0.04
KTVPN	–0.04	3.44	–4.42	4.81	0.31	0.01
EECOS	–0.07	3.17	–2.80	3.85	0.27	0.03
EINDSE	–0.05	2.95	–3.14	3.74	0.30	0.02
EBAUSE	–0.03	2.93	–2.75	3.66	0.26	0.04
IFOERW	0.16	2.64	–2.48	3.35	0.31	0.01
IFOKL	0.03	2.16	–2.45	2.81	0.38	0.00
IFOGL	–0.11	2.27	–3.12	3.19	0.34	0.01
GHPIG	0.26	0.54	–0.51	0.69	0.28	0.03
GHPIOS	0.26	0.60	–0.60	0.75	0.31	0.01
EXPG	1.49	1.85	–1.97	2.52	0.44	0.00
EXP6	1.07	1.71	–2.20	2.46	0.31	0.01
EXP7	1.55	2.40	–3.09	4.23	0.40	0.00
EXP-EU	1.34	2.12	–2.12	2.79	0.46	0.00
EXP-DE	1.64	1.99	–2.26	2.67	0.45	0.00
IMP-EU	1.56	2.01	–1.77	3.08	0.35	0.00
IMP-DE	1.45	2.20	–2.20	3.09	0.30	0.02
ALQN	0.02	0.14	–0.14	0.17	–0.30	0.02
ALQNSA	0.02	0.16	–0.14	0.18	–0.30	0.02
ALOSM	0.59	3.19	–2.48	3.54	–0.32	0.01
OFST	–0.36	5.77	–5.09	6.41	0.42	0.00
STANDR	0.92	6.66	–7.09	8.08	–0.40	0.00
INDPROD	0.79	1.24	–1.24	1.57	0.58	0.00
STI	–0.04	0.36	–0.30	0.46	0.38	0.00
SEKMRE	–0.04	0.30	–0.24	0.34	0.42	0.00
DCR-HH	1.78	0.75	–0.51	0.71	0.32	0.01
DEBT	1.31	0.53	–0.53	0.66	0.30	0.02
DCR	1.24	0.54	–0.58	0.68	0.31	0.01

[4] Source of all tables and charts: Author's calculations.

Table 2: Series Classification

Contemporaneous	Leading
YER	QTAUF
PCR	QTEXPA
ITR	QTPR
MTR	QTPRO
XTR	QTBAUF
TOT	QTBPR
EHANSE	QTBBGL
HICP-E	QTBAGL
GHPIG	INDSEN
GHPIOS	KTPROL
GHPIVBG	KTAUF
GHPIKONG	KTAUSL
EXP6	KTPRON
IMPG	KTVPN
IMP6	BAUVPN
IMP7	EECOS
IMP8	EINDSE
EXP-EU	EBAUSE
EXP-DE	IFOERW
IMP-US	IFOKL
IMP-EU	IFOGL
IMP-DE	PMI
INDPROD	EXP7
	EXP-US
	ATX
	DAX

Table 3: Results

coefficient	$I_{S_it}=2$		$I_{S_it}=1$	
	$S_i=2$	$S_i=3$	$S_i=2$	$S_i=3$
$\mu^{S_i}_{I_{S_it}}$	0.48	1.92	–0.41	–2.07
	(0.37 0.60)	(1.65 2.21)	(–0.51 –0.30)	(–2.36 –1.79)
$\phi^{S_i}_1$	–0.02	0.24		
	(–0.08 0.03)	(0.19 0.30)		
$\phi^{S_i}_2$	0.04	0.09		
	(–0.01 0.08)	(0.04 0.14)		
$\phi^{S_i}_3$	–0.01	0.02		
	(–0.06 0.04)	(–0.03 0.07)		
$\phi^{S_i}_4$	–0.02	–0.15		
	(–0.07 0.03)	(–0.19 –0.10)		
unc. mean	0.47	2.42	–0.41	–2.61
	(0.36 0.59)	(2.07 2.80)	(–0.51 –0.30)	(–2.98 –2.25)
number of series	23	26		
$\xi^{S_i}_{11}$	0.83	0.82		
conf. int.	(0.71 0.94)	(0.69 0.93)		
quarters	5.98	5.52		
$\xi^{S_i}_{22}$	0.79	0.81		
conf. int.	(0.64 0.92)	(0.67 0.94)		
quarters	4.72	5.17		

Table 4: Growth Cycle Peak and Trough Dates, 1988Q1–2003Q4.

	P	T	P	T	P	T	P	T	P	T
MS leading group	90:1	93:1	94:4	96:2	97:4	98:4	00:2	01:4	02:2	02:4
ECRI*										
quarterly	90:1	93:1	94:4	96:1	98:2	99:1	99:3	01:3		
monthly	2/90	3/93	11/94	3/96	5/98	2/99	7/99	9/01		

* The ECRI dates growth cycles on a monthly basis. The quarterly dates are derived from the monthly ones.

Appendix B: Charts

Chart 1: Posterior Probabilities, $P(I_{kt}=1|Y^T)$, of the Coincident ($S_i=2$) and the Leading Group ($S_i=3$), 1988Q1–2003Q4, $K=3$, $p=4$. The Series are Standardized by their Specific Variance, σ^2/λ_i.

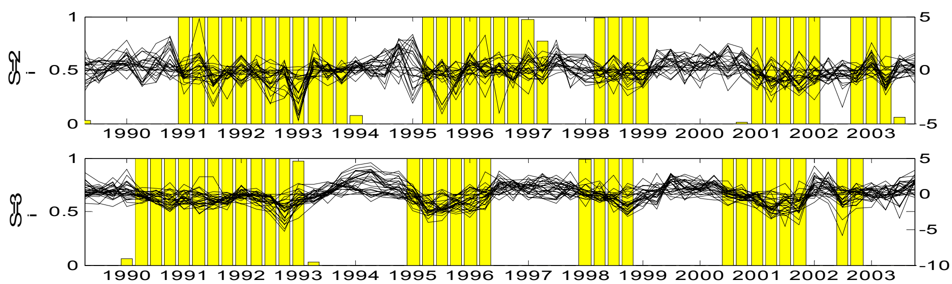
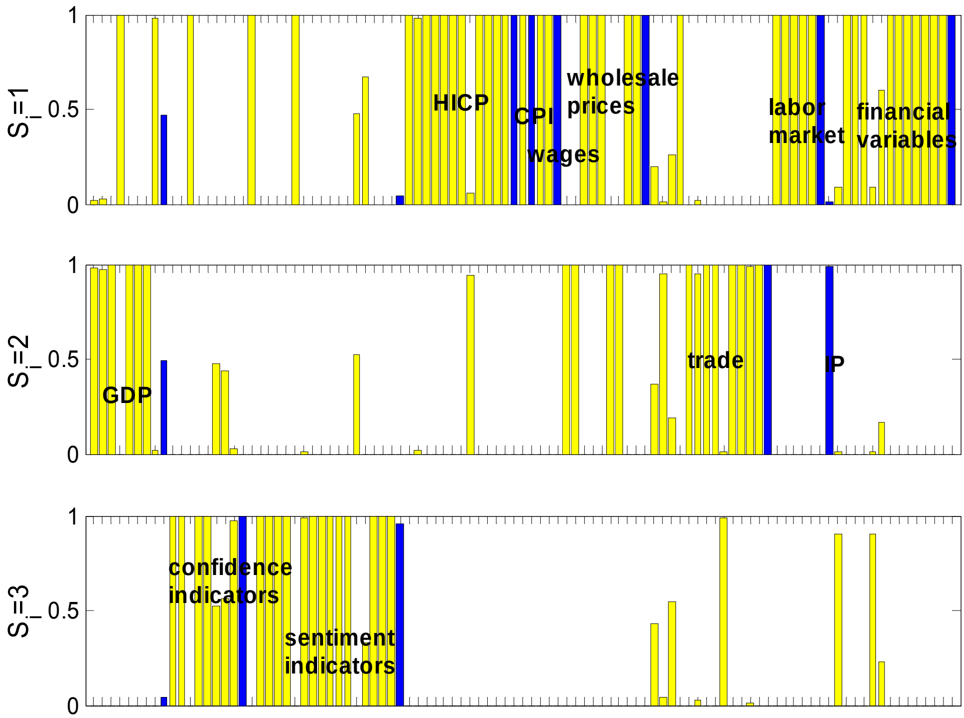
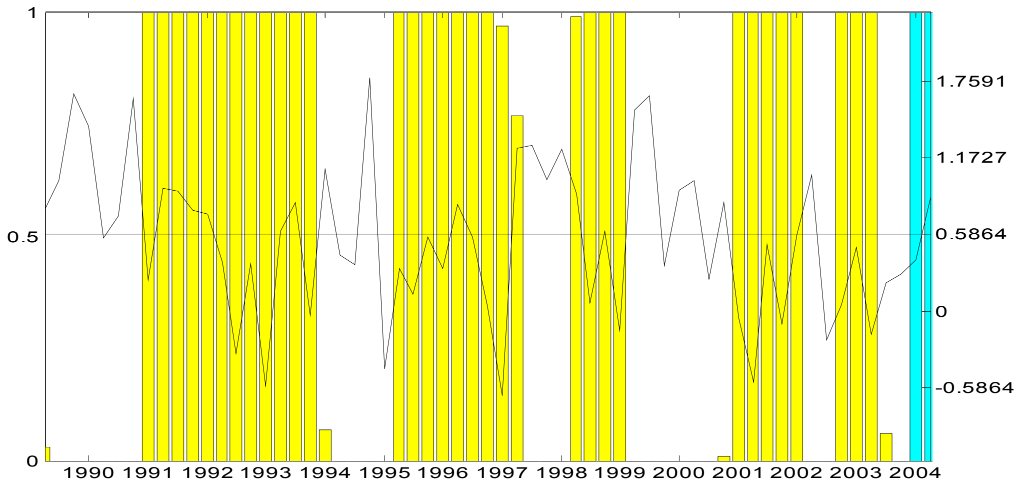


Chart 2: Posterior Group Probabilities of the Coincident ($S_i = 2$) and the Leading Group ($S_i = 3$), 1988Q1–2003Q4, $K = 3$, $p = 4$.



Note: The shaded bars demarcate the last series in a specific class of series.

Chart 3: GDP Growth (Right–Hand Scale) Along with the Posterior Probability of below–average Growth for the Second Group, $P(I_{2t}=1|Y^T)$ *(Left-Hand Scale).*



Comment on "Dating Turning Points for Austria: A Suggestion"

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This is certainly a high-tech contribution in the area of dynamic factor modeling in Austrian macroeconomics.

I would like to focus on the two main assumptions, which the model is based upon:

1. There are two distinct states of the economy: good and bad
2. The transition between the two states is called a 'turning point'. It is of interest to predict these transitions.

Regarding the first point, I feel that there is no consensus in the economic literature. For one, dichotomization of the business cycle has a long tradition, including the classical contribution by Burns and Mitchell, which the current business-cycle chronology is still based upon. It is also reflected in the popular U.S. business forecasts, which tend to summarize the current state of the business cycle in the form of a traffic light—i.e., green, yellow, and red for good, intermediate, and bad. On the other hand, there is no reliable statistical backing to the claim that such a business cycle really exists, i.e. in the traditional sense, with the economy moving back and forth between clearly recognizable *peaks* and *troughs*. If that was the case, one might indeed label the phase from peak to trough as 'bad' and the remainder as 'good'. However, visual impression as well as statistical methods do not yield any clear indication of cycles in real growth, beyond a known perceptory illusion: the human mind and eye tend to see cycles in random walks without any particular periodic structure.

Note that even the validity of the two-state model is not sufficient for backing the quest for 'turning points'. The prediction of such turning points only makes sense if the lengths of cycles are relatively irregular, while the peak-trough and trough-peak phases have a certain minimum length and are sufficiently regular with regard to falling and rising, respectively. If any of these conditions is not fulfilled by economic reality, the pronounced target disappears. If cycles are regular, like seasonal cycles or sunspot cycles, peaks can simply be forecasted from previous peaks, and every lagging indicator is also some sort of leading indicator. Alternatively, if there is a chance that 'recession' or 'recovery' episodes are very short, even short-run prediction may do better by ignoring such occasional dips. Finally, if the two types of episodes show prolonged sub periods with rising tendencies within recession or falling tendencies within recovery, labeling a current period as, for example, a recession may be severely misleading.

This could be an interesting feature of Kaufmann's research. If the basic assumptions allow more accurate modeling and prediction, this may be viewed as some sort of empirical backing for the two assumptions.

Finally, it is interesting to motivate why a *leading* indicator is possible at all. Apparently, the existence of a leading indicator requires that either there are variables in the economy that react faster to business-cycle innovations than GDP does, or that some economic agents process information faster and more accurately than economic forecasters do. Regarding the first possibility, one may surmise that adjustment costs play a role, such that increased demand does not *immediately* entail increased production. Regarding the latter option, I feel that it may be worth while to investigate where this information is formed. In other words, if consumer sentiment or business surveys regularly precede actual economic behavior, which type of information leaves such important marks on economic agents, i.e. information that is not visible from traditional economic variables.

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A Long-run Macroeconomic Model of the Austrian Economy (A-LMM):[1] Model Documentation and Simulations

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Abstract

In this paper we develop a long-run macroeconomic model for Austria to simulate the effects of aging on employment, output growth, and the solvency of the social security system. By disaggregating the population into six age cohorts and modelling sex specific participation rates for each cohort, we are able to account for the future demographic trends. Apart from a baseline scenario, we perform six alternative simulations that highlight the effects of aging from different perspectives. These include two population projections with high life expectancy and with low fertility, a dynamic activity rate scenario, two scenarios with a stable fiscal balance of social security and an alternative pension indexation, and a scenario with higher productivity growth.

JEL classification: C6, E2, O4
Key words: Economic growth, aging, Austria

[1] Acknowledgments: We would like to thank Werner Roeger, Stephen Hall, Arjan Lejour, Bert Smid, Johann Stefanits, Andreas Wörgötter, Peter Part, and the participants of two WIFO-IHS-LMM workshops hosted by the Institute for Advanced Studies (IHS) in Vienna for helpful comments and suggestions. We are particularly indebted to Fritz Breuss and Robert Kunst for valuable discussions during the project. We are very grateful to Ursula Glauninger, Christine Kaufmann (both WIFO) and Alexander Schnabel (IHS) for excellent research assistance. The responsibility for all remaining errors remains entirely with us.

1. Introduction and Overview

A-LMM is a long-run macroeconomic model for the Austrian economy developed jointly by the Austrian Institute of Economic Research (WIFO) and the Institute for Advanced Studies (IHS). This annual model has been designed to analyse the macroeconomic impact of long-term issues on the Austrian economy, to develop long-term scenarios, and to perform simulation studies. The current version of the model foresees a projection horizon until the year 2075. The model puts an emphasis on financial flows of the social security system.

Should the current demographic trends continue, the long-term sustainability of old-age pension provision and its consequences for public finances will remain of high priority for economic policy in the future[2]. Social security reforms have usually long lasting consequences. These consequences depend on demographic developments, the design of the social security system, and last, but not least, on long-term economic developments.

The presence of lagged and long lasting effects of population aging and the infeasibility of real world experiments in economics justifies the need for a long-run economic model in which the main determinants and interactions of the Austrian economy are mapped. Different scenarios for the economy could then be developed in a flexible way and set up as simulation experiments contingent on exogenous and policy variables.

A-LMM is a model derived from neoclassical theory which replicates the well-known stylised facts about growing market economies summarised by Nicholas Kaldor (recit. Solow, 2000). These are: (i) the output to labour ratio has been rising at a constant rate, (ii) similarly, the capital stock per employee is rising at a constant rate, (iii) the capital output ratio and (iv) the marginal productivity of capital have been constant. Together, facts (iii) and (iv) imply constant shares of labour and capital income in output. An economy for which all of the above facts hold is said to be growing in steady state.

In A-LMM, the broad picture outlined by Kaldor emerges as a result of optimizing behaviour of two types of private agents: firms and private households. Private agents' behavioural equations are derived from dynamic optimisation principles under constraints and based on perfect foresight. As the third major actor

[2] Since the beginning of the nineties, macroeconomic consequences of population aging, especially for public budgets, are an issue of concern to international organisations like the OECD or the IMF (see Leibfritz et al., 1996, Koch and Thiemann, 1997). In the context of the Stability and Growth Pact of the European Union, the budgetary challenges posed by aging populations have become a major concern in the European Union under the headline 'Long-term Sustainability of Public Finances' (see Economic Policy Committee, 2001 and 2002, European Commission, 2001 and 2002). For an Austrian perspective see Part and Stefanits (2001) and Part (2002).

we consider the general government. We assume a constant legal and institutional framework for the whole projection period. The government is constrained by the balanced budget requirement of the Stability and Growth Pact. The structure of A-LMM is shown in chart 1.1.

The long-run growth path is determined by supply side factors. Thus, the modelling of firm behaviour becomes decisive for the properties of our model[3]. Firms are assumed to produce goods and services using capital and labour as inputs. It is well known that a constant return to scale production technology under Harrod-neutral technical progress is one of the few specifications consistent with Kaldor›s facts. We therefore assume a Cobb-Douglas production function with exogenous Harrod-neutral technical progress. Factor demand is derived under the assumption of profit maximisation subject to resource constraints and the production technology. Capital accumulation is based on a modified neoclassical investment function with forward looking properties. In particular, the rate of investment depends on the ratio of the market value of new additional investment goods to their replacement costs. This ratio (Tobin›s Q) is influenced by expected future profits net of business taxes. Labour demand is derived directly from the first order condition of the firms' profit maximisation problem.

Private households' behaviour is derived from intertemporal utility maximisation according to an intertemporal budget constraint. Within this set-up, decisions about consumption and savings (financial wealth accumulation) are formed in a forward looking manner. Consumption depends on discounted expected future disposable income (human wealth) and financial wealth but also on current disposable income since liquidity constraints are binding for some households.

To afford consumption goods, household supply their labour and receive income in return. A special characteristic of A-LMM is the focus on disaggregated labour supply. In general, the labour force can be represented as a product of the size of population and the labour market participation rate. In the model we implement highly disaggregated (by sex and age groups) participation rates. This gives us the opportunity to account for the different behaviour of males and females (where part-time work is a major difference) and young and elderly employees (here early retirement comes into consideration).

Another special characteristic of A-LMM is a disaggregated model of the social security system as part of the public sector. We explicitly model the expenditure and revenue side for the pension, health and accident, and unemployment insurance, respectively. Additionally, expenditures on long-term care are modelled. Demographic developments are important explanatory variables in the social security model. Although, individual branches of the public sector may run

[3] See, for example, Allen and Hall (1997).

permanent deficits, for the public sector as a whole, the long-run balanced-budget condition is forced to hold.

These features of A-LMM ensure that its long-run behaviour resembles the results of standard neoclassical growth theory and is consistent with Kaldor's facts. That is, the model attains a steady state growth path determined by exogenous growth rates of the labour force and technical progress.

A-LMM as a long-run model is supply side driven. The demand side adjusts in each period to secure equilibrium in the goods market. The adjustment mechanism runs via disequilibria in the trade balance. The labour market equilibrium is characterised by a time varying natural rate of unemployment. Prices and financial markets are not modelled explicitly; rather we view Austria as a small open economy. Consequently, the real interest and inflation rates coincide with their foreign counterparts. We impose that the domestic excess savings correspond to the income balance in the current account.

Because of the long projection horizon and a comparatively short record of sensible economic data for Austria, the parameterisation of the model draws extensively on economic theory[4]. This shifts the focus towards theoretical foundations, economic plausibility, and long-run stability conditions and away from statistical inference. As a consequence, many model parameters are either calibrated or estimated under theory based constraints[5]. A-LMM is developed and implemented in EViews©.

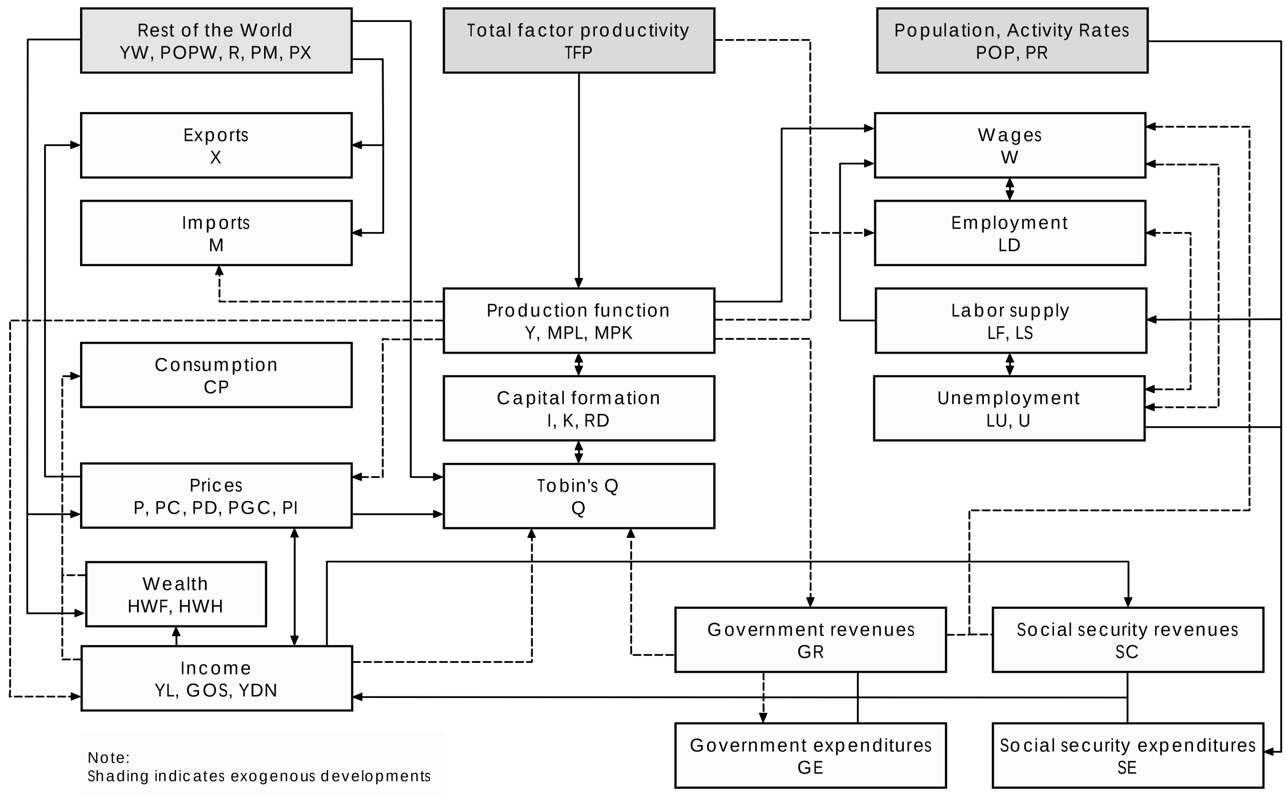
The report is structured as follows. First, firm behaviour is presented in section 2, where investment determination, capital accumulation and the properties of the production function are analysed. Section 3 discusses consumption and savings decisions of private households. In sections 4 and 5 we consider the labour market, and income determination, respectively. The public sector in general and the social security system in particular are dealt with in sections 6 and 7. How the

[4] For consistency A-LMM relies on the system of national accounts. On the basis of the current European System of National Accounts framework (ESA, 1995), official data are available from 1976, in part only from 1995, onwards. The projection outreaches the estimation period by a factor of three. All data in charts and tables prior to 2003 are from the national accounts as published by Statistics Austria. With the exception of the population forecast, all presented projections result from model simulations by the authors.

[5] "[S]o called 'calibrated' models [...] are best described as numerical models without a complete and consistent econometric formulation [...]" Dawkins et al. (2001, p. 3655). Parameters are usually calibrated so as to reproduce the benchmark data as equilibrium. A typical source for calibrated parameters is empirical studies which are not directly related to the model at hand, for example cross section analysis or estimates for other countries, or simple rules of thumb that guarantee model stability. For a broader introduction and discussion of the variety of approaches subsumed under the term 'calibrated models' see Hansen and Heckman (1996), Watson (1993) and Dawkins et al. (2001).

model is closed is the focus of section 8. In section 9 we conclude with a discussion of several projections based on different assumptions for key exogenous variables. These scenarios concern changes in population growth and labour market participation rates, a reduction of the fiscal deficit of the social security system, an alternative rule for indexing pensions and an increase in total factor productivity growth.

Chart 1: A-LMM Structure



2. Firm Behaviour

2.1 The Modified Neo Classical Investment Function

In A-LMM, the investment function closely follows the neoclassical theory modified by the inclusion of costs of installation for new capital goods. This approach ensures smoothness of the investment path over time and offers sufficient scope for simulations.

Lucas and Prescott (1971) were the first to note that adding the costs of installing new investment goods to the neoclassical theory of investment by Jorgenson (1963) reconciles the latter with the Q-theory of investment by Tobin (1969). Hayashi (1982) shows how this can be done in a formal model. Our modelling of investment behaviour closely follows Hayashi's approach.

Jorgenson (1963) postulates a representative firm with perfect foresight of future cash flows. The firm chooses the rate of investment so as to maximise the present discounted value of future net cash flows subject to the technological constraints and market prices. Lucas (1967) and others have noted several deficiencies in the early versions of that theory. Among them are the indeterminacy of the rate of investment and the exogeneity of output. The former can be remedied by including a distributed lag function for investment. If installing a new capital good incurs a cost, then this cost can be thought of as the cost of adjusting the capital stock.

Tobin (1969) explains the rate of investment by the ratio of the market value of new additional investment goods to their replacement costs: the higher the ratio, the higher the rate of investment. This ratio is known as Tobin's marginal Q. Without resorting to optimisation, Tobin argued that, when unconstrained, the firm will increase or decrease its capital until Q is equal to unity.

Hayashi (1982) offers a synthesis of Jorgenson's neoclassical model of investment with Tobin's approach by introducing an installation function to the profit maximisation problem of the firm. The installation function gives the portion of gross investment that turns into capital. The vanishing portion is the cost of installation. A typical installation function is strictly monotone increasing and concave in investment. In addition, the function takes the value of zero when no investment is taking place, is increasing because for a given stock of capital the cost of installation per unit of investment is greater, the greater the rate of investment, and concave due to diminishing marginal costs of installation. The installation function is commonly defined by its inverse.

For an installation function that is linear homogenous in gross investment I_t and the capital stock K_t, Hayashi (1982) derives the following general investment function:

$$\frac{I_t}{K_{t-1}} = F(Q_t) \quad . \tag{2.1}$$

The left hand side of *(2.1)* is approximately the rate of change of K_t.

Since the marginal Tobin's Q is unobservable, the usual practice is to turn to the average Q_t:

$$Q_t = CONQ + \frac{1}{P_t K_t} \sum_{i=0}^{T} \frac{(1 - RTC_t - RTDIR_t) NOS_{t+i} + DPN_{t+i}}{(1 + RN_{t+i} + RD_t)^i} \quad , \tag{2.2}$$

where $i = 0,1,...,T$. Hayashi shows that the average and marginal Q are essentially the same for a price-taking firm subject to linearly homogenous production and installation functions. Tobin's Q introduces a forward looking element into our model. In 2.2, the theoretically infinite sum is approximated by the first 11 terms, or $T = 10$, plus a constant *CONQ*. The numerator in Q_t is a proxy for the market value of new investment computed as the present value of future cash flows of the firm. The cash flow is given by the net operating surplus NOS_t, net of business taxes plus the current depreciation DPN_t. RTC_t denotes the average rate of corporation tax and $RTDIR_t$ the average rate of all other direct taxes paid by the business sector. The replacement costs of capital are approximated by the value of the capital stock at current prices (inflated by the GDP deflator P_t). The relevant discount rate is the sum of nominal rate of interest, RN_t, and the rate of physical depreciation of capital RD_t. The fiscal policy variables RTC_t, $RTDIR_t$, and the rate of physical depreciation of capital, RD_t, are exogenous and are held constant in the baseline.

For a particular inverse installation function

$$\psi(I_t, K_{t-1}) = I_t \left(1 + \frac{PHI}{2} \frac{I_t}{K_{t-1}}\right) \frac{PI_t}{P_t} \quad , \tag{2.3}$$

the investment function becomes

$$\frac{I_t}{K_{t-1}} = \frac{1}{PHI} \left(\frac{Q_t P_t}{PI_t} - 1 \right), \tag{2.4}$$

where PI_t the investment deflator and the constant parameter $PHI \geq 0$ reflects adjustment costs of capital. In the model $PHI = 7.18$.

2.2 Capital Stock and Depreciation

For a comprehensive discussion of the methodology for measuring the capital stock in Austria see Böhm et al. (2001) and Statistics Austria (2002). In the model, the capital stock at constant 1995 prices is accumulated according to the perpetual inventory method:

$$K_t = (1 - RD_t)^{0.5} I_t + (1 - RD_t) K_{t-1}, \tag{2.5}$$

subject to a constant rate of physical depreciation $RD_t = 0.039$ and an initial stock. This value implies that an average investment good is scrapped after 25.6 years. The factor $(1\text{-}RD_t)^{0.5}$ accounts for the fact that investment goods depreciate already in the year of their purchase. Specifically, we assume that new investment goods depreciate uniformly in the year of their purchase as well as thereafter. Physical depreciation at current prices is thus given by the sum of depreciation on current investment and on the existing capital stock:

$$DPN_t = \left(\left(1 - (1 - RD_t)^{0.5}\right) I_t + RD_t K_{t-1}\right) PI_t. \tag{2.6}$$

2.3 The Neoclassical Production Function

Output is produced with a Cobb-Douglas technology by combining labour and physical capital under constant returns to scale. After taking the natural logarithm, the Cobb-Douglas production function is given by:

$$\log(Y_t) = CONY + TFP \cdot t + ALPHA \log(K_t) + (1 - ALPHA)\log(LD_t), \tag{2.7}$$

where Y_t denotes GDP at constant 1995 prices. *CONY* denotes the constant in the production function, *TFP* is the growth rate of total factor productivity, *t* is a time trend, LD_t the number of full-time equivalent employees[1], and K_t the stock of capital. The parameter *ALPHA* = 0.491 is the output elasticity of capital. The value of (*1 = ALPHA*) corresponds to share of labour income in nominal GDP in 2002. The labour income share in Austria is lower than in most other developed countries. This can be partially explained by Austria's practice of including incomes of self-employed into the gross operating surplus, i.e., profits. This makes

[1] Following the convention of the National Accounts, the compensation of self-employed are included in the gross operating surplus and therefore are not part of the compensation of employees. We therefore exclude labour input by the self-employed from the production function.

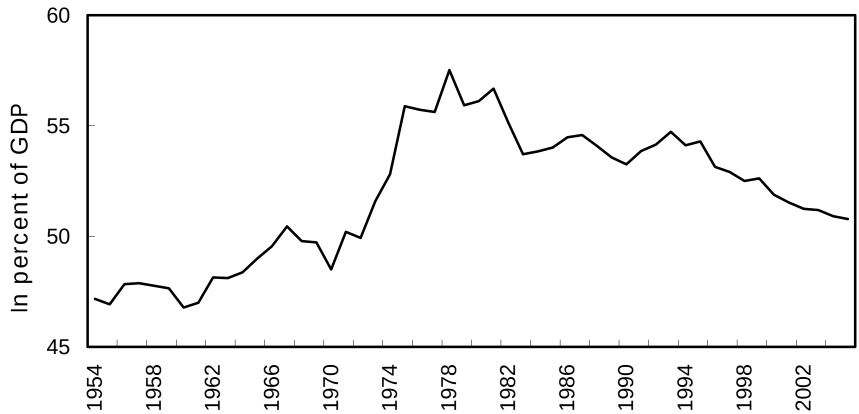
our specification closer in spirit to the augmented neoclassical growth model along the lines of Mankiw, Romer and Weil (1992). By augmenting the production function by the stock of human capital, these authors obtain an estimate the labour coefficient of 0.39.

The Cobb-Douglas production function implies a unit elasticity of substitution between the factor inputs. The elasticity of substitution is a local measure of technological flexibility. It characterises alternative combinations of capital and labour which generate the same level of output. In addition, under the assumption of profit maximisation (or cost minimisation) on the part of the representative firm, the elasticity of substitution measures the percentage change in the relative factor input as a consequence of a change in the relative factor prices. In our case, factor prices are the real wage per full-time equivalent and the user costs of capital. Thus, other things being equal, an increase of the ratio of real wage to the user costs will lower the ratio of the number of employees to capital by the same magnitude.

A Cobb-Douglas production function implies constancy of the income shares of factor inputs in the total value added. These are given by the ratios of the gross operating surplus and wages to GDP at constant prices. Although the labour income share in Austria has been falling since the late seventies, in the longer term it has varied in a narrow range (chart 2.1). For this reason the assumption of long-term constancy of the labour income share over a long-run seems appropriate. One of the plausible reasons for time a varying income share is structural change in the economy. For example, a shift towards capital intensive sectors leads to a decrease in the aggregate labour income share even if sector specific production functions imply constant income shares. Since we abstract from modelling structural change by assuming a representative firm producing a homogenous good, a constant labour income share is adequate.

Another feature of Cobb-Douglas technology is that the marginal and the average products of input factors grow at identical rates, their levels differing by the respective factor shares. In the baseline, we assume a constant annual rate of change of labour productivity of 1.7%. The corresponding annual rate of change of total factor productivity TFP_t is 1.7 (1-ALPHA) = 0.85%.

Chart 2.1: Labour Share in Percent of GDP in Austria



3. Consumption of Private Households

3.1 The Model of Perpetual Youth

The consumption behaviour of private households is based on the model of perpetual youth as presented in Blanchard and Fischer (1989). This is a continuous time version of an overlapping generations model. For simplicity, the individual in this model faces a constant probability of dying (*PRD),* at any moment; throughout his life. This implies that the individual life time is uncertain but independent of age. The assumption of a constant probability of death, although unrealistic, allows for tractability of the model and generates reasonable steady state characteristics.

At every instant of time a new cohort is born. The size of the new born cohort declines at the rate *PRD* over time. If the size of a newly born cohort is normalised such that it equals *PRD* and the remaining life time has an exponential distribution, then the size of the total population equals 1 at any point in time.

We impose that individuals consume their total life time income, which implies that there are no bequests left over to potential heirs. To achieve this, we suppose a reverse insurance scheme with full participation of the total population. The insurance pays out the rate $PRD\ hwf_t$ per unit of time in exchange for the amount of financial wealth, *hwf,* accumulated by the individual at his time of death[2]. This

[2] In this section, lower case letters indicate individual specific values, whereas upper case letters refer to aggregate values.

insurance scheme is sustainable because the individual probability of death is uncertain, while the probability of death in the aggregate is deterministic, and because the size of newly born cohorts is kept constant. The insurance fund receives bequests from those who die at the rate $PRD\ hwf_t$, and pays out claims at the rate $PRD\ hwf_t$ to all surviving individuals. This allows all individuals to consume their total expected life time income.
The individual maximises the objective function

$$v_t = \int_t^{\infty} \log(cp_{t+i}) e^{-(RTP+PRD)i} di\,, \qquad (3.1)$$

which describes expected utility as the discounted sum of instantaneous utilities from current and future consumption (cp_{t+i}) for i = 0,...,∞ with *RTP* as the rate of time preference, i.e., the subjective discount factor. In this case the utility function is logarithmic, which imposes a unit elasticity of substitution between consumption across different periods. The only source of uncertainty in this model comes from the possibility of dying. Given an exponential distribution for the probability of death, the probability of surviving until period $t + i$ is:

$$e^{-PRD(t+i-t)} = e^{-PRDi}\,, \qquad (3.2)$$

This equation shows that the discount function in *(3.1)* accounts for the effect of uncertain life time on consumption. Because of this uncertainty future consumption has a lower present value, i.e., the discount factor is smaller as compared to a certain world.

For a given level of financial wealth in period $t + i$, interest is accrued at the real rate of R_{t+i}. Additionally, the individual receives the claims payment from the insurance fund to the extent of $PRD\ hwf_{t+i}$. Consequently, during life time the budget constraint is given by

$$\frac{d}{d}\frac{hwf_{t+i}}{(t+i)} = (R_{t+i} + PRD)hwf_{t+i} + yl_{t+i} - cp_{t+i}\,, \qquad (3.3)$$

where *yl* represents the individual's labour income. The change in financial wealth thus depends on interest income, the claims payment, and current savings. The following
No-Ponzi-Game-Restriction prevents individuals from borrowing infinitely:

$$\lim_{t+i\to\infty} hwf_{t+i} \exp\left(-\int_t^{t+i} (R_j + PRD) dj \right) = 0\,. \qquad (3.4)$$

An individual cannot accumulate debt at a rate higher than the effective rate of interest he faces. Households have to pay regular interest, R_t, on debt and a life insurance premium at rate *PRD* to cover the uncertainty of dying while indebted. Human wealth is given by the discounted value of future labour income hwh_t:

$$hwh_t = \int_t^{\infty} yl_{t+i} \exp\left(- \int_t^{t+i} \left(R_j + PRD \right) dj \right) di , \tag{3.5}$$

where the discount factor corresponds to the risk adjusted interest rate ($R_t + PRD$). The individual maximises expected utility *(3.1)* subject to the accumulation equation *(3.3)* and the tranversality condition *(3.4)*. The resulting first order condition is:

$$\frac{d}{d} \frac{cp_{t+i}}{(t+i)} = \left\{ \left(R_{t+i} + PRD \right) - \left(RTP + PRD \right) \right\} cp_{t+i} = \left(R_{t+i} - RTP \right) cp_{t+i} . \tag{3.6}$$

This Euler equation states that individual consumption varies positively with the difference between the real rate of interest and the rate of time preference. Interest rates above the subjective discount rate will be associated with higher levels of consumption, while interest rates below it, will cause lower consumption levels. Integrating *(3.6)* gives the optimal level of individual consumption in period t:

$$cp_t = \left(RTP + PRD \right) \left(hwf_t + hwh_t \right) . \tag{3.7}$$

Thus, the consumption level depends on the sum of financial and human wealth in period t, from which a constant fraction, $RTP + PRD$, will be consumed. The propensity to consume is independent of the interest rate because of the logarithmic utility function. It is also independent from the individual's age because the probability of death is assumed to be constant.

Since individuals of a generation are identical, the individual optimality condition holds for the whole generation. In order to achieve a representation of aggregate consumption we have to sum over generations of different size which does not affect the shape of the optimal consumption function *(3.7)*. Instead, different concepts for financial and human wealth must be used. The optimal level of aggregate consumption CP_t is:

$$CP_t = \left(RTP + PRD \right) \left(HWF_t + HWH_t \right), \tag{3.8}$$

where HWF_t represents aggregate financial wealth and HWH_t aggregate human wealth.

The formulas for the accumulation of aggregate financial wealth recognise that the effect of uncertain life time cancels throughout generations because financial wealth at death is collected by the insurance scheme and redistributed to surviving individuals. The accumulation equation for the society is:

$$\frac{dHWF_t}{dt} = R_t HWF_t + YL_t - CP_t\,, \tag{3.9}$$

where YL_t is aggregate labour income in period t. Aggregate financial wealth accumulates only at the rate R_t because $PRD\ HWF_t$ is a pure transfer from dying individuals to survivors through the insurance fund. Consequently, the individual rate of return on wealth is above social returns.

In order to derive the behaviour of aggregate human wealth, HWH_t, we have to define the distribution of labour income among individuals at any point in time. Since labour income may depend on the age profile of an individual, we will introduce an additional parameter, φ, that characterises the curvature of labour income with increasing age. Aggregate human wealth then corresponds to the present value of future disposable income of private households net of profits and interest income, $HYNSI_t$:

$$HWH_t = \int_t^{\infty} HYNSI_{t+i} \exp\left(\int_t^{t+i} \left(\varphi + PRD + r_j \right) dj \right) di\,, \tag{3.10}$$

where the discount factor now includes the change in labour income with increasing age. This formulation allows for exponentially growing or falling age income profiles. If $\varphi = 0$ the age income profile is flat and labour income is independent of age. Any positive value of φ results in a falling individual income over time and, thereby, will increase the discount factor and reduce the value of aggregate human wealth relative to the case of age independent income profiles. A falling age income profile over time is consistent with a reduction in income levels after retirement.

This small scale consumption model implies that the propensity to consume and the discount rate for human wealth are increasing functions of the probability of death. If individuals face a longer life horizon, the probability of death, *PRD*, will get smaller and the propensity to consume will decrease, while at the same time the value of human wealth will increase because of the lower discount factor.

The introduction of a negative slope in the age income profile has implications for the dynamics and the steady state behaviour of the model. Assuming a stationary economy or, equivalently, subtracting the constant trend growth from all relevant variables, Blanchard and Fischer (1989) show that this model is saddle path stable. This property holds if the production function has constant returns to scale and the rate of capital depreciation is constant. Both assumptions are satisfied in our model.

3.2 The Implementation of the Perpetual Model of Youth in A-LMM

The perpetual youth model is based on an economy without state intervention. To achieve a realistic framework, we will have to introduce taxes and transfers into the definition of income. The optimal level of aggregate consumption is given by equation *(3.8)*. If aggregate consumption follows such a rule, households will smooth their consumption over life time. If actual income is below its expected value, households will accumulate debt, while they start saving in periods when actual income is in excess of expected income. If one allows for uncertainty about future labour income and returns on assets by introducing stochastic shocks with zero mean and assumes a quadratic utility function, the time series for aggregate consumption follows a random walk (Hall*,* 1978). Such a process for private consumption implies that there is no significant correlation between actual disposable income and private consumption. Actually, the correlation between both variables in Austria is 0.99 (1976 through 2002). Many empirical studies on the behaviour of consumption find a stable and long-run relation between consumption and disposable income, which is only a fraction of human wealth and which fluctuates more strongly.

Davidson et al. (1978) develop the workhorse for empirical consumption functions, which is still widely tested and applied, cf. Clements and Hendry (1999). Wüger and Thury (2001) base their consumption model also on the error correction mechanism approach. Their estimation results for quarterly data are the most recent for Austria.

Models based on the error correction mechanism clearly contradict the notion of consumption following a random walk. Thus for a better fit of data we will follow Campbell and Mankiw (1989) and introduce two groups of consumers. The first group follows the optimal consumption rule resulting from the solution of the above maximisation problem. A fraction λ of the population belongs to the second group which follows a different rule. The second group are the so called rule-of-thumb consumers, because they consume their real disposable income YDN_t/P_t. Nominal disposable income, YDN_t, will be divided into two components:

$$YDN_t = HYNSI_t + \left(HYS_t + HYI_t\right), \tag{3.11}$$

where by definition:

$$HYNSI_t = YDN_t - \left(HYS_t + HYI_t\right). \tag{3.11'}$$

These two components differ according to their source of income. The variable HYS_t represents income from entrepreneurial activity and HYI_t corresponds to interest earnings, both at current prices. All other nominal income components are for simplicity related to labour market participation and are summarised as $HYNSI_t$ (cf. section 6). This distinction follows our definition of human and financial wealth.

The rule of thumb behaviour can be motivated by liquidity constraints that prevent households from borrowing the amount necessary to finance the optimal consumption level (Deaton, 1991). Quest II, the multi country business cycle model of the European Commission also uses this approach (Roeger and In't Veld, 1997).

By assuming two groups of consumers we arrive at the following aggregate consumption function:

$$CP_t = CONCP + (1-\lambda)(RTP + PRD)(HWH_t + HWF_t)\frac{P_t}{PC_t} + \lambda\frac{YDN_t}{PC_t} \quad ,(3.12)$$

where $CONCP$ is a constant. The fraction of liquidity constrained households $\lambda = 0.3$, the rate of time preference $RTP = 0.0084$ and $PRD = 0.02$ are set in accordance with Roeger and In't Veld (1997). The value for PRD implies a fifty year forward looking horizon. We also tried a time variable version for PRD that accounts for the increase in the expected average age of the Austrian population (Hanika, 2001), but the difference is minimal.

Savings of private households in period t result from the difference between disposable income and private consumption ($YDN_t - CP_tPC_t$).

Human capital is computed as the discounted sum of future disposable non-entrepreneurial income, $HYNSI_t$, plus distributed profits of the business sector from the current period. The discount factor comprises not only the interest rate but also the probability of death:

$$HWH_t = \sum_{i=0}^{30} \frac{HYNSI_{t+i}}{P_{t+i}} \frac{1}{(1 + R_{t+i} + PRD)^i} . \quad (3.13)$$

Because a forward looking horizon of 30 years with a real rate of interest of 3% and a probability of death of 2% captures already 80% of the present value of the future income stream, we choose 30 years as the cut off date. As can be seen from (3.13) we assume a constant age income profile, i.e., $\varphi = 0$. Actually, age income profiles for blue collar workers are of this shape, whereas white collar workers have hump shaped profiles, and civil servants show increasing age income profiles (Alteneder, Révész and Wagner-Pinter, 1997, Url, 2001).

There is a trade off between achieving more accuracy in the computation of human capital and a longer forward looking period needed in this case. The cut off date of 30 years implies comparatively short forward looking solution periods. This is preferable in our situation because the available horizon of the population forecast is 2075 and we have to rely on a simple extrapolation of the population beyond that date.

Financial wealth is computed as the sum of three components: the initial net foreign asset position of Austria at current prices at the beginning of period t, NFA_t, and the present value of future gross operating surplus, GOS_t, as well as the future current account balances, CA_t, is the forward looking component of aggregate financial wealth HWF_t:

$$HWF_t = \frac{(1-QHYS_t)GOS_t}{P_t} + \sum_{i=1}^{30}\left(\frac{GOS_{t+i}+CA_{t+i}}{P_{t+i}}\right)\frac{1}{(1+R_{t+i}+PRD)^i} + \frac{NFA_t}{P_t} \tag{3.14}$$

In order to avoid double counting we only put retained earnings from the current period into the computation of financial wealth for period t. For all future periods we use the discounted sum of future total gross operating surplus. This formulation departs from equation *(3.9)*, which uses initial financial wealth and adds interest as well as national savings. The reason is, first, that we have to capture the open economy characteristic of Austria. Today's negative net foreign asset position will result in a transfer of future interest payment abroad and thus reduce future income from wealth.

Second, by including the gross operating surplus, GOS_{t+i}, into *(3.14)* we use the standard valuation formula for assets. Assets are valued by their discounted stream of future income. This formulation has the big advantage that all sources of capital income enter the calculation of financial wealth. This includes also hard to measure items like the value of small businesses not quoted on a stock exchange and retained earnings. We also do not distinguish between equity and bonds. Bonds will be regarded as net wealth as long as the stream of interest payments has a positive value.

Because individuals only consider after tax income in their consumption decision, the impact of deficit financed government spending on the households' consumption level depends on the timing between spending and taxation. Equivalently to human wealth our discount horizon is cut off at 30 years. This implies that compensatory fiscal and social policy decisions which are delayed beyond this cut off date will not affect the actual consumption decision and thus, Ricardian equivalence does not hold in our model.

4. The Labour Market

The labour market block of the model consists of three parts (labour supply; labour demand; wage setting, and unemployment). In the first part aggregate labour supply is projected until 2075. Total labour supply is determined by activity rates of disaggregated sex-age cohorts and the respective population shares. Labour demand is derived from the first order conditions of the cost minimisation problem. Real wages are assumed to be determined in a bargaining framework and depend on the level of (marginal) labour productivity, the unemployment rate, and a vector of so-called wage push factors (tax burden on wages and the income replacement rate from unemployment benefits).

For the projections of labour supply and the wage equation we use elements of the neo-classical labour supply hypothesis (Borjas, 1999). There labour supply is derived from a household utility function where households value leisure positively. Supplied hours of work depend positively on the net real wage rate (substitution effect) and negatively on the household wealth (income effect). Households choose their optimal labour supply such that the net real consumption wage is equal to the ratio between marginal utility of leisure and the marginal utility of consumption.

We use the following data with respect to labour. Total labour supply, LF_t, comprises the dependent employed, LE_t, the self-employed, LSS_t, and the unemployed, LU_t. We take our data from administrative sources (Federation of Austrian Social Security Institutions[3] for LE_t, AMS for LU_t, WIFO for LSS_t)[4] and not from the labour force survey. Only this database provides consistent long-run time series for the calculation of labour force participation rates. Note that the reported activity rates are below the values from the labour force survey. Dependent labour supply (employees and unemployed), LS_t, and the unemployed are calculated as:

$$LS_t = QLS_t \, LF_t \, . \tag{4.1}$$

$$LU_t = LS_t - LE_t \, . \tag{4.2}$$

In the projections we set $QLS = 0.9$, the value for the year 2002. Therefore LSS_t amounts to 10% of LF_t. In our projections we differentiate between self-employed

[3] Hauptverband der österreichischen Sozialversicherungsträger.
[4] For a description of the respective data series see Biffl (1988).

persons in agriculture, $LSSA_t$, and in other industries, $LSSNA_t$. $LSSA_t$ is calculated as:

$$LSSA_t = QLSSA_t \, LSS_t \,. \tag{4.3}$$

$QLSSA_t$ denotes the share of $LLSA_t$ in LSS_t. We project a continuously falling $QLSSA_t$, which assumes an ongoing structural decline in agriculture[5].

In LE_t persons on maternity leave and persons in military service (Karenzgeld- bzw. Kindergeldbezieher und Kindergeldbezieherinnen und Präsenzdiener mit aufrechtem Beschäftigungsverhältnis − $LENA_t$) are included due to administrative reasons. In the projection of $LENA_t$ we assume a constant relationship, $QLENA_t$, between $LENA_t$ and the population aged 0 to 4 years, $POPC_t$, which serves as proxy for maternity leave. We use the number of dependent employed in full-time equivalents, LD_t, as labour input in the production function. The data source for employment in full-time equivalents is Statistics Austria. Employment (in persons) is converted into employment in full-time equivalents through the factor QLD_t. For the past, QLD_t is calculated as $LD_t/(LE_t\text{-}LENA_t)$. QLD_t is kept constant over the whole forecasting period at 0.98, the value for 2002).

QWT_t denotes an average working time-index, which takes the development of future working hours into account. QTW_t is calculated in the following way: the share of females in the total labour force times females average working hours plus the share of males in the labour force times the average working hours of males. The average working time for males and females is 38.7 hours per week and 32.8 hours per week, respectively. These values are taken from the Microcensus 2002. QWT_t is standardised to 1 in 2002. In general we could simulate the impact of growing part-time work on production by changing average working time of males and females, respectively. In our scenarios we assume constant working hours for males and females, respectively, over time. An increasing share of females in the labour force implies that total average working time will fall. The relationship between LE_t and LD_t is as follows:

$$LE_t = \frac{LD_t}{QLD_t \, QWT_t} + LENA_t \,. \tag{4.4}$$

[5] We thank Franz Sinabell (WIFO) for providing information about the future development of $QLSSA_t$.

4.1 Labour Supply

In this section we present two scenarios for labour supply in Austria covering the period 2003 to 2075. The development of the Austrian labour force depends on the future activity rates and the population scenario. In our model population dynamics is exogenous. We use three different scenarios of the most recent population projections 2000 to 2075 (medium variant; high life expectancy; low fertility) by Statistics Austria[6] (Statistics Austria, 2003, Hanika et al., 2004).

We project the activity rates for 6 male (PRM_{1t} to PRM_{6t}) and 6 female (PRF_{1t} to PRF_{6t}) age cohorts separately. The following age groups are used (PRM_{it} and PRF_{it}: 15 to 24 years; 25 to 49 years; 50 to 54 years; 55 to 59 years; 60 to 64 years and 65 years and older). $POPM_{1t}$ to $POPM_{6t}$ and $POPF_{1t}$ to $POPF_{6t}$ denote the corresponding population groups. Total labour supply, LF_t, is given by

$$LF_t = \sum_{i=1}^{6} PRM_{it} POPM_{it} + PRF_{it} POPF_{it} \,. \qquad (4.5)$$

In order to consider economic repercussions on future labour supply we model future activity rates as trend activity rates, PRT_t, which are exogenous in A-LMM, and a second part, depending on the development of wages and unemployment:

$$PRM_{it} = PRTM_{it} + ELS \cdot WA_t \,; \qquad (4.6a)$$

$$PRF_{it} = PRTF_{it} + ELS \cdot WA_t \,. \qquad (4.6b)$$

ELS denotes the uniform participation elasticity with respect to WA_t, and WA_t is given by

$$WA_t = \log\left(\frac{w_t (1 - u_t)}{w_{2002} (1 + g_{wa})^t (1 - u_{wa})} \right). \qquad (4.7)$$

WA_t is a proxy for the development of the ratio of the actual wage to the reservation wage. It measures the (log) percentage difference between the actual wage at time t, weighted by the employment probability $(1 - u_t)$, and an alternative wage[7]. For the path of the alternative wage (see the denominator in 4.7) we assume for the

[6] We received extended population projections from Statistics Austria until the year 2125. Therefore we are able to solve the model until 2100.

[7] We use lagged WA_t instead of current WA_t to avoid convergence problems in EViews©.

future a constant employment probability $(1 - u_{wa})$ and that wages grow at a constant rate g_{wa}. In our simulations we set g_{wa} to 1.8% and u_{wa} to 5.4%. These values are taken from the simulation of our base scenario with the assumption $ELS = 0$ (see section 9.1.1). Setting g_{wa} and u_{wa} to these values implies (on average) the same values for the labour force in the base scenario with and without endogenous participation. With other words, our trend activity rate scenario implicitly assumes an average wage growth of 1.8% and an average unemployment rate of 5.4%.

Since no actual estimate for the Austrian participation elasticity is available we use an estimate for Germany with respect to gross wages and set $ELS = 0.066$ (Steiner, 2000). This estimate implies that a 10% increase in the (weighted) wage leads to a 0.66%age point increase in the participation rate.

In the following we explain the construction of the two activity rate scenarios. First we present stylised facts about labour force participation in Austria and actual reforms in the old-age pension system. Similar to most other industrialised countries, Austria experiences a rapid decrease in old age labour-force participation (see, e.g., Hofer and Koman, 2001). Male labour force participation declined steadily for all ages over 55 since 1955. This decrease accelerated between 1975 and 1985. In the 1990s, the labour force participation rate for males between age 55 and 59 stayed almost constant, but at a low level of 62% in 2001. The strongest decrease can be observed in the age group 60 to 64. In 1970, about 50% of this age group was in the labour market, as opposed to 15% in 2001. The pattern of female labour force participation is different. For age groups younger than 55 labour force participation increased, while for the age group 55 to 59 a strong tendency for early retirement can be observed. One should keep in mind that the statutory retirement age was 60 for women and 65 for men until 2000. In the period 1975 to 1985 the trend towards early retirement due to long-time insurance coverage or unemployment shows a strong upward tendency. This reflects up to a certain extent the deterioration of the labour market situation in general. Early retirement was supported by the introduction of new legislation. Given the relatively high pension expenditures and the aging of the population, the government introduced reforms with the aim to rise the actual retirement age and to curb the growth of pension expenditures. For example, the reform in 2000 gradually extended the age limit for early retirement due to long-time insurance coverage to 56½ years for female and 61½ years for male. The recent pension reform abolishes early retirement due to long-time insurance coverage gradually until 2017. Starting from the second half of 2004, the early retirement age will be raised by one month every quarter.

4.1.1 Baseline Trend Labour Supply Scenario

In the following we explain the construction of the baseline trend labour supply scenario. We model the trend participation rates outside the macro-model because empirical evidence shows that the retirement decision is determined by non-monetary considerations and low pension reservation levels (Bütler et al., 2004). The Austrian pension reform 2003 increased the statutory minimum age for retirement and leaves only small room for individual decisions on the retirement date.

Projections of aggregate activity rates are often based on the assumption that participation rates by age groups remain unchanged in the future (static scenario). Another methodology used for long-term labour force projections is to extrapolate trends for various age and sex groups (see, e.g., Toossi, 2002). This method assumes that past trends will continue.

We use trend extrapolation to derive scenarios for the female labour supply in the age group 25 to 49. In general, we project that the trend of rising female labour force participation will continue. We use data on labour force participation rates for age groups 20 to 24, 25 to 29, 30 to 39, and 40 to 49 since 1970 and estimate a fixed effects panel model to infer the trend. In our model labour force participation depends on a linear trend, a human capital variable (average years of schooling) and GDP growth. We apply a logistic transformation to the participation rates (see Briscoe and Wilson, 1992). The panel regression gives a trend coefficient of 0.06. Using this value for forecasting female participation rates and the projected increase in human capital due to one additional year of schooling would imply an increase in the female participation rate of 15%age points until 2050. Given the increase in female participation in the last 30 years and the already relatively high level now, we assume that trend growth will slow down and only ⅔ of the projected increase will be realised. This implies that the female participation rate in the 25 to 49 year cohort will increase from 73% in 2000 to 83% in 2050. With respect to male labour force participation in the age group 25 to 49 years we assume stable rates. Given these projections the gender differential in labour force participation would decrease from 15%age points in 2000 to 7percentage points in 2050 in the age group 25 to 49. For the age cohort 15 to 24 years we project stable rates for males and a slight reduction for females, where the apprenticeship system is less important.

Austria is characterised by a very low participation rate of older workers. In the past, incentives to retire early inherent in the Austrian pension system have contributed to the sharp drop in labour force participation among the elderly (Hofer and Koman, 2001). In our scenario the measures taken by the federal government to abolish early retirement due to long-time insurance coverage reverse the trend of labour force participation of the elderly (see Burniaux et al., 2003 for international evidence).

We project the following scenario for the different age cohorts (chart 4.2). For the male 50 to 54 age cohort we observe a drop from 87% to 80% in the last ten years. We project a slight recovery between 2010 and 2025 to 85% and a constant rate afterwards. A similar tendency can be observed for the age cohort 55 to 60.

The participation rate is expected to increase from 68% in 2002 to 77% in 2030. The activity rate of 77% corresponds to the values in the early eighties. The abolishment of the possibility for early retirement due to long-time insurance coverage should lead to a strong increase in the participation rate of the age group 60 to 64. We project an increase to 50% until 2025. Note that the higher participation rates in the age cohorts under the age of 60 automatically lead to a higher stock of employees in the age group of 60 to 64 in the future. For the age group 64 plus we assume a slight increase. These projections imply for the male participation rate a steady increase to 82% until the end of the projection period. Therefore, our projections imply that male participation reverts to the values recorded in the early eighties.

The long-run projections of female participation rates for the elderly are characterised by cohort effects and by changes in pension laws. For the age group of 50 to 54 we project a steady increase from 65% to 76% in 2050. We project an increase from 33% in 2002 to 57% in 2050 for the age group 55 to 59. For the age cohort 60 to 64 years we expect a slight increase until 2025 mainly due to cohort effects. In the period 2024 to 2033 the female statutory retirement age will be gradually increased from 60 to 65 years. Therefore we expect a strong increase in the participation rate of this group from 20% in 2025 to 38% in 2040. Our projections imply for the female participation rate of the age group 15 to 64 a slight increase from 60% in 2002 to 63% in 2025. Due to cohort effects and the change in statutory retirement age the trend in the activity rate increases in the following years. At 2050 the participation rate of females amounts to 70%.

We extend our projections up to 2075 by assuming constant participation rates for all sex-age groups as of 2050. One should note that we have projected a relatively optimistic scenario for the trend activity rate. This scenario implies that the attachment of females to the labour market will be considerably strengthened and the pension reform leads to a considerable increase in the labour force. As the activity rate is an important factor for economic growth in A-LMM, we have developed a second labour force scenario.

The static approach is one alternative for constructing the second scenario. However, due to problems with this method (see below) we use a dynamic approach (see Burniaux et al., 2003). Additionally, we add more pessimistic assumptions concerning the impact of the pension reform. We follow the OECD in calling this method dynamic approach, because it extends the static approach by using information about the rate of change of labour force participation rates over time. To avoid misunderstandings, the baseline trend labour supply scenario is not based on a static approach. In the following we describe the methodology and the results of the alternative activity rate scenario.

4.1.2 Dynamic Activity Rate Scenario

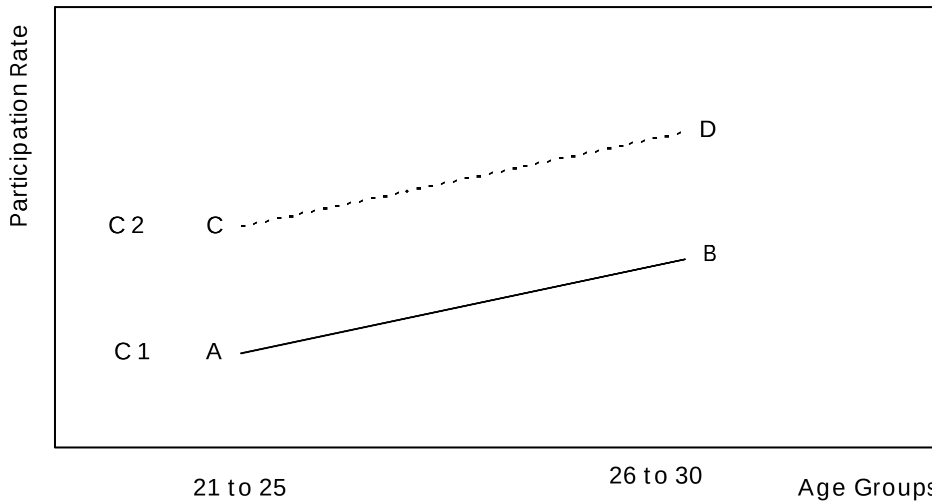
Projections of aggregate activity rates are often based on the assumption that activity rates by age groups remain at the current level (i.e., the "static approach"). These projections are static in the sense that they do not incorporate the dynamics resulting from the gradual replacement over time of older cohorts by new ones with different characteristics. The static model runs into problems if cohort specific differences in the level of participation rates exist, e.g., a stronger attachment of females to the labour market. For that reason we use the dynamic model of *Scherer* (2002), considering cross-cohort shifts of activity. This projection method is based on an assumption that keeps lifetime participation profiles in the future parallel to those observed in the past (see Burniaux et al. 2003, pp. 40ff.).

Chart 4.1 gives a simplified example of the difference between the static and dynamic approach to model the evolution of participation rates over time. Assume two female cohorts (C1 and C2) in 2002: C1 is aged 26–30 and C2 is aged 21–25. Chart 4.1 shows how the activity rate for C2 in the year 2007 is projected. Note that A and B are the observed activity rates for C1 at age 21–25 (in the year 1997) and age 26–30 (in the year 2002), respectively. For C2 we observe C, the activity rate at the age 21–25 in 2002, and we have to project the activity rate of C2 at the age of 26–30 in the year 2007. In the static approach the activity rate of C1 at the age of 26–30 (B) is used as estimate for the activity rate of C2 at age 26–30.

The dynamic approach takes account of the difference in the activity rates of the two cohorts at the age 21–25. The dynamic approach uses information about the change in the activity rate of C1 between age 21–25 and age 26–30. The activity rate of C2 is projected to grow at the same rate as the activity rate of C1 did between 1997 and 2002 (illustrated by the parallel lines in chart 4.1). Therefore, in the dynamic approach, the activity rate of C2 at the age of 26–30 is projected to be D in 2007.

Note that the assumption of an unchanged (age specific) participation rate has been replaced by the assumption of an unchanged (age specific) slope of the lifetime participation profile. In other words, the (age specific) probabilities of entry and exit in and out of the labour market are assumed constant in the dynamic approach.

Chart 4.1: The Dynamic Projection Approach. Dynamic versus Static Participation Rates



Formally, the dynamic projection method is based on the observed distribution of entry and retirement probabilities by age. Let $PR^t_{x,x+4}$ be the activity rate of age group x to $x+4$ in period t (e.g., the activity rate of the age group 20 to 24 in 2002). Then the probability $WX^t_{x,x+4}$ of persons aged x to $x+4$ to retire before period t and $t+5$, respectively, is

$$WX^t_{x,x+4} = 1 - \frac{PR^t_{x+5,x+9}}{PR^{t-5}_{x,x+4}} \geq 0, \qquad (4.8)$$

the probability WN^t_x to enter into the job market is

$$WN^t_{x,x+4} = 1 - \frac{\overline{PR} - PR^t_{x+5,x+9}}{\overline{PR} - PR^{t-5}_{x,x+4}} \geq 0, \qquad (4.9)$$

where $\overline{PR}$ is an upper limit on activity rates (we assume 99% for men and 95% for women).

We use the male and female activity rates in 5-year age-groups (15 to 19, 20 to 24, ... , 60 to 64 and 65 plus) for the years 1997 and 2002, respectively, to calculate the entry and retirement probabilities for the year 2002 for men and women separately (4.8 and 4.9). Based on the assumption that these probabilities will not change during the projection period 2003 to 2075, the projected activity rates for this period are given by (t = 2003,...,2075):

$$\begin{aligned}
&PR^{t}_{x+5,x+9} = PR^{t-5}_{x,x+4}\left(1 - WX^{2002}_{x,x+4}\right), && \text{if } WX^{2002}_{x,x+4} > 0,\\
&PR^{t}_{x+5,x+9} = \overline{PR} \cdot WN^{2002}_{x,x+4} + PR^{t-5}_{x,x+4}\left(1 - WN^{2002}_{x,x+4}\right) && \text{if } WN^{2002}_{x} > 0,\\
&PR^{t}_{x+5,x+9} = PR^{t-5}_{x,x+4}, && \text{otherwise.}
\end{aligned} \tag{4.10a}$$

We assume constant activity rates for the age groups 15 to 19 and 20 to 24:

$$PR^{t}_{15,19} = PR^{2002}_{15,19}, \quad t = 2003,...,2075. \tag{4.10b}$$

$$PR^{t}_{20,24} = PR^{2002}_{20,24}, \quad t = 2003,...,2075. \tag{4.10c}$$

Women today are more active than decades ago. This catching-up process vis-à-vis men is currently still in progress, but this may not be the case for the entire future. For this reason the non-critical application of this model (which comprehend this current catching-up process) would lead to implausible results for female activity rates. Therefore, we make the following four assumptions:

1) The activity rates of women aged 35 to 39 is not higher than the activity rates of women aged 30 to 34:

$$PR^{female,t}_{35,39} \leq PR^{female,t}_{30,34}. \tag{4.11a}$$

2) The activity rates of women aged 45 to 49 is not higher than the activity rates of women aged 40 to 44:

$$PR^{female,t}_{45,49} \leq PR^{female,t}_{40,44}, \tag{4.11b}$$

3) The activity rates of females in the age group 50–54 increased considerably over the last five years. Using the resulting exit probabilities would lead to unreasonably high activity rates in the future. Therefore, we use the average of the male and female exit probability:

$$WX^{female,new,t}_{50,54} = \frac{WX^{female,t}_{50,54} + WX^{male,t}_{50,54}}{2}, \tag{4.11c}$$

4) The activity rate of the age group 65+ does not exceed 5%:

$$PR_{65+}^{male,t} \leq 0.05 \, , \; PR_{65+}^{female,t} \leq 0.05 \, . \qquad (4.11d)$$

All modifications replace the original values in the calculations, thus they lead to changes in the successive age groups of the same cohorts indirectly.

We make the following assumptions with respect to the effects of the pension reform of 2003. We calculated the activity rates for males and females under the assumption that $^2/_3$ of all persons currently in early retirement due to long-term insurance coverage and $^4/_5$ of all persons in early retirement due to unemployment would be in the labour force. Note that this seems to be a rather conservative assumption about the effects of the pension reform. This exercise yields an increase in the participation rate of females in the age group of 55 to 60 of 17 percentage points, and 21 percentage points for males aged 60 to 64, respectively. We consider the transition period until 2017 by assuming a linear increase of the activity rate. With respect to the impact of the increasing statutory retirement age for females, we assume an increase in the participation rate in the age group 60 to 64 by 21%age points until 2033.

The projection method yields the following results with respect to PRT_1 to PRT_6 (see chart 4.3). The participation rate of the young age-cohort is assumed to remain constant. The activity rate of males aged 25–49 will fall from 88.2% to 86.3%. For the age cohorts 50–54 (55–59) we project a 3 (4.5) percentage point decrease in the participation rate to 77.4% (62.5%). Due to the effects of the pension reform 2003, we project an increase of 21.3 percentage points in the age cohort 60–64. Overall the male activity rate is almost unchanged and amounts to 75.5%. For females we project a significant increase in all age cohorts but the first. This is caused by the catching up of females and is further augmented by the pension reform. According to the projections the activity rate of females aged 25–49 will increase by 4.3%age points to 79.3%. For the age group 50–54 we expect an increase from 64.7% to 77.5%. The cohort effect and the pension reform will cause a strong increase in the participation rate of females aged 55–59 from 33.4% to 60%. For the age cohort 60–64 the activity rate will increase from 5.1% to 34.4%. In total the female activity rate will increase from 60% to 71.6%.

Biffl and Hanika (2003) provide also a long-term labour force projection for Austria. According to their main variant the Austrian labour force will increase by 4.4% between 2002 and 2031. Hence labour force growth from Biffl and Hanika is stronger as in our baseline scenario (1.8%). The main difference is caused by the assumptions concerning the development of the female labour force. In our scenarios we make relative conservative assumptions about future female activity rates. In contrast, Biffl and Hanika project that the increasing trend in female activity rates will continue until the Austrian rates are similar to the rates of the

Nordic countries. Extending the projection period to the year 2050 considerably narrows the gap between our baseline scenario and that of Biffl and Hanika. In our baseline scenario labour force declines by 3.2% between 2002 and 2050; in Biffl and Hanika the decline amounts to 2.6%. One should further note that Biffl and Hanika expect that working time will be reduced for both sexes. Overall both projections are relatively similar, given the uncertainty and the long projection period, and more optimistic than the forecasts in Burniaux et al. (2003).

4.2 Labour Demand

In our model the production technology is expressed in terms of a two-factor (labour and capital) constant returns-to-scale Cobb-Douglas production function. Labour input, LD_t, is measured as the number of dependent employed persons in full-time equivalents. Consistent with the production technology, optimal labour demand, LD^*_t, can be derived from the first order conditions of the cost minimisation problem as follows

$$\log(LD_t^*) = \log(1 - ALPHA) - \log(W_t) + \log(Y_t)\,. \qquad (4.12)$$

Labour demand rises with output, Y_t, and is negatively related to real wages, W_t. As it takes time for firms to adjust to their optimal workforce (Hamermesh, 1993), we assume the following partial adjustment process for employment. The partial adjustment parameter *ALD* denotes the speed of adjustment:

$$\left(\frac{LD_t}{LD_{t-1}}\right) = \left(\frac{LD_t^*}{LD_{t-1}}\right)^{ALD}, \qquad (4.13)$$

with $0 < ALD < 1$. Actual labour demand is then given by

$$\log(LD_t) = ALD\big(\log(1 - ALPHA) - \log(W_t) + \log(Y_t)\big) + (1 - ALD)\log(LD_{t-1})\,. \qquad (4.14)$$

The speed of adjustment parameter *ALD* is set to 0.5.

4.3 Wage Setting and Unemployment

We follow the simple theoretical framework of *Blanchard* and *Katz* (1999) to motivate the wage equation in our model. Wage setting models imply that, given the workers' reservation wage, the tighter the labour market, the higher will be the real wage. Bargaining and efficiency wage models deliver a wage relation that can be represented as

$$\log\left(\frac{wn_t}{p_t}\right) = \mu\log(b_t) + (1-\mu)\log(prod_t) - \gamma_1 U_t\,, \tag{4.15}$$

where wn_t and p_t (the actual instead of the expected value as in Blanchard and Katz*,* 1999) are, respectively, the nominal wage and the price level, b_t denotes the reservation wage and $prod_t$ labour productivity. The parameter μ ranges from 0 and 1. The replacement rate of unemployment benefits is one important determinant of the reservation wage. The dependency of unemployment benefits on previous wages implies that the reservation wage will move with lagged wages. Another determinant of the reservation wage is the utility of leisure that includes home production and earning opportunities in the informal sector. Assume that increases in productivity in home production and in the informal sector are closely related to those in the formal sector. This implies that the reservation wage depends on productivity. Furthermore, the condition that technological progress does not lead to a persistent trend in unemployment implies that the reservation wage is homogeneous of degree 1 in the real wage and productivity in the long-run. Blanchard and Katz (1999) state the following simple relation among the reservation wage, the real wage, and the level of productivity, where λ is between 0 and 1

$$\log(b_t) = \alpha + \lambda\log\left(\frac{wn_{t-1}}{p_{t-1}}\right) + (1-\lambda)\log(prod_t)\,. \tag{4.16}$$

Substituting b_t into the wage equation (4.15) and rearranging we receive the following equation:

$$\Delta\log(wn_t) = \mu\alpha + \Delta\log(p_t) - (1-\mu\lambda)\log\left(\frac{wn_{t-1}}{p_{t-1}prod_{t-1}}\right)$$

$$+(1-\mu\lambda)\Delta\log(prod_t) - \gamma_1 U_t\,. \tag{4.17}$$

This reformulation shows the connection between the wage curve, a negative relation between the level of the real wage and unemployment, and the (wage) Philips-curve relationship as a negative relationship between the expected change of the real wage and the unemployment rate.

Whether μ and λ are close to 1 or smaller has important consequences for the determination of equilibrium unemployment. Empirical evidence indicates that $\mu\lambda = 1$ is a reasonable approximation for the USA, whereas in Europe $(1-\mu\lambda)$ is on average around 0.25 (Blanchard and Katz, 1999). We close our model of the labour market with the following demand wage relation, where z_t represents any factor, e.g., energy prices, payroll taxes, interest rates, that decreases the real wage level conditional on the technology used:

$$\log\left(\frac{wn_t}{p_t}\right) = \log(prod_t) - z_t\,. \tag{4.18}$$

For constant z and *prod* the equilibrium unemployment rate, u^*, is:

$$u^* = \left(\frac{1}{\gamma_1}\right)\left[\mu\alpha + (1-\mu\lambda)z\right]. \tag{4.19}$$

If $\mu\lambda$ is less than unity, the higher the level of z, the higher will be the natural rate of unemployment.

OECD and IMF have pointed out repeatedly the high aggregate real wage flexibility in Austria as a major reason for the favourable labour market performance. The characteristics of the wage determination process in Austria can be summarised as follows (see, e.g., Hofer and Pichelmann, 1996, Hofer, Pichelmann and Schuh, 2001). The development of producer wages essentially follows an error correction model, whereby the share of national income claimed by wages serves as the error correction term. This implies that the labour share remains constant in long-term equilibrium. In terms of dynamics, this corresponds to the well-known relationship of real wage growth (based on producer prices) being equal to the increase in productivity. Note, however, that wage growth is lagging behind productivity since the second half of the 1990s. Inflation shocks triggered by real import price increases or indirect tax increases were fully absorbed in the process of setting wages to the extent that such price shocks apparently did not exert any significant influence on real producer wages. However, the increase in the direct tax burden on labour (primarily in the form of higher social security contributions) seems to have exerted significant pressure on real product wages (see also Sendlhofer, 2001).

Based on the aforementioned empirical findings for Austria and the theoretical considerations we set up a wage equation for Austria. We assume no errors in price expectations and model only real wages per full-time equivalent, W_t. W_t is determined in a bargaining framework and depends in the long-run on the level of (marginal) labour productivity, MPL_t, the unemployment rate, U_t, and several wage push factors, such as the tax wedge on labour taxes, $TWED_t$, and the gross replacement rate, GRR_t, (i.e., the relation of unemployment benefits to gross wages) and $CONW_t$. $CONW_t$ is an exogenous variable used to calibrate the rate of structural unemployment. We postulate the following wage equation:

$$\log(W_t) = CONW_t + \alpha_1 MPL_t - \alpha_2 UR_t + \alpha_3 TWED_t + \alpha_4 GRR \quad (4.20)$$

MPL_t is derived from the Cobb-Douglas production function:

$$\log(MPL_t) = \log(1 - ALPHA) + \log(Y_t) - \log(LD_t)\,. \quad (4.21)$$

Following our theoretical considerations and empirical estimates for Austria (e.g., Hofer, Pichelmann and Schuh, 2001) we set $\alpha_1 = 1$. We estimate α_2 the coefficient of the dampening influence of unemployment on wages to be around 2. Note that a higher coefficient implies a lower equilibrium unemployment rate. $TWED_t$ is defined as the log of gross compensation of employees over net wages and salaries. The wedge includes social security contributions and the tax on labour income. The tax wedge is calculated as

$$TWED_t = \log\left[\frac{YL_t}{(1 - RTW_t)(YL_t - QSCL_t SC_t)}\right], \quad (4.22)$$

where YL_t is the labour compensation, RTW_t wage tax rate, and $QSCL_t$ corrects for statistical discrepancy in the national accounts in security contributions, SC_t.

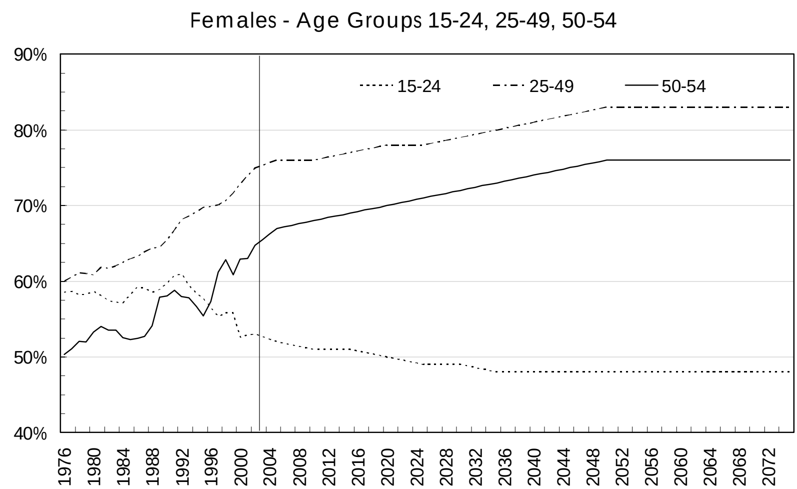
For α_3 we adopt a coefficient of 0.4[8]. This is in accordance with Pichelmann and Hofer (1996) and slightly below the values of Sendlhofer (2001). The data for the gross unemployment benefit replacement rate are taken from the OECD. In our estimation we cannot find any significant effect from GRR_t on wages (see also Sendlhofer, 2001). This could be caused by measurement errors. Due to theoretical reasons, we include GRR_t in our wage equation and calibrate $\alpha_4 = 0.3$ such that we receive a smaller effect of changes in GRR_t on unemployment as compared to the tax wedge. The ratio α_4/α_3 corresponds to the coefficients measuring the impact of the tax wedge, and the gross replacement rate, respectively, on the unemployment rate reported in Nickell et al. (2003).

Note that for an economy consistent with Cobb-Douglas technology equilibrium real wages are in steady state equal to (log) labour productivity plus the log of the labour share parameter (see, e.g., Turner et al., 1996). Under the condition that in the long-run real wages have to be equal to equilibrium real wages, the unique equilibrium rate of unemployment, U^*_t, is given by

[8] To avoid convergence problems in EViews©, we use the lagged value of $TWED_t$.

$$U_t^* = \frac{CONW_t + \alpha_3 TWED_t + \alpha_4 GRR}{\alpha_2}. \tag{4.23}$$

Chart 4.2: Activity Rates of Different Sex and Age Groups on the Austrian Labour Market (1976–2075)



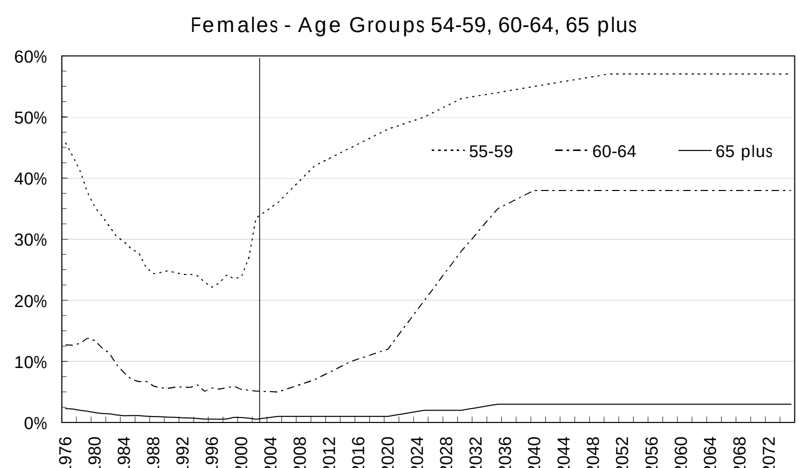
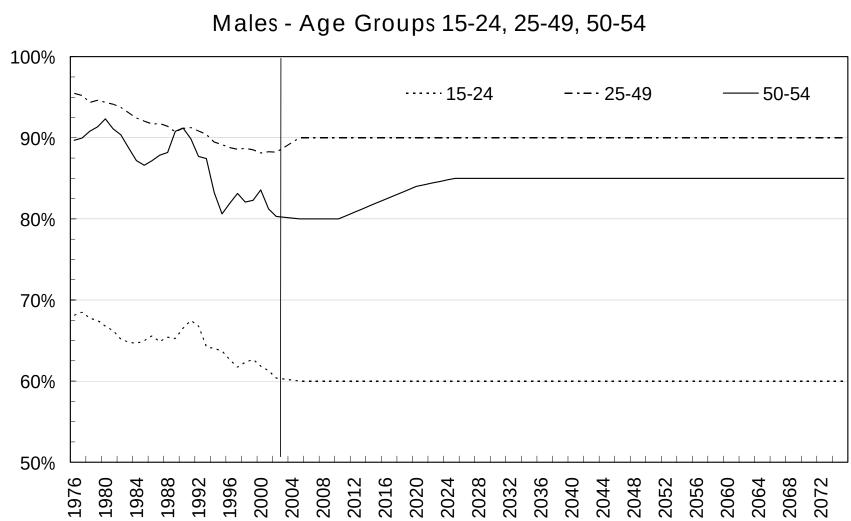
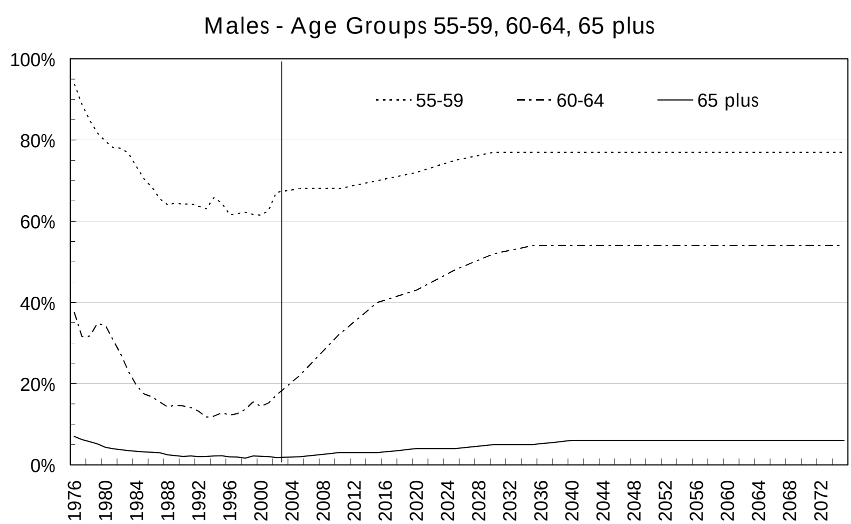


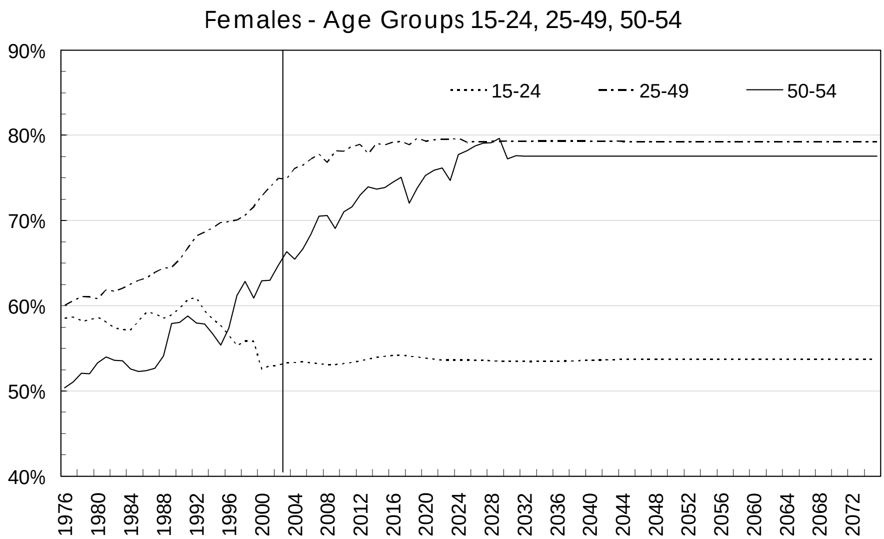
Chart 4.2 (continued): Activity Rates of Different Sex and Age Groups on the Austrian Labour Market (1976–2075)





Source: WIFO 1976–2002; 2003–2075 projections.

Chart 4.3: Dynamic Activity Rates of Different Sex and Age Groups on the Austrian Labour Market (1976–2075)



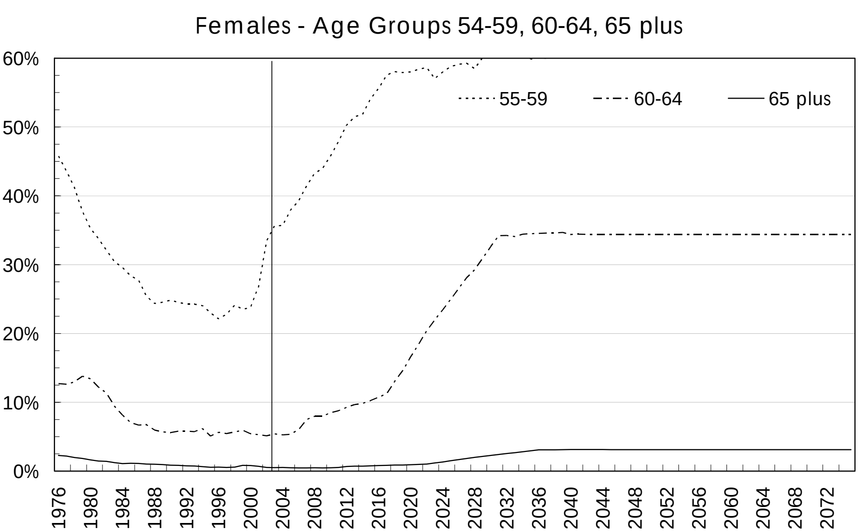
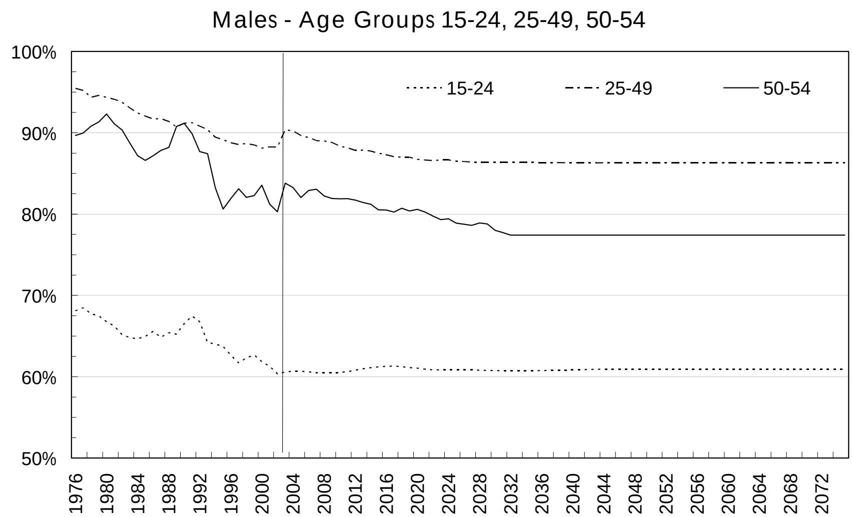
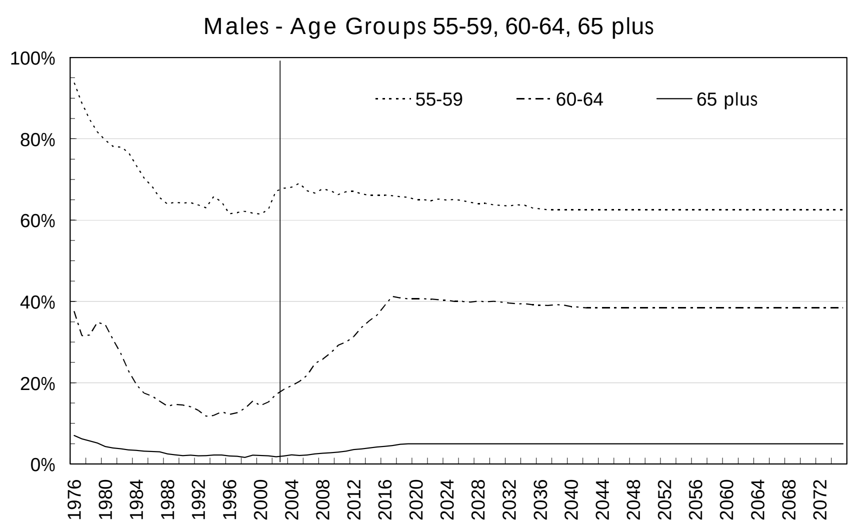


Chart 4.3 (continued): Dynamic Activity Rates of Different Sex and Age Groups on the Austrian Labour Market (1976–2075)





Source: WIFO 1976–2002; 2003–2075 projections.

5. Income Determination and Domestic Financial Balance

In this section we show how disposable income is related to gross domestic product. Since disposable income is usually measured at current prices we transform real variables by multiplication with the GDP-deflator, P_t, into nominal variables. The biggest component of national income is compensation of employees:

$$YL_t = W_t \ LD_t \ P_t \, . \tag{5.1}$$

For our particular purpose, we do not use the standard definition of national income; rather we include capital depreciation into national income. The gross operating surplus, GOS_t, thus corresponds to the sum of proprietors' income, the rental income of persons, corporate profits, net interest income, and capital depreciation. For its computation we use the identities from national income accounting. Starting from GDP at current prices, we subtract indirect taxes, $TIND_t$, and add subsidies SUB_t (cf. section 6). The Cobb-Douglas production function guarantees that factor shares will remain constant in the steady state. The gross operating surplus is

$$GOS_t = Y_t P_t - YL_t - (TIND_t \ - SUB_t) \, , \tag{5.2}$$

which includes capital depreciation into the gross operating surplus. This formulation has two specific purposes. First, it corresponds to the aggregate cash flow of firms and consequently we allow firms to distribute their full cash flow to households, i.e., we allow for the consumption of the capital stock at the rate of depreciation. Second, the investment decision of firms is based on cash flow considerations, cf. section 2.1.

The next step is to compute disposable income of private households from the nominal compensations of labour and capital. Labour income is supposed to be fully attributable to private households:

$$HYL_t = QHYL_t \ YL_t \, , \tag{5.3}$$

thus $QHYL_t$ is set to 1 for simulations. This assumption is fully backed by column one in table 5.1.

The computation of entrepreneurial income attributable to private households needs one more step. We have to recognise retained profits, interest income, as well as capital depreciation. For this reason income accrued by private households from entrepreneurial activity, HYS_t, is substantially lower than the gross operating surplus. We use the average share $QHYS$ = 0.33 from table 5.1:

$$HYS_t = QHYS_t \; GOS_t \, . \tag{5.4}$$

Table 5.1: Adjustment Factors and Shares to Compute Disposable Income of Private Households

	Labour income	Capital income	Interest income	Monetary transfers	Social security contribut.	Direct taxes	Other transfers
	QHYL	QHYS	QHYI	QHTRM	QHSC	QHTDIR	QHTRO
1995	1.007	0.331	0.174	1.198	1.110	0.858	0.014
1996	1.007	0.331	0.208	1.184	1.110	0.829	0.016
1997	1.006	0.329	0.217	1.164	1.112	0.836	0.011
1998	1.006	0.331	0.222	1.146	1.111	0.828	0.014
1999	1.005	0.335	0.225	1.146	1.111	0.851	0.012
2000	1.006	0.327	0.229	1.150	1.116	0.833	0.011
2001	1.006	0.327	0.223	1.140	1.128	0.782	0.023
2002	1.003	0.330	0.222	1.141	1.128	0.828	0.020
Mean	1.006	0.330	0.215	1.159	1.116	0.831	0.015
Standard deviation	0.001	0.003	0.018	0.022	0.008	0.022	0.004
Minimum	1.003	0.327	0.174	1.140	1.110	0.782	0.011
Maximum	1.007	0.335	0.229	1.198	1.128	0.858	0.023

Thereby, we assume that investment plans are not credit constrained. Again, this assumption results in a constant legal environment for simulations.

We differentiate between interest earned on foreign and domestic assets. The former is earned on the stock of net foreign assets accumulated in the past, NFA_{t-1}. Interest earned on domestic assets is modelled as the share of interest income in the gross operating surplus, $QHYI_t$, going to private households:

$$HYI_t = NFA_{t-1} RN_t + QHYI_t \; GOS_t \, . \tag{5.5}$$

This ratio varied between 0.17 and 0.23 (cf. table 5.1). The average value is biased from years with a lower tax rate (1995 and 1996). Therefore, we set $QHYI_t$ equal to 0.23 throughout the simulation period.

The fourth important component of disposable income of private households is monetary transfers received from the government, $HTRM_t$. We model transfer income mainly in the social security block of the model (cf. section 7) and adjust the sum of monetary payments by the health, pension, accident, and unemployment insurance system, and the long-term care expenditures, STR_t, by a factor, $QHTRM_t$, to the level given by the national accounts:

$$HTRM_t = QHTRM_t \; STR_t \, . \tag{5.6}$$

This factor slowly decreased from 1995 through 2002 (table 5.1). In simulations of future scenarios we will set the factor equal to 1.141.

Two components reduce disposable income of private households. These are social security contributions, HSC_t, and direct taxes, $HTDIR_t$. Both variables will be determined as ratios to total social contributions, SC_t, and total direct taxes, $TDIR_t$, respectively, according to the national accounts definition:

$$HSC_t = QHSC_t \; SC_t \, , \tag{5.7}$$

$$HTDIR_t = QHTDIR_t \; TDIR_t \, , \tag{5.8}$$

where $QHSC_t$ and $QHTDIR_t$ are those ratios. Table 5.1 shows that $QHSC_t$ increased in 2001 and 2002, reflecting revenue increasing reforms in the social security system. We use this fact and fix it for simulations at 1.13. $QHTDIR_t$ shows much more variation in the past, especially at the end of our sample period. We assume a value of 0,831 which corresponds to the mean over the period 1985 through 2002. Other net transfers to private households, $HTRO_t$, follow a rule that relates this item to total government revenues GR_t:

$$HTRO_t = QHTRO_t \; GR_t \, . \tag{5.9}$$

As can be seen from table 5.1 the ratio is small but experiences a jump in 2001 and 2002. We assume a value of 0.02, which is slightly above the mean from the sample period.

Finally all these components are aggregated into the disposable income of private households YDN_t:

$$YDN_t = HYS_t + HYL_t + HYI_t + HTRM_t - HSC_t - HTDIR_t + HTRO_t \, . \tag{5.10}$$

6. The Public Sector

This section describes the modelling of the public sector. The details of the social security system are dealt with in section 7. The public sector block is modelled by using constant quotas relating either taxes or expenditures to reasonable bases. Thus, in simulations those ratios will be extrapolated into the future, reflecting the consequences of constant long-run revenue and expenditure elasticities set equal to unity. We close the government sector by a simple policy target:

$$GE_t = GR_t, \tag{6.1}$$

which states that government expenditures at current prices, GE_t, must equal revenues, GR_t, in each period. This simple target corresponds to a balanced budget for the government in compliance with the Pact on Stability and Growth (SGP). Although it is not reasonable to impose this policy rule in a business cycle model, we believe this to be a good assumption for the long-run position of government finances. Since the Austrian government already accumulated substantial debt in the past, this assumption imposes a surplus in the primary budget balance. The debt level, although constant, will decline as a share of GDP since no new debt is accumulated in the future. An alternative rule would be to stabilise the debt to GDP ratio at the 60% value mentioned in the Maastricht treaty. This policy rule would violate the balanced budget rule of the SGP, thus we disregard it.

We will model the public sector as being restricted from the revenue side. The government cannot spend more than it receives from imposing taxes, social security contributions SC_t, and other minor revenue components. We express other minor revenues simply as a surcharge, $QGRO_t$. Government revenues, GR_t, are thus equal to:

$$GR_t = \frac{TIND_t + TDIR_t + SC_t}{1 - QGRO_t}, \tag{6.2}$$

where SC_t are social contributions according to the national accounts. The ratio $QGRO_t$ decreased substantially from 1995 onwards. Table 6.1 shows that the observation for 2002 represents only two thirds of the maximum value from 1995. We fix this factor at 0.11 which is clearly below the mean but only slightly above the last observation from 2002.

Indirect taxes, $TIND_t$, move in line with GDP at current prices:

$$TIND_t = RTIND_t \; Y_t \; P_t, \tag{6.4}$$

where the average tax rate, $RTIND_t$, varies in a narrow band between 14.2 and 16.3% (table 6.2). We choose 14.9% in all simulations to reflect the fact that observations from the last few years are below the mean value. The effect of variations in the average tax rate depends on the assumption of pass through mechanism, i.e. the degree to which a change in the tax rate is borne by consumers. Since all prices in the model are exogenous, we implicitly assume a zero pass through (cf. chapter 8). For example, an increase in the average tax rate lowers producer prices and, therefore, reduces the gross operating surplus, GOS_t, by the full amount of additional tax revenues. Forward looking firms and households react to lower current and future incomes by cutting their spending on investment and consumption. This corresponds to the income effect of an increase in the tax rate. By neglecting a partial pass through we overestimate the total outcome of adjustments in indirect taxes.

Direct taxes, $TDIR_t$, depend on the two main tax bases: labour income net of social security contributions and capital income net of depreciation:

$$TDIR_t = RTW_t(YL_t - QSCL_t SC_t) + (RTC_t + RTDIR_t)(GOS_{t-1} - DPN_{t-1}) \quad (6.5)$$

where RTW_t represents the average tax rate on wages, $QSCL_t$ corrects for statistical discrepancy in the national accounts. For the simulation we assume that $QSCL_t = 1.067$ (cf. table 6.1). RTC_t is the average corporate tax rate, $RTDIR_t$ the average direct tax rate on profits, and DPN_t is the aggregate capital depreciation at current prices. The computation of wage taxes recognises the fact that social security contributions are fully tax deductible. Because we assume that the tax code will be constant over the full simulation period, we usually use the last realisation of an average tax rate for simulations. For a simulation of a change in the tax code we will have to compute the effect of such a measure on the average tax rates RTW_{t+i}, RTC_{t+i} or $RTDIR_{t+i}$. Equation 6.5 reflects the fact that depreciation is a tax deductible item and that last period's profits are the base for tax payments by firms and the self employed. This formula may suffer from the discrepancy between the taxable result and commercial financial statements on an accrual basis.

Subsidies, SUB_t, are also simply modelled as a ratio to government revenues excluding social contributions:

$$SUB_t = QSUB_t\,(GR_t - SC_t). \quad (6.6)$$

After the substantial drop in subsidies in the year after joining the European Union, the ratio $QSUB_t$ is steadily climbing towards its long-run mean value (cf. table 6.1). We choose $QSUB_t = 0.08$ for our simulation.

Social expenditures, SE_t, are composed of monetary transfers and non-monetary services of the pension insurance, SEP_t, the health insurance, SEH_t, the accident insurance, SEA_t, the unemployment insurance system, TRU_t, and expenditures on long-term care, $GELTC_t$. (cf. section 8):

$$SE_t = SEP_t + SEH_t + SEA_t + TRU_t + GELTC_t. \quad (6.7)$$

Monetary transfers comprise only cash payments and are included in STR_t:

$$STR_t = TRP_t + TRH_t + TRA_t + TRU_t + GELTC_t\,. \qquad (6.8)$$

Social security contributions according to the national accounts, SC_t, are related to contributions to health, SCH_t, pension, SCP_t, accident, SCA_t, and unemployment insurance, SCU_t. The difference between numbers from the social security system and the national accounts is captured by a constant factor, QSC_t:

$$SC_t = QSC_t(SCH_t + SCP_t + SCA_t + SCU_t)\,. \qquad (6.9)$$

This factor is assumed to be equal to 1.35 throughout the simulation period.

Public spending on interest for government debt is based on the implicit rate of interest RGD_t:

$$RGD_t = \frac{1}{2}\left(\frac{1}{6}\sum_{i=0}^{5} RN_{t-i} + RGD_{t-1}\right), \qquad (6.10)$$

which is an average of lagged nominal interest rates RN_t and the previous implicit rate of interest. This combination reproduces the effect of government debt maturity on the level of the implicit interest rate.

This equation recognises the fact that the average maturity of Austria's government debt is 5.5 years. Thus the implicit interest rate depends on a moving average of the nominal interest rate, RN_t, with five lags. Averaging between the lagged implicit rate and the weighted nominal interest rate improves the fit, because the federal debt agency uses the slope of the yield curve – which is not modelled here – in managing public debt. Government expenditures on interest, GEI_t, are then:

$$GEI_t = RGD_t GD_{t-1}\,. \qquad (6.11)$$

where GD_t represents the level of public debt.

Thus we model the following parts of total government expenditures explicitly: social expenditures, subsidies, other monetary transfers to private households, and interest expenditures. The remainder is summarised as other government expenditures GEO_t. Total government expenditures are:

$$GE_t = SE_t + SUB_t + HTRO_t + GEI_t + GEO_t\,. \qquad (6.12)$$

The policy rule for the government sector is to adjust one of the components of other government expenditures, GEO_t:

$$GEO_t = GR_t - \left(SE_t + SUB_t + HTRO_t + GEI_t\right), \qquad (6.1')$$

such that equation 6.1 holds in each simulation period. The share of GEO_t in GE_t was in 2002 roughly 51%. Other government expenditures comprise items like purchases from the private sector, compensations for employees and pensioners (civil servants), public investment, and transfers to the European Union. Our policy rule requires that any of those components must be adjusted in order to achieve a balanced budget. Furthermore, we assume that a change in government consumption leaves the output level unchanged. This is true for example, when labour employed in private and public sectors are perfect substitutes, which is a reasonable assumption in the long-run.

One important feature of this policy rule arises in combination with the production technology and the supply side driven structure of the model. Any reduction in other government expenditures, GEO_t, does not feed back into disposable income of private households, nor does it change the level of production in the economy. This is due to the fact that we do not distinguish government production from private sector production (cf. section 2.3) and, therefore, public sector wage income and purchases from the private sector do not respond to variations in GEO_t. By changing GEO_t, however, the government affects aggregate demand and thus the level of imports, the level of private households' financial wealth, and finally private consumption.

The level of government debt, GD_t, evolves according to:

$$GD_t = GD_{t-1} + \left(GR_t - GE_t\right) + GDMV_t, \qquad (6.13)$$

where $GDMV_t$ represents the effects of government debt management, exchange rate revaluations, and swap operations on the nominal value of government debt. We assume that $GDMV_t$ follows:

$$GDMV_t = QGDMV_t GD_t, \qquad (6.14)$$

where $QGDMV_t$ is the ratio of the value of ex-budgetary transactions to government debt. In the baseline we fix $QGDMV_t$ at zero (cf. table 6.1). Thus government debt is fixed at the level of 2002, as the public sector net savings are also zero by our policy rule.

One can also simulate an alternative scenario where other government expenditures, $GEOC_t$, are held constant as a share of nominal GDP:

$$GEOC_t = QGEOC_t YN_t, \qquad (6.15)$$

where $QGEOC_t$ represents the share of nominal other government expenditures from the last year of the pre-simulation period. In this case government debt and hence interest payment on government debt will take on alternative values. This policy rule implies that the current setting of government expenditures will not be changed in the future and, given increasing expenditures on social security, the public sector will be in a deficit. Other policy rules, for example, pre-funding for an expected increase in old-age related expenditures can be easily implemented.

General government consumption, GC_t, is only a fraction of government expenditures. It consists of the public sector gross value added excluding market oriented activities of public sector enterprises and intermediary demand. Since social expenditures, subsidies, and expenditures on interest are not part of government consumption, we exclude them from the base for the computation:

$$GC_t = QGCN_t \frac{GE_t - SE_t - SUB_t - GEI_t}{PGC_t}, \qquad (6.16)$$

where $QGCN_t$ is the ratio of government consumption to government expenditures less social security expenditures, subsidies and expenditures on interest. This ratio increases over time (cf. table 6.1). We fix $QGCN_t$ at the last observed value. Because all items of government expenditures are measured at current prices we use the deflator of government consumption PGC_t to compute real values.

Table 6.1: Adjustment Factors and Ratios to Compute Variables in the Government Sector

	Other government revenues	Social security contributions attributable to wages	Subsidies	Social contributions according to national accounts	Debt management and valuation changes	Other government expenditures	Government consumption	Inventory change, change in valuable and statistical difference
	QGRO	QSCL	QSUB	QSC	QGDMV	QGEOC	QGCN	QSDIFF
1976	0.1410	1.1852	0.0941	1.3126	–	–	–	0.0156
1977	0.1397	1.1548	0.0914	1.3019	0.0944	–	–	0.0126
1978	0.1400	1.1257	0.0937	1.2883	0.0770	–	–	0.0136
1979	0.1419	1.1032	0.0887	1.2886	0.0684	–	–	0.0252
1980	0.1469	1.0909	0.0905	1.4218	0.0648	–	–	0.0243
1981	0.1525	1.0936	0.0877	1.4410	0.0563	–	–	0.0036
1982	0.1527	1.0743	0.0904	1.4550	0.0397	–	–	0.0042
1983	0.1526	1.0627	0.0897	1.4853	0.0548	–	–	0.0016
1984	0.1491	1.0531	0.0834	1.5301	0.0388	–	–	0.0161
1985	0.1471	1.0439	0.0866	1.3485	0.0372	–	0.6112	0.0102
1986	0.1467	1.0384	0.0978	1.3435	0.0585	–	0.6167	0.0102
1987	0.1488	1.0326	0.0979	1.3436	0.0304	–	0.6256	0.0109
1988	0.1502	1.0326	0.0934	1.3425	0.0040	–	0.6310	0.0076
1989	0.1538	1.0295	0.0914	1.3430	–0.0056	–	0.6420	0.0071
1990	0.1549	1.0217	0.0877	1.3455	0.0204	–	0.6404	0.0067
1991	0.1526	1.0188	0.0933	1.3490	0.0187	–	0.6421	0.0059
1992	0.1581	0.9988	0.0904	1.3345	0.0172	–	0.6545	0.0035
1993	0.1542	0.9963	0.0919	1.3426	0.0368	–	0.6301	–0.0009
1994	0.1577	0.9933	0.0826	1.3585	0.0171	–	0.6259	0.0036
1995	0.1606	1.0701	0.0598	1.3617	0.0260	0.3233	0.6181	0.0091
1996	0.1464	1.0718	0.0659	1.3645	–0.0267	0.3134	0.6303	0.0030
1997	0.1225	1.0782	0.0592	1.3492	–0.0722	0.2959	0.6525	0.0073
1998	0.1174	1.0623	0.0706	1.3611	0.0058	0.2953	0.6457	0.0066
1999	0.1201	1.0601	0.0637	1.3632	0.0354	0.2994	0.6484	0.0100
2000	0.1182	1.0586	0.0644	1.3546	0.0142	0.2831	0.6654	0.0027
2001	0.1054	1.0635	0.0689	1.3244	0.0318	0.2678	0.6753	0.0016
2002	0.1085	1.0696	0.0808	1.3230	0.0154	0.2611	0.6826	0.0034
Mean	0.1422	1.0624	0.0836	1.3621	0.0292	0.2924	0.6410	0.0083
Standard Deviation	0.0158	0.0448	0.0122	0.0572	0.0339	0.0212	0.0198	0.0064
Minimum	0.1054	0.9933	0.0592	1.2883	–0.0722	0.2611	0.6112	–0.0009
Maximum	0.1606	1.1852	0.0979	1.5301	0.0944	0.3233	0.6826	0.0252

Table 6.2: Average Tax Rates, 1976–2002

	Wage tax	Tax on capital income	Corporate tax	Indirect taxes
	RTW	RTDIR	RTC	RTIND
In %				
1976	10.5	–	–	15.9
1977	11.4	30.4	7.9	16.3
1978	13.7	31.3	7.8	15.8
1979	13.6	34.0	9.3	15.7
1980	13.8	30.1	8.4	15.7
1981	14.3	32.7	8.1	15.8
1982	13.8	34.9	7.4	15.6
1983	13.6	30.6	6.7	15.7
1984	14.1	29.1	6.5	16.3
1985	14.9	32.6	7.3	16.2
1986	15.1	31.8	6.6	16.0
1987	13.9	31.2	6.0	16.1
1988	14.5	30.1	7.0	16.0
1989	11.6	30.5	7.7	15.9
1990	12.8	31.5	7.0	15.6
1991	13.5	31.4	6.7	15.4
1992	14.1	31.8	7.7	15.5
1993	14.7	33.7	4.5	15.6
1994	13.9	29.2	5.2	15.5
1995	15.4	28.8	6.4	14.2
1996	16.4	30.6	9.1	14.5
1997	17.9	27.4	9.3	14.9
1998	18.0	28.6	10.4	14.9
1999	18.3	27.0	8.2	15.0
2000	17.9	27.4	9.7	14.6
2001	18.1	29.0	14.1	14.6
2002	18.3	27.2	9.9	14.9
Mean	14.7	30.5	7.9	15.5
Standard deviation	2.2	2.1	1.9	0.6
Minimum	10.5	27.0	4.5	14.2
Maximum	18.3	34.9	14.1	16.3

7. Social Security and Long -term Care

The social security sector in Austria comprises the publicly provided pension, health and accident insurance. In the European System of National Accounts (ESA95) these three sectors form the main components of monetary social transfers (contributions) to (from) households. As ESA also includes the unemployment insurance as one part of social transfers (contributions), it was added to the social security sector in the model. Expenditures on long-term care form another important social expenditure item, which is also included in this section.

As there is no disaggregated information on the development of the individual components of social security revenues and expenditures available at the national accounts level, we use administrative data from the social security administration and the employment services. Administrative charts are then transformed into the corresponding ESA aggregates using historical ratios.

For every sector of social security, expenditures and revenues are modelled separately. For expenditures a distinction is made between transfers and other expenditures of the respective social insurance fund. On the revenue side, the model depicts the development of contributions of insured persons.

7.1 Social Expenditures

As mentioned above the model contains four components of social expenditures (pensions, health, accidents, unemployment). Total social expenditures, SE_t, are the sum of expenditures of the pensions insurance, SEP_t, health insurance, SEH_t, accident insurance, SEA_t, the transfer expenditures of unemployment insurance, TRU_t, and expenditures on long-term care, $GELTC_t$:

$$SE_t = SEP_t + SEH_t + SEA_t + TRU_t + GELTC_t \,. \tag{7.1}$$

Total expenditures of pension insurance, SEP_t, contain transfer expenditures, TRP_t, and other expenditures of the pension insurance, $SEPO_t$:

$$SEP_t = TRP_t + SEPO_t \,. \tag{7.2}$$

Transfer expenditures of the pension system include all expenditures on pensions (direct pensions, invalidity pensions and pensions for widows/widower and orphans) for retirees from the private sector (employees, self employed, and farmers). Public sector pensions (civil servants) are not included. The development of expenditures on pension transfers depends on the change in the number of pensions, PEN_t, and on the growth rate of the average pension payment.

The number of pensions depends both on the demographic development and on labour market participation:

$$PEN_t = QRP_t(POP_t^0 + POP_t^{1to3}) + (QPP_t^{4to5} - PR_t^{4to5})POP_t^{4to5}$$

$$+\left(POP_t^6 - \alpha_t PR_t^6 POP_t^6\right). \tag{7.3}$$

The equation implies that the number of pensions is a fraction, QRP_t, of the number of persons aged below 55 ($POP^0 + POP^{1to3}$) and that it develops proportional with demography (depicted by the population between 55 and 64, POP^{4to5}) and employment participation at the age above 54, PR^{4to5} and PR^6, for participation rates for persons aged 55 to 64 and 65+ respectively). It is assumed that a rise of employment participation reduces the number of pensions one to one at the age 55 to 64 and by a factor of α_t above the age of 65. The parameter α_t which is strictly smaller than one (0.5 for simulations) reflects the fact that for the age group older than 65 it is possible for employees to receive direct pension payments.

The labour force and the number of pensions do not necessarily add up to total population within the relevant age group for a number of reasons:

- the model depicts the development of pensions rather than the number of retirees;
- persons may receive multiple pensions;
- pensions of civil servants are not included;
- persons living abroad can receive pension payments;
- persons may temporarily be out of labour force.

The parameter QPP^{4to5} adjusts for the difference between total population and the sum of pensions and the active labour force.

Since the pension reform of the year 1993, pensions are indexed to net wages. The annual adjustment of existing pension claims is based on the principle that the average pension and the average wage, both net of social contributions, should increase at the same rate. Pension adjustment accounts for the fact that new pensions are considerably higher than benefits for persons leaving the pension system. The pension formula implies that the average net benefit develops proportionally to the average net wage. In the model it is assumed that the government will continue to apply this form of indexation of average pension benefits:

$$\Delta \log\left(QSCP_t \frac{TRP_t}{PEN_t}\right) = QPEN_t \ \Delta \log(QSCE_t \, W_t \ P_t) \,. \tag{7.4}$$

The percentage change in benefits per pension, TRP_t/PEN_t, adjusted by the social (health) contribution rate of pensioners, $QSCP_t$, is equal to the change in gross nominal wages, W_tP_t, adjusted by social contribution rates of employees to social security, $QSCE_t$. The pension adjustment formula applies to direct pensions. Pensions for orphans and widows/widower usually grow by less then direct pensions. Consequently, average pension benefits grow somewhat less than average net wages. The adjustment factor, $QPEN_t$, with $QPEN_t$ being equal or less than one, reflects this fact. The indexation of average pensions to average wages, net of social security contributions, implies that the development of pension expenditures as a percentage of output is determined solely by the development of the number of pensions. Specifically, changes in the level of productivity do not affect the evolution of pension expenditures as a share of GDP[9]. Another implication of this form of pension indexation is that any modifications in the generosity of pension benefits are ineffective with respect to the total public pension expenditures: any reduction or increases in pension benefits for new pensioners are automatically completely offset by corresponding adjustments of the benefits of existing pensioners.

Other expenditures of the pension insurance funds, $SEPO_t$, comprise mainly expenditures on administration. Given historical experience, administrative expenditures depend on overall pension expenditures (α_1 is estimated to be 0.004) but the share of these expenditures in total pension expenditures is likely to fall over time (α_2 is estimated to be significantly smaller than one):

$$\log(SEPO_t) = \alpha_1 \log(TRP_t) + \alpha_2 \log(SEPO_{t-1}) \,. \tag{7.5}$$

Total expenditures of health insurance funds, SEH_t, consist of transfer expenditures, TRH_t, and other expenditures, $SEHO_t$:

$$SEH_t = TRH_t + SEHO_t \,. \tag{7.6}$$

Riedel et al. (2002) show that public health expenditures in Austria are determined by demographic developments, the size of the health sector, and country specific institutional factors (i.e., number of specialists, number of hospital beds, and relative costs of health services). Based on the results of this study transfer

[9] Note that in the model the wage share is constant in the long-run and that wages correspond to the marginal product of labour.

expenditures of the health sector in the model depend on the first two factors holding the impact of institutional factors constant:

$$\Delta \log\left(\frac{TRH_t}{P_t}\right) = \alpha_0 + \Delta \log(POP_t) + \alpha_1 \Delta \log\left(\frac{POPM^6{}_t + POPF^6{}_t}{POP_t}\right) + \alpha_2 \log\left(\frac{TRH_{t-1}}{YN_{t-1}}\right) \quad (7.7)$$

The estimated parameters of this equation imply that the growth of real transfer expenditures, TRH_t/P_t, is increasing with the (log) change in the share of persons aged above 65 $(POPM^6{}_t + POPF^6{}_t/POP_t)$ and declining with the overall share of health expenditures in GDP, TRH_t/YN_t. The constant α_0 is estimated to be negative in sign and reflects efficiency improvements in the public health sector partly offsetting the upward pressure on expenditures stemming from demographic trends.

Other expenditures of the public health insurance funds comprise mainly administrative expenditures. Given historical trends it is assumed that other expenditures are influenced by aggregate transfer expenditures of the health sector (α_1 being strictly positive) but that their share of total health expenditures will decline over time (reflected by the estimated negative coefficient for α_2):

$$\log(SEHO_t) = \alpha_0 + \alpha_1 \log(TRH_t) + \alpha_2 \log(SEHO_{t-1}) . \quad (7.8)$$

Long-term care (LTC) forms an important component of age related public expenditures. Expenditures for long-term care are not part of social insurance, but are financed out of the budgets of federal (Bund) and state governments (Länder). The provision of LTC is under the responsibility of the regional governments; however, the federal and regional governments have established an agreement that ensures nationwide uniform criteria for the provision of LTC transfers.

In Austria LTC expenditures comprise the federal nursing scheme (Bundespflegegeld) and local nursing schemes of the Länder. As coherent data for LTC expenditures of the states is unavailable, we only include the federal nursing scheme into the model.

The Bundespflegeld amounts to about 84% of total public expenditures on LTC. In modelling the expenditures for the Bundespflegeld we follow the methodology used in Riedel and Hofmarcher (2001). Age specific expenditures for the federal nursing scheme of the year 2000 are used to project the future developments of expenditures. Data have been kindly provided by the IHS Health-Econ group for the age groups 0–15 years, age 15 to 65, 65–80 and persons aged above 80.

Federal nursing scheme expenditures are a function of age specific costs, which are revalued every year by the growth rate of nominal GDP per capita. This specification corresponds to the one used in Riedel and Hofmarcher (2001).

Inspection of the results obtained in the base scenario confirms that the model very well reproduces the results of the study mentioned above:

$$GELTC = \alpha_0 POP_t^0 + \alpha_1 POP_t^{15to64} + \alpha_2 POP_t^{65to80} + \alpha_3 POP_t^{80+} . \tag{7.9}$$

Expenditures for accident insurance, SEA_t, consist of transfer expenditures, TRA_t, and other expenditures, $SEAO_t$:

$$SEA_t = TRA_t + SEAO_t . \tag{7.10}$$

Transfer payments of the accident insurance funds include accident benefits and therapies of casualties as main components. Based on historical developments these payments rise proportionally to the wage bill, YL_t:

$$\Delta \log(TRA_t) = \Delta \log(YL_t) . \tag{7.11}$$

Other expenditures are determined by transfer payments but their share in total expenditures is also assumed to decline over time (indicated by a negative coefficient for α_2, implying a negative impact of the trend variable on this expenditures component):

$$\log(SEAO_t) = \alpha_0 + \alpha_1 \log(TRA_t) + \alpha_2 TREND_t . \tag{7.12}$$

Finally, expenditures on unemployment benefits, TRU_t, depend on the number of unemployed persons and the replacement rate. Econometric evidence points to unit elasticities of the change of expenditures on unemployment benefits with respect to LU_t and nominal wages, W_tP_t:

$$\Delta \log(TRU_t) = \Delta \log(LU_t) + \Delta \log(W_tP_t) . \tag{7.13}$$

This equation implies that the structure of unemployment and the replacement rate remain constant over time.

7.2 Social Security Contributions

Social security benefits in Austria are financed by contributions of employees and employers to the respective social insurance funds, which are supplemented by transfers from other systems and federal contributions. Contributions by insured persons are a fraction of the contributory wage, which is equivalent to the gross wage below the upper earnings threshold (Höchstbeitragsgrundlage).

Total social contributions are the sum of contributions to pensions insurance, SCP_t, health insurance, SCH_t, accident insurance, SCA_t, and unemployment insurance, SCU_t:

$$SC_t = QSC_t(SCP_t + SCH_t + SCA_t + SCU_t). \tag{7.14}$$

The sum of all contributions is transformed by the parameter, QSC_t, into the respective aggregate used in national accounts.

Revenues of the pension insurance funds, SCP_t, have been modelled separately for the dependent employed, $SCPE_t$, and the self employed, $SCPS_t$, because both contribution rates and contribution bases are different:

$$SCP_t = SCPE_t + SCPS_t. \tag{7.15}$$

The change in pension insurance contributions of employees, $SCPE_t$, depends on the change in contribution rates ($RSPE_t$ and $RSPC_t$ for the rates of employees and employers respectively), the change in the wage bill, YL_t, and the change in the ratio of the upper earnings threshold, $UTPA_t$, to the average wage level, YL_t/LE_t. The elasticity of revenues with respect to the wage bill is estimated to be equal to one. For the parameters α_1 and α_2 positive values smaller than one are estimated:

$$\begin{aligned}\Delta\log(SCPE_t) &= \alpha_1\Delta\log(RSPE_t + RSPC_t)\\ &+ \Delta\log(YL_t) + \alpha_2\Delta\log\left(\frac{UTPA_t}{YL_t / LE_t}\right).\end{aligned} \tag{7.16}$$

The change in contributions of self employed to pension insurance, $SCPS_t$, depends with unit elasticity ($\alpha_1 = 1$) on the change of the respective contribution rate, $RSPS_t$. It furthermore depends on the current and lagged change in net operating surplus, NOS_t, which is used as a proxy for the income of the self employed, where α_2 and α_3, sum to 0.9. Finally, it depends, with an elasticity of 0.65, on the change of the minimum contribution basis of self employed, $MCBS_t$, relative to the upper earnings threshold, $UTPA_t$:

$$\Delta \log(SCPS_t) = \alpha_1 \Delta \log(RSPS_t) + \alpha_2 \Delta \log(NOS_t)$$

$$+ \alpha_3 \Delta \log(NOS_{t-1}) + \alpha_4 \Delta \log\left(\frac{MCBS_t}{UTPA_t}\right). \tag{7.17}$$

Contributions to health insurance funds, SCH_t, originate from two sources: contributions of employees, $SCHE_t$, and contributions of pensioners, $SCHR_t$. Total contributions to pension insurance are the sum of these two aggregates:

$$SCH_t = SCHE_t + SCHR_t. \tag{7.18}$$

The change in the contributions of employees, $SCHE_t$, depends positively on the change of the contribution rates, RSH_t, with unit elasticity on the change in the wage bill, YL_t, and positively on the change of the relation between the upper earnings threshold in health insurance, UTH_t, and the average wage, YL_t/LE_t:

$$\Delta \log(SCHE_t) = \alpha_1 \Delta \log(RSH_t) + \Delta \log(YL_t) + \alpha_2 \Delta \log\left(\frac{UTH_t}{YL_t / LE_t}\right). \tag{7.19}$$

The change of the contributions of pensioners to the health insurance depends on the variation of contribution rates of the pension insurance funds, $RSPF_t$, plus the contribution rate of pensioners, $RSHR_t$, and with unit elasticity on the change in aggregate pension transfers, TRP_t:

$$\Delta \log(SCHR_t) = \alpha_1 \Delta \log(RSPF_t + RSHR_t) + \Delta \log(TRP_t). \tag{7.20}$$

The change in contributions to the accident insurance, SCA_t, is determined by the change in the contribution rate, RSA_t, the change in the wage bill, YL_t, and the change in the relation between the upper earnings threshold, UTH_t, and the average wage, YL_t/LE_t:

$$\Delta \log(SCA_t) = \alpha_1 \Delta \log(RSA_t) + \Delta \log(YL_t) + \alpha_2 \Delta \log\left(\frac{UTH_t}{YL_t / LE_t}\right). \tag{7.21}$$

Finally, the change in contributions to unemployment insurance, SCU_t, similarly depends on the change in the contribution rates, RSU_t, with unit elasticity on the growth of the wage bill, YL_t, and on the relative size of the upper earnings threshold, UTU_t:

$$\Delta\log(SCU_t) = \alpha_1 \Delta\log(RSU_t) + \Delta\log(YL_t) + \alpha_2 \Delta\log\left(\frac{UTU_t}{YL_t / LE_t}\right). \quad (7.22)$$

8. Closing the Model

For simplicity, and in view of our focus on the long-run, we assume homogeneity of output in goods and services across countries and perfect competition. For Austria, as a small open economy, the world market price thus completely determines domestic prices. In particular, this implies the absence of terms of trade fluctuations. Otherwise, with heterogeneous output, any growth differential between Austria and the rest of the world would cause terms of trade effects due to excess demand or supply in one region relative to the other.

To ensure price homogeneity on the demand side of the national accounts, we set inflation rates of all components of domestic demand: private consumption, PC_t, government consumption PGC_t, investment, PI_t, exports, PX_t, and the GDP, P_t, to the inflation rate of import (world) prices PW_t. Since Austria's closest trading relationships will continue to be those with EU member states, the import price is assumed to increase at an annual rate of 2%, which is in line with the implicit inflation target of the ECB.

To ensure dynamic efficiency, we assume that the domestic real rate of interest, R_t, follows the foreign rate, which is a function of the real rate of growth of the world economy, YW_t,

$$R_t = \frac{1}{5}\sum_{i=0}^{4} \Delta\log(YW_{t-i}), \quad (8.1)$$

Here YW_t is the aggregate GDP of 25 OECD countries[10] measured in US-Dollars at constant 1995 prices and exchange rates. In the baseline, aggregate real GDP of the 25 OECD countries grows on average by 2.5% per annum between 2002 and 2075. The nominal rate of interest, RN_t, is

$$RN_t = R_t + \Delta\log(PI_t), \quad (8.2)$$

where PI_t is the deflator for total investment.

[10] The 25 OECD countries included are: Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Iceland, Italy, Japan, South Korea, Luxembourg, Mexico, The Netherlands, Norway, New Zealand, Portugal, Sweden, Turkey, and United States of America.

We use the current account to achieve a balance between savings and investment and at the same time equilibrium in the goods market. The current account, CA_t, is disaggregated into three components: (i) the balance in trade of goods and services, $CAXM_t$, (ii) the balance of income flows, CAY_t, (iii) and the balance of transfer payments, CAT_t:

$$CA_t = CAXM_t + CAY_t + CAT_t \,. \tag{8.3}$$

The balance of trade at current prices is computed as the difference between aggregate output and the three demand components modelled separately. Those are private and public consumption and investment. This can be motivated by our homogeneous good assumption. The balance of trade follows:

$$CAXM_t = P_t Y_t - PC_t CP_t - PGC_t GC_t - PI_t I_t - SDIFFN_t \,, \tag{8.4}$$

where the statistical difference at current prices, $SDIFFN_t$, is set to zero for the future. Identity (8.4) is an equilibrium condition that ensures that any difference between aggregate demand and supply, as determined by the production function, will be eliminated by a corresponding imbalance in goods and services trade. The balance of trade, $CAXM_t$, is further disaggregated into exports and imports of goods and services. Assuming unit elasticity of exports with respect to income and constant terms of trade, exports at constant 1995 prices, X_t, grow with real aggregate income of the rest of the world:

$$\Delta \log(X_t) = \Delta \log(YW_t) \,. \tag{8.5}$$

Imports at constant 1995 prices, M_t, are then recovered as:

$$M_t = (PX_t X_t - CAXM_t) / PW_t \,, \tag{8.6}$$

The balance of income flows, CAY_t, is proportional to the interest earned on the stock of net foreign assets, NFA_{t-1}, accumulated in the past:

$$CAY_t = QCAY_t NFA_{t-1} RN_t \,, \tag{8.7}$$

where the factor $QCAY_t$ is equal to 1.5.
Domestic savings of the economy, S_t, is the sum of private household savings, government savings and savings by the business sector:

$$S_t = (YDN_t - PC_t CP_t) + (GR_t - GE_t) + QSB_t PI_t I_t \,. \tag{8.8}$$

Business sector saving is determined as a constant ratio to investment at current prices. The ratio is fixed at $QSB_t = 0.168$ as of 2002. This formulation implies that a constant share of investment is financed with cash flow. The cash flow financed amount of investment corresponds to business sector savings.

Excess savings of the total economy corresponds to the right hand side in the following equation:

$$CAT_t = S_t - (PI_t I_t - DPN_t) - CAXM_t - CAY_t - SDIFFN_t \,. \tag{8.9}$$

The left hand side is the balance of transfer payments. Equating excess saving to the balance of transfer payments closes the savings investment identity for an open economy.

Current account imbalances will cumulatively change the net foreign asset position, NFA_t, which evolves according to

$$NFA_t = NFA_{t-1} + CA_t \,, \tag{8.10}$$

where every year the current account balance is added to the previous year stock of assets. This characterisation does not take account of changes in the valuation of net foreign assets. Together with the definition of financial wealth of private households this condition provides a feedback mechanism that brings about a zero current account balance in the long-run. Disequilibria in the model will be corrected by the build up or run down of net foreign assets, respectively, which in turn affect the level of consumption of private households. This feedback mechanism is illustrated in chart 8.1.

Disaggregating current account into trade, income and transfer flows allows us to distinguish between the gross domestic product and the gross national product, $YNPN_t$:

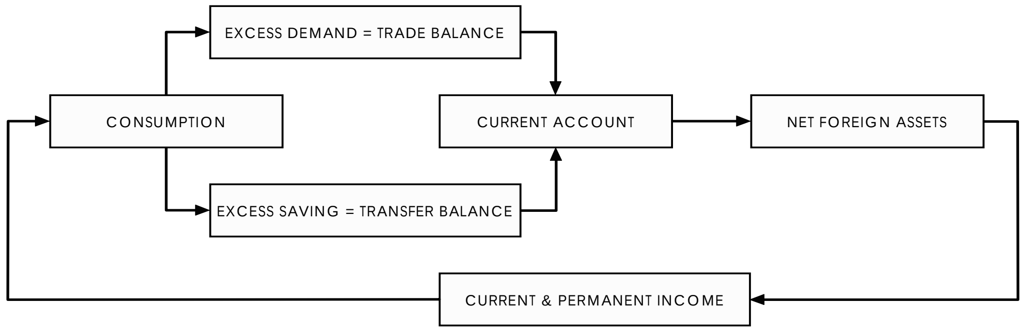
$$YNPN_t = YN_t + CAY_t \,. \tag{8.11}$$

The difference between the two income concepts reveals the amount by which domestic consumption may deviate from domestic production. A positive income balance allows for levels of demand in excess of supply of domestic goods and services, because of interest earnings received from the rest of the world. With a net foreign liability position, servicing the debt will reduce consumption possibilities below domestic output.

Finally, we compute the disposable income of the total economy, $YDEN_t$:

$$YDEN_t = YNPN_t - DPN_t + CAT_t \,. \tag{8.12}$$

Chart 8.1: Closing A-LMM



9. Simulations with A-LMM

A good insight into the properties of a model can be gained by simulating shocks to exogenous variables. Such an exercise highlights the workings and the stability properties of the model. Stability is studied with constant employment with steady state solutions up to the year 2500. In the following we first discuss a scenario using the main variant of the latest Austrian population forecast (Hanika et al., 2004). The baseline scenario has been created for the purpose of comparisons. The other six scenarios will be presented not as deviations from the baseline, but in full detail.

The population forecast by Statistics Austria extends to 2075 and is exogenous to the model. Since the model is intended for projections up to 2075, the population forecast horizon is too short for computing the forward looking part of A-LMM. Therefore, we use an extended population forecast going up to 2150 by assuming constant fertility and mortality rates. The extension is provided by Statistics Austria and enables us to obtain a forward looking solution until 2075. Forward looking terms appear in private consumption and investment functions.

The following section 9.1.1 presents the baseline scenario based on the main variant of the population projection by Statistics Austria. In the section 9.1.2 we discuss the effects of higher life expectancy. The consequences of lower fertility rates can be seen in the scenario documented in section 9.1.3. Since participation rates have a major effect on the fiscal balance of the social security system, we also include a scenario with dynamic participation rates. This is studied in section 9.2. Another point of interest is studying the macroeconomic effects of a balanced fiscal position of the social security system. Here the balance is brought about by an increase in contribution rates such that the share of government transfers to the social security system in relation to GDP is constant. Section 9.3.1 shows the results of this simulation. Following that we discuss the effects of an alternative indexation of the pensions in section 9.3.2. Finally, section 9.4 studies an increase in total factor productivity growth by 0.5 percentage points.

9.1 Base Scenario with Different Population Projections

9.1.1 Baseline Scenario with Main Variant of the Population Projection (Scenario 1A)

The base scenario documents the simulation with the main variant of the population forecast for Austria (Hanika et al., 2004). In this variant the working age population (15–64) increases until 2012 reaching a peak value of 5.61 million persons. Afterwards, the working age population abates with a slightly negative rate of change between 2002 and 2070 (table 9.1A). The old age dependency ratio (population aged 65+ over labour force) soars from the current value of 23 to the peak value of 52.5% in 2062. This development is accompanied by a substantial decline in the number of pensions per person aged 65+.

Despite the starting decline in the size of the working age population in 2012, the labour force keeps rising until 2015 and shows a weak downward trend until 2070. This pattern is due to the increase in the overall participation rate throughout the simulation period by 8%age points. Labour market participation rates of women increase in all age cohorts, whereas for males only those of the elderly rise. Despite higher activity rates, the number of economically active persons in full time equivalents decreases on average by 0.1% per year, amounting to a cumulated reduction of 200,000 persons until 2070. The gradual decline of unemployment built into the model keeps the number of unemployed rising until 2011. After 2020 unemployment shrinks rapidly towards the natural rate level of 4.5%, as implied by the wage equation.

The investment to GDP ratio converges rapidly towards its long-run value of 21.5%. This results in a modest increase in the capital to output ratio, which is associated with a gradual decline in the marginal product of capital. We assume a constant rate of growth of total factor productivity of 0.85% per year. In the case of a Cobb-Douglas production function with $\alpha = 0.5$ this is equivalent to a labour augmenting technical progress at a rate of 1.7% per year. With only a modest degree of capital deepening and lower employment due to the decelerating size of the working age population, the model predicts an average annual growth rate of real GDP of 1.6%.

The rate of inflation is set exogenously to the long-run implicit target of the European Central Bank of 2%. This results in an average annual growth rate of nominal GDP of 3.7%. Since the Cobb-Douglas technology implies constant factor shares, the long-run annual growth rates of real and nominal labour compensation amount to 1.7 and 3.7%, respectively. Per capita real wages grow in tandem with real GDP.

Because the parameters in the revenue equations of the social security block remain unchanged, social contributions in relation to nominal GDP remain almost constant throughout the simulation horizon. Social expenditures, on the other hand, increase by 0.4% per year on average, reaching a maximum of 24.2% of nominal GDP in 2054. The government transfers to the pension insurance system rise from 2.2% of nominal GDP in 2002 to a maximum of 6.3% in the year 2057.

As we impose the balanced budget on the public sector, any increase in social expenditures has to be matched by a reduction in other components of government spending. This fiscal policy rule keeps government spending in line with GDP-growth. Consequently, the government debt declines rapidly relative to nominal GDP.

Table 9.1A: Baseline (Scenario 1A)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
				1,000 persons						
Working Age Population (15-64)	5,464.7	5,577.6	5,562.9	5,237.2	4,944.1	4,759.1	4,551.2	4,423.9	-0.3	
Economically active population (Labour force)	3,765.3	3,895.8	3,931.1	3,838.6	3,750.8	3,638.3	3,490.9	3,390.3	-0.2	
Economically active employees in full time equivalents	3,006.8	3,108.3	3,148.9	3,125.4	3,083.2	2,990.9	2,870.2	2,787.6	-0.1	
Number of pensions	1,999.0	2,142.8	2,407.4	2,682.3	2,827.9	2,884.3	2,830.0	2,717.5	0.5	
				In percent						
Participation rate, total	68.9	69.8	70.7	73.3	75.9	76.4	76.7	76.6	0.2	7.7
Women	61.1	61.7	62.3	65.6	69.4	70.6	70.9	70.8	0.2	9.7
Men	76.7	77.9	79.0	80.9	82.2	82.2	82.4	82.3	0.1	5.6
Unemployment rate	6.9	7.2	6.9	5.4	4.5	4.4	4.4	4.4	-0.6	-2.4
Old age dependency ratio	22.8	26.2	30.2	39.6	47.5	50.6	52.4	51.8	1.2	28.9
Pensions relative to insured persons	62.4	64.5	71.7	82.0	88.7	93.5	96.1	95.3	0.6	32.8
Pensions relative to population aged 65+	1.60	1.46	1.43	1.29	1.20	1.20	1.19	1.19	-0.4	
				Bill. €						
Gross domestic product at constant 1995 prices	201.2	237.5	286.0	338.5	397.2	459.2	525.7	605.0	1.6	
Gross domestic product at current prices	218.3	302.0	443.3	639.7	915.0	1,289.3	1,799.3	2,524.1	3.7	
				1,000 €						
Real GDP per capita	25.0	28.8	34.0	40.2	47.7	56.3	66.5	79.1	1.7	
				2002 = 100						
Real wage per capita, in full time equivalents (MPL)	100.0	113.7	136.0	162.1	192.9	230.3	274.8	325.2	1.7	
				Percentage change against previous year						
Gross domestic product at constant 1995 prices	1.4	2.1	1.7	1.7	1.6	1.4	1.4	1.4	1.6	
Compensation to employees, at current prices	2.2	4.2	3.8	3.7	3.6	3.4	3.4	3.5	3.7	
Real wage per employee	1.3	1.6	1.9	1.7	1.7	1.8	1.7	1.7	1.7	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	

Table 9.1 (continued): Baseline (Scenario 1A)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.5	7.5	7.4	7.4	7.4	7.4	7.4	0.0	-0.2
Contributions to pension insurance by employees	7.0	6.9	7.0	7.0	7.0	7.0	7.0	7.0	0.0	0.0
Contributions to pension insurance by self-employed	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	-0.4	-0.2
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.1
Total social security expenditures pension insurance	11.0	11.2	12.3	13.6	14.3	14.8	14.8	14.4	0.4	3.4
Government transfers to pensions insurance system	2.2	2.5	3.6	4.9	5.6	6.1	6.2	5.8	1.5	3.6
Social security contributions health insurance	4.0	3.9	4.1	4.2	4.2	4.3	4.3	4.2	0.1	0.3
Total social security expenditures health insurance	5.0	6.0	6.3	6.6	6.7	6.5	6.4	6.2	0.3	1.3
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
Total social security expenditures accident insurance	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	16.4	16.6	16.7	16.7	16.8	16.8	16.7	0.0	0.1
Transfer expenditures - pensions, health and long term care	16.0	16.7	18.2	20.0	20.9	21.6	21.6	21.1	0.4	5.0
Social expenditures	17.7	19.9	21.3	22.7	23.5	24.1	24.0	23.4	0.4	5.7
	2002=100									
Average real pension per year [1])	100.0	112.0	131.5	153.9	179.8	210.6	246.7	286.7	1.6	
	In percent of GDP, at current prices									
Government expenditures	51.3	50.6	50.8	50.8	50.8	50.8	50.7	50.6		-0.8
Other government expenditures	25.5	25.3	24.6	23.6	23.2	22.8	22.9	23.5		-1.9

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

9.1.2 A Population Projection with High Life Expectancy (Scenario 1B)

Scenario 1B and 1C demonstrate the impact of different population projections on the model results of A-LMM (see charts 9.1.1 and 9.1.2). Scenario 1B uses the main population projection of Statistics Austria adjusted for higher life expectancy (see Hanika et al., 2004). In this projection life expectancy of new born males will increase between 2002 and 2050 from 75.8 years to 87 years (main scenario 83 years). Female life expectancy increases from 81.7 years to 91 years (88 years). In this scenario the population in the year 2050 amounts to 8.5 million persons (8.2 millions). The increase in life expectancy affects mainly the age group 65 and older (2.7 millions to 2.4 millions). The working age population decreases in this scenario from 5.5 million persons in 2002 to 4.8 millions in 2050. This is almost the same amount as in scenario 1A.

Table 9.1B presents the results for scenario 1B. Between 2002 and 2010 the average economic growth of the Austrian Economy is slightly above 2%. In the following decades the declining labour force leads to slower growth. In the year 2050 the growth rate of the Austrian economy is 1.4% and remains at this value until the end of the projection horizon. Over the whole simulation period average growth is 1.6%. The levels and patterns of economic growth are almost identical with scenario 1A. This is caused by the almost identical development of the working age population and therefore labour supply. The assumed 2.5percentage points decline in the structural unemployment rate between 2020 and 2035 contributes to economic growth in this time period. Labour productivity and real wages will grow on average with 1.7% between 2002 and 2070.

Whereas the economic development is similar to scenario 1A, the increased life expectancy implies significant consequences for the social security system. The old age dependency ratio increases from 22.8% to 31.3 in 2020. After 2020 the speed accelerates considerably and the old-age dependency ratio reaches its maximum of 61% in 2062. In accordance with this development the number of pensions increases from currently 2 millions to 3.1 millions in 2070. In scenario 1A the number of pensions in 2070 is 2.7 millions only.

Whereas social security contributions are of similar magnitude as in scenario 1A, social security expenditures are significantly higher after 2020 due to the higher life expectancy. Between 2020 and 2060 the pension insurance expenditures increase from 12.6% of GDP to 16.7% (chart 9.1.3). The government transfers to the pension insurance system will increase from 3.9% of GDP to 8.1% in this time period. At the end of the forecasting period the government transfers are almost 2%age points higher as in scenario 1A (chart 9.1.4). The gap between social contributions and social expenditures will increase during the forecasting period and amounts to 9.1 percentage points in 2060 (7.2 percentage points in scenario 1A).

Table 9.1B: Population Projection with High Life Expectancy (Scenario 1B)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
				1,000 persons						
Working Age Population (15-64)	5,464.7	5,580.5	5,574.2	5,255.3	4,965.8	4,784.0	4,576.9	4,450.4	-0.3	
Economically active population (Labour force)	3,765.3	3,897.8	3,939.1	3,854.4	3,774.9	3,669.1	3,525.2	3,425.2	-0.1	
Economically active employees in full time equivalents	3,006.8	3,109.7	3,154.7	3,137.3	3,101.4	3,013.9	2,895.7	2,813.7	-0.1	
Number of pensions	1,999.0	2,158.5	2,472.0	2,817.4	3,050.8	3,209.6	3,222.0	3,110.4	0.7	
				In percent						
Participation rate, total	68.9	69.8	70.7	73.3	76.0	76.7	77.0	77.0	0.2	8.1
Women	61.1	61.7	62.2	65.6	69.4	70.7	71.0	71.0	0.2	9.9
Men	76.7	77.9	79.0	81.0	82.5	82.5	82.8	82.8	0.1	6.1
Unemployment rate	6.9	7.2	6.9	5.5	4.6	4.6	4.6	4.6	-0.6	-2.3
Old age dependency ratio	22.8	26.5	31.3	41.9	51.8	57.2	60.8	60.4	1.4	37.5
Pensions relative to insured persons	62.4	65.0	73.7	86.2	95.7	104.1	109.4	109.0	0.8	46.6
Pensions relative to population aged 65+	1.60	1.46	1.42	1.28	1.19	1.17	1.16	1.16	-0.5	
				Bill. €						
Gross domestic product at constant 1995 prices	201.2	237.6	286.4	339.6	399.2	462.3	529.8	610.2	1.6	
Gross domestic product at current prices	218.3	302.1	444.0	641.7	919.5	1,297.9	1,813.4	2,545.7	3.7	
				1,000 €						
Real GDP per capita	25.0	28.7	33.8	39.6	46.6	54.3	63.6	75.6	1.6	
				2002 = 100						
Real wage per capita, in full time equivalents (MPL)	100.0	113.6	135.9	161.9	192.7	230.0	274.5	325.0	1.7	
				Percentage change against previous year						
Gross domestic product at constant 1995 prices	1.4	2.1	1.7	1.7	1.6	1.4	1.4	1.4	1.6	
Compensation to employees, at current prices	2.2	4.2	3.8	3.7	3.6	3.5	3.4	3.5	3.7	
Real wage per employee	1.3	1.6	1.9	1.7	1.7	1.8	1.7	1.7	1.7	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
				Ratio						
Marginal product of capital	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	-0.1	
Capital-output-ratio	3.62	3.62	3.64	3.67	3.69	3.73	3.76	3.77	0.1	0.2

Table 9.1B (continued): Population Projection with High Life Expectancy (Scenario 1B)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.5	7.5	7.4	7.4	7.4	7.4	7.4	0.0	-0.2
Contributions to pension insurance by employees	7.0	6.9	7.0	7.0	7.0	7.0	7.0	7.0	0.0	0.0
Contributions to pension insurance by self-employed	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	-0.5	-0.2
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.1
Total social security expenditures pension insurance	11.0	11.3	12.6	14.2	15.3	16.2	16.7	16.3	0.6	5.3
Government transfers to pensions insurance system	2.2	2.6	3.9	5.5	6.6	7.6	8.1	7.7	1.9	5.5
Social security contributions health insurance	4.0	3.9	4.1	4.2	4.3	4.4	4.5	4.4	0.2	0.5
Total social security expenditures health insurance	5.0	6.1	6.4	6.7	6.8	6.7	6.6	6.3	0.4	1.4
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
Total social security expenditures accident insurance	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	16.4	16.6	16.7	16.8	17.0	17.0	16.9	0.0	0.3
Transfer expenditures - pensions, health and long term care	16.0	16.8	18.6	20.7	22.1	23.3	23.6	23.0	0.5	7.0
Social expenditures	17.7	19.9	21.6	23.4	24.6	25.8	26.0	25.4	0.5	7.7
	2002=100									
Average real pension per year [1])	100.0	112.0	131.5	153.7	179.6	210.4	246.4	286.4	1.6	
	In percent of GDP, at current prices									
Government expenditures	51.3	50.6	50.8	50.8	50.9	50.9	50.9	50.8		-0.6
Other government expenditures	25.5	25.2	24.2	23.0	22.1	21.2	21.1	21.7		-3.7

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

Chart 9.1.1: Population 65 and Older (Main Variant and High Life Expectancy)

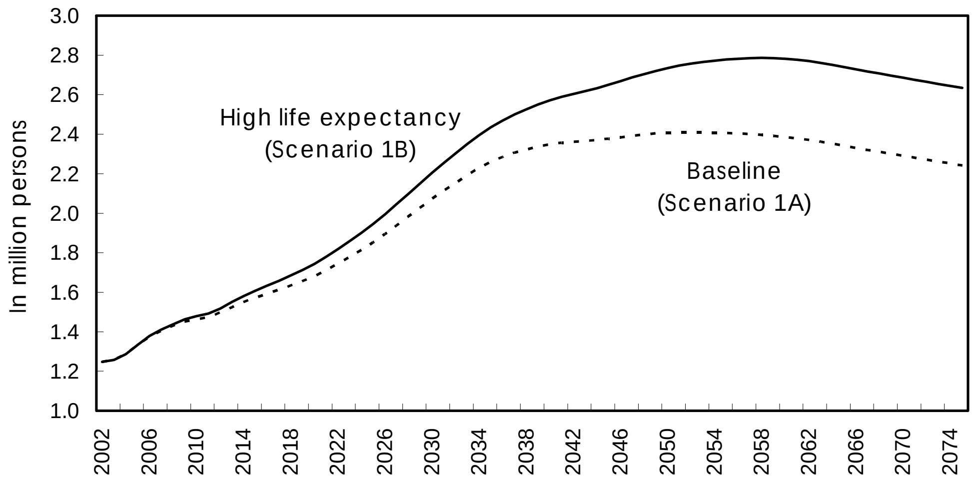


Chart 9.1.2: Labour Force for Different Population Projections

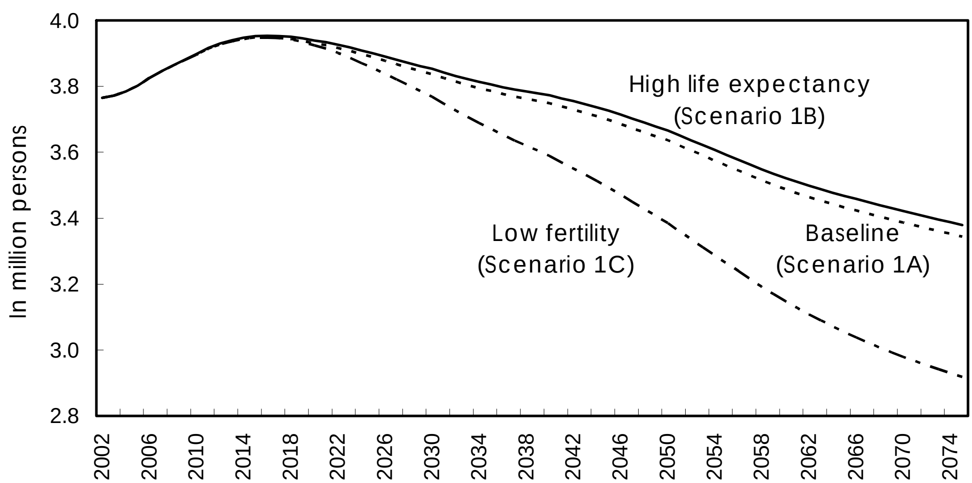


Chart 9.1.3: Social Security Expenditures of Pension Insurance (Baseline and High Life Expectancy)

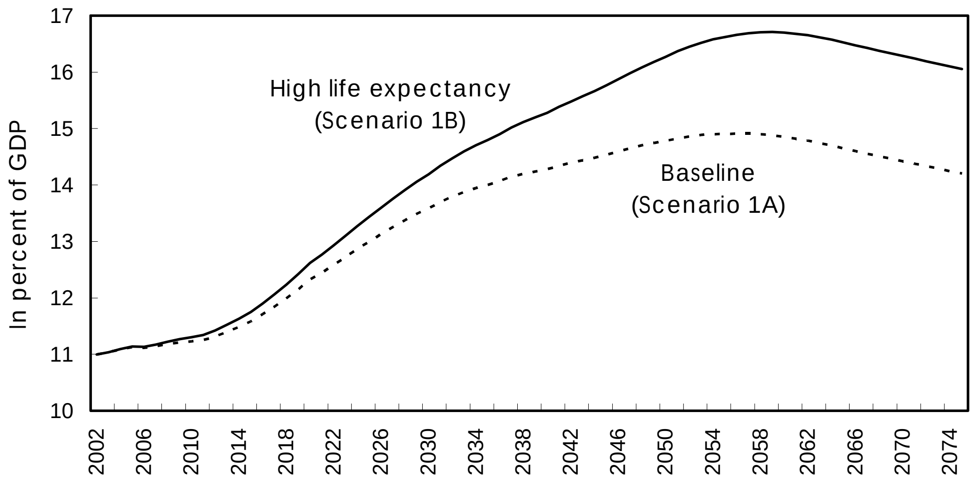
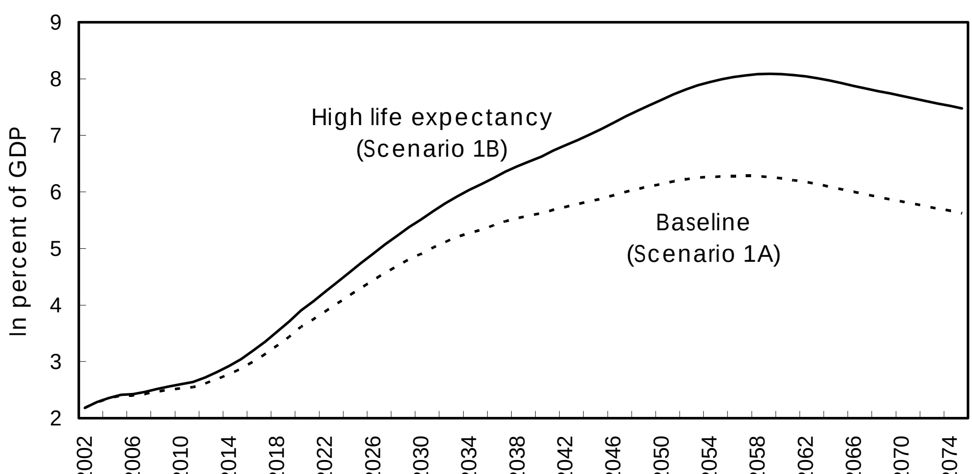


Chart 9.1.4: Government Transfers to Pension Insurance System (Baseline and High Life Expectancy)



9.1.3 A Population Projection with Low Fertility (Scenario 1C)

Scenario 1C uses the base population projections but with a lower fertility rate. In the main variant of Statistics Austria the fertility level is kept constant at 1.4 children per female. In this projection the fertility level is reduced to 1.1 children per female after 2015. According to this projection the population decreases from currently 8 million persons to 7.8 millions in 2050. In 2075 the population is further reduced to 6.9 million people.

The working age population decreases in this scenario from 5.5 million persons in 2002 to 3.9 millions in 2070. The working age population in 2070 is reduced by 570.000 persons in comparison with scenario 1A. The lower population growth affects labour supply (see chart 9.1.1). Until the year 2020 no big differences to scenario 1A emerge. Due to the measures of the pension reform labour supply in 2020 is higher by 160.000 persons as in 2002. In the following decades labour supply falls, due to the smaller size of the cohorts entering the labour force. In 2070, labour supply merely amounts to 3 million persons (3.4 millions in scenario 1A).

Table 9.1C presents the result for scenario 1C. Between 2002 and 2010 the average economic growth of the Austrian economy is slightly above 2%. In the following decades the decrease in the labour force leads to slower growth. In 2070 the growth rate of the Austrian economy is 1.2%. Over the whole simulation period average annual growth is 1.5%. After 2020, economic growth is on average 0.25 percentage points slower as in scenario 1A. In 2070 the GDP is 11% lower than in scenario 1A. This lower growth is only caused by the population differences, as age specific participation rates are kept constant. Labour productivity and real wages will grow on average with 1.8% per year between 2002 and 2070 and therefore almost at the same pace as in scenario 1A.

The lower fertility rate has severe consequences for the old age dependency ratio. This ratio increases from 22.8 to 30.3% in 2020. After 2020 the speed accelerates and the old-age dependency ratio rises up to 59.2% in the year 2070. In contrast to scenario 1B this increase is caused by the lower working age population and not by a strong increase of persons with age above 65. The number of pensions increases in line with scenario 1A from currently 2 millions to 2.7 millions in 2070.

Social contributions amount to 16.6% of nominal GDP in 2020. In the following decades the share of social security contributions in GDP will increase slightly up to 17% in 2070. In contrast social expenditures (as share of GDP) grow considerably faster. Between 2020 and 2060 the pension insurance expenditures increase from 12.3% of GDP to 16.4% (chart 9.1.5). The government transfers to the pension insurance system will increase from 3.6% of GDP to 7.8% in this time period (chart 9.1.6). At the end of the forecasting period the government transfers are 1.7 percentage points higher than in scenario 1A. Between 2002 and 2030, the share of social expenditures in GDP will increase by 5.3 percentage points. In the year 2059, the share of social expenditures in GDP reaches its maximal value of 25.8%. In this year the gap between contributions and expenditures amounts to 8.8 percentage points.

The aim of scenario 1B and 1C was to present the impacts of different assumptions about population development on economic growth and on the fiscal balance of the social security system. In these scenarios age-specific participation rates and technical progress have been kept constant to isolate the population impact. We have shown that a population scenario with higher life expectancy leads to similar economic growth as in scenario 1A, but the strengthened aging has consequences for social expenditures as the number of pensions is considerably increased. The scenario with lower fertility implies weaker growth in the future and puts also pressure on the solvency of the social security system.

Table 9.1C: Population Projection with Low Fertility (Scenario 1C)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
					1,000 persons					
Working Age Population (15-64)	5,464.7	5,577.6	5,552.3	5,110.7	4,700.7	4,411.4	4,089.2	3,855.2	-0.5	
Economically active population (Labour force)	3,765.3	3,895.8	3,925.1	3,769.3	3,590.3	3,388.0	3,152.1	2,982.8	-0.3	
Economically active employees in full time equivalents	3,006.8	3,108.3	3,145.0	3,070.8	2,951.4	2,783.1	2,587.5	2,445.1	-0.3	
Number of pensions	1,999.0	2,142.8	2,407.2	2,678.5	2,820.5	2,873.8	2,814.6	2,669.5	0.4	
					In percent					
Participation rate, total	68.9	69.8	70.7	73.8	76.4	76.8	77.1	77.4	0.2	8.5
Women	61.1	61.7	62.3	66.0	69.8	70.8	71.1	71.4	0.2	10.3
Men	76.7	77.9	79.0	81.4	82.8	82.7	82.9	83.1	0.1	6.5
Unemployment rate	6.9	7.2	6.9	5.3	4.4	4.4	4.4	4.4	-0.6	-2.4
Old age dependency ratio	22.8	26.2	30.3	40.5	49.9	54.6	58.4	59.2	1.4	36.4
Pensions relative to insured persons	62.4	64.5	71.8	83.6	92.8	100.8	107.0	107.9	0.8	45.5
Pensions relative to population aged 65+	1.60	1.46	1.43	1.29	1.20	1.19	1.18	1.17	-0.5	
					Bill. €					
Gross domestic product at constant 1995 prices	201.2	237.5	285.4	333.5	383.2	432.2	481.2	539.9	1.5	
Gross domestic product at current prices	218.3	301.9	442.4	630.1	882.6	1,213.6	1,647.0	2,252.6	3.5	
					1,000 €					
Real GDP per capita	25.0	28.8	34.0	40.2	47.4	55.3	64.6	76.3	1.7	
					2002 = 100					
Real wage per capita, in full time equivalents (MPL)	100.0	113.7	136.0	162.8	194.9	233.7	279.9	331.6	1.8	
					Percentage change against previous year					
Gross domestic product at constant 1995 prices	1.4	2.1	1.6	1.5	1.3	1.1	1.1	1.2	1.5	
Compensation to employees, at current prices	2.2	4.2	3.8	3.5	3.4	3.2	3.1	3.2	3.5	
Real wage per employee	1.3	1.6	2.0	1.8	1.8	1.8	1.8	1.7	1.8	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
					Ratio					
Marginal product of capital	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	-0.1	
Capital-output-ratio	3.62	3.62	3.64	3.68	3.73	3.78	3.83	3.85	0.1	0.2

Table 9.1C (continued): Population Projection with Low Fertility (Scenario 1C)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.5	7.5	7.5	7.4	7.4	7.4	7.4	0.0	-0.2
Contributions to pension insurance by employees	7.0	6.9	7.0	7.0	7.0	7.0	7.0	7.0	0.0	0.0
Contributions to pension insurance by self-employed	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	-0.5	-0.2
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	0.0
Total social security expenditures pension insurance	11.0	11.2	12.3	13.8	14.9	15.8	16.4	16.1	0.6	5.1
Government transfers to pensions insurance system	2.2	2.5	3.6	5.1	6.2	7.2	7.8	7.5	1.8	5.4
Social security contributions health insurance	4.0	3.9	4.1	4.2	4.3	4.4	4.4	4.4	0.2	0.4
Total social security expenditures health insurance	5.0	6.0	6.3	6.7	6.7	6.7	6.6	6.4	0.4	1.4
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
Total social security expenditures accident insurance	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	16.4	16.6	16.7	16.8	16.9	17.0	16.9	0.0	0.3
Transfer expenditures - pensions, health and long term care	16.0	16.7	18.2	20.2	21.6	22.8	23.3	23.0	0.5	7.0
Social expenditures	17.7	19.9	21.3	23.0	24.2	25.3	25.8	25.4	0.5	7.7
	2002=100									
Average real pension per year [1]	100.0	112.0	131.5	154.6	181.6	213.6	251.1	292.0	1.6	
	In percent of GDP, at current prices									
Government expenditures	51.3	50.6	50.8	50.8	50.8	50.8	50.7	50.6		-0.7
Other government expenditures	25.5	25.3	24.6	23.4	22.5	21.5	21.1	21.5		-3.9

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

Chart 9.1.5: Social Security Expenditure of Pension Insurance (Baseline and Low Fertility)

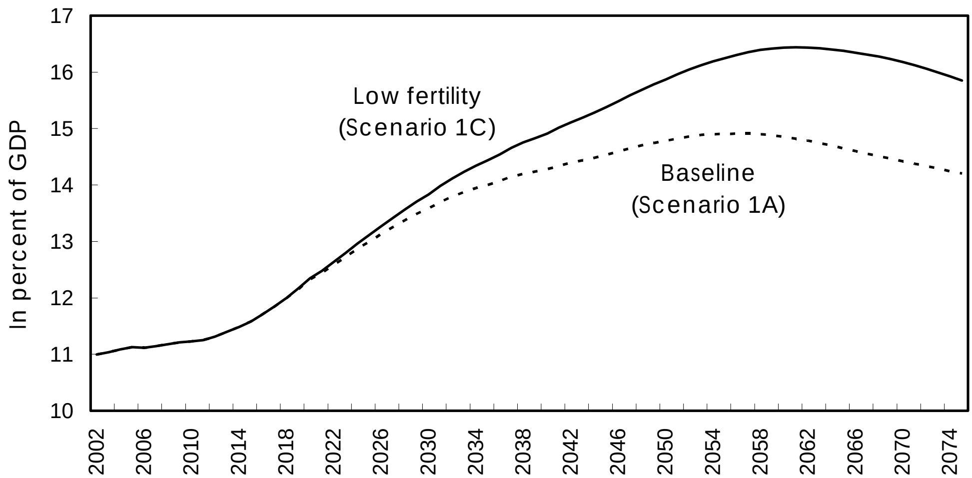
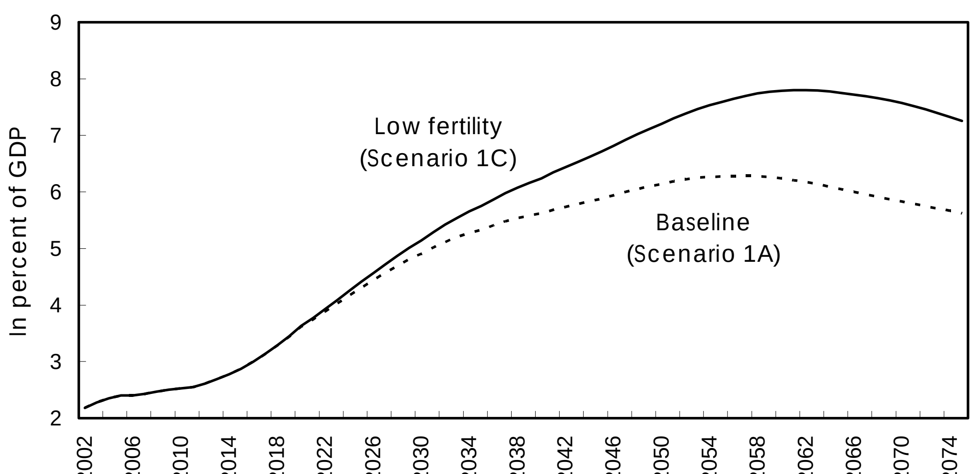


Chart 9.1.6: Government Transfers to Pension Insurance (Baseline and Low Fertility)



9.2 A Dynamic Activity Rate Scenario (Scenario 2)

The development of labour supply is one important determinant of economic growth. In this scenario we discuss the impact of an alternative activity rate scenario. The baseline activity rate scenario is relatively optimistic. Therefore, we simulate the impact of an alternative activity rate scenario. We use the dynamic approach augmented with more pessimistic assumptions concerning the impact of the pension reform on labour market participation to derive the activity rates for scenario 2 (see section 4.1.2). The participation rate of the young age cohort is assumed to be constant. We expect a slight decrease in the activity rates of males between 25 and 59. Due to the effects of the pension reform we project an increase of around 20 percentage points in the age cohort 60–64. For females we project a significant increase in all age cohorts but the first. This is caused by the catching up of females and is further augmented by the pension reform.

Table 9.2 demonstrates the results for scenario 2. The aggregate participation rate of females will slightly increase because of cohort effects and the pension reform. Over the forecasting period we expect an increase of 10.6 percentage points. The aggregate male activity rate stays almost constant over the simulation period. This implies an increase for the total participation rate from currently 68.9% to 73.7% in 2070. In this year the activity rate is 3 percentage points below the value in scenario 1A.

Population development and the activity rates determine labour supply. Labour supply will increase between 2002 and 2020 by 97.000 persons, mainly because of the pension reform. In the following decades labour supply falls. In 2070, labour supply amounts to 3.3 million persons (130.000 less than in scenario 1A; chart 9.2.1). Due to the rising labour supply, employment will grow until 2020. In the following years employment growth will become negative. However, the assumed 2.3 percentage points decline in the structural unemployment rate between 2020 and 2037 cushions the fall in employment. Over the whole forecasting period employment will shrink by an annual average rate of 0.2%.

Between 2002 and 2010 the average economic growth rate of the Austrian economy is close to 2%. In the following decades the decrease in the labour force leads to slower growth. The Austrian economy will grow with 1.5% per year in the period 2010 to 2040 and with 1.4% afterwards. Over the whole simulation period average annual growth is 1.6%. In 2070 the level of GDP is 4.2 percentage points lower as in scenario 1A. Labour productivity and real wages will grow on average with 1.7% between 2002 and 2070 and therefore at the same pace as in scenario 1A.

The share of social contributions in GDP of 16.4% in 2010 will increase slightly to 16.8% in 2070. Due to aging, social expenditures (as a share of GDP) will grow considerably faster. Between 2002 and 2020 the share of social expenditures in

Chart 9.2.1: Labour Force with Different Participation Rates

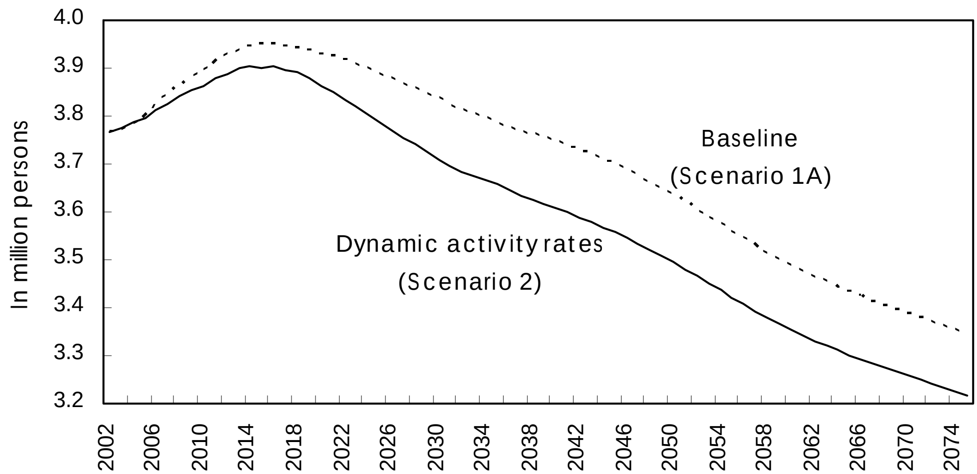
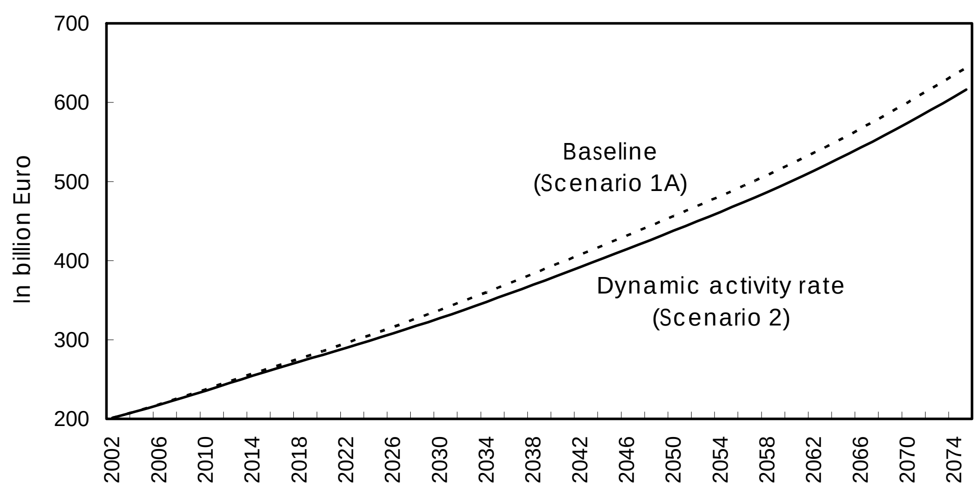


Chart 9.2.2: Real Gross Domestic Product



GDP will increase by 3 percentage points. In the year 2050 the share of social expenditure in GDP is 25.3% and it is slightly reduced until the 2070. In this year the gap between contributions and expenditures amounts to 7.7 percentage points. The pension insurance expenditures increase continuously from 11% of GDP in 2002 to 15.9% in 2060. As a consequence the government transfers to the pension insurance system will also rise and will reach their maximum at 7.3% in 2060. After 2060 the pressure on the fiscal stance of the pension system is slightly reduced (6.9% in 2070). At the end of the forecasting period the government transfers are 1.1 percentage points higher as in scenario 1A.

Table 9.2: Dynamic Activity Rate Scenario (Scenario 2)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
				1,000 persons						
Working Age Population (15-64)	5,464.7	5,577.6	5,562.9	5,237.2	4,944.1	4,759.1	4,551.2	4,423.9	-0.3	
Economically active population (Labour force)	3,765.3	3,863.1	3,862.0	3,710.6	3,611.0	3,498.7	3,357.2	3,260.2	-0.2	
Economically active employees in full time equivalents	3,006.8	3,081.2	3,089.5	3,010.0	2,953.4	2,859.9	2,744.6	2,665.7	-0.2	
Number of pensions	1,999.0	2,155.6	2,433.8	2,754.8	2,910.4	2,969.2	2,909.6	2,794.5	0.5	
				In percent						
Participation rate, total	68.9	69.3	69.4	70.9	73.0	73.5	73.8	73.7	0.1	4.8
Women	61.1	62.1	62.9	66.4	70.3	71.5	71.8	71.7	0.2	10.6
Men	76.7	76.3	75.9	75.2	75.7	75.5	75.7	75.6	0.0	-1.1
Unemployment rate	6.9	7.1	6.8	5.4	4.5	4.5	4.5	4.5	-0.6	-2.4
Old age dependency ratio	22.8	26.2	30.2	39.6	47.5	50.6	52.4	51.8	1.2	28.9
Pensions relative to insured persons	62.4	65.5	73.9	87.4	95.2	100.5	103.1	102.3	0.7	39.9
Pensions relative to population aged 65+	1.60	1.47	1.45	1.33	1.24	1.23	1.22	1.22	-0.4	
				Bill. €						
Gross domestic product at constant 1995 prices	201.2	235.9	281.4	328.4	382.8	441.0	504.1	579.5	1.6	
Gross domestic product at current prices	218.3	300.0	436.3	620.5	881.8	1,238.3	1,725.3	2,417.9	3.6	
				1,000 €						
Real GDP per capita	25.0	28.6	33.5	39.0	46.0	54.0	63.8	75.7	1.6	
				2002 = 100						
Real wage per capita, in full time equivalents (MPL)	100.0	114.1	136.7	163.6	194.3	231.3	275.6	325.8	1.8	
				Percentage change against previous year						
Gross domestic product at constant 1995 prices	1.4	2.0	1.5	1.5	1.5	1.4	1.4	1.4	1.6	
Compensation to employees, at current prices	2.2	4.1	3.7	3.6	3.5	3.4	3.4	3.4	3.6	
Real wage per employee	1.3	1.7	2.1	1.8	1.8	1.7	1.7	1.7	1.7	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
				Ratio						
Marginal product of capital	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	-0.1	
Capital-output-ratio	3.62	3.62	3.65	3.70	3.72	3.75	3.78	3.78	0.1	0.2

Table 9.2 (continued): Dynamic Activity Rate Scenario (Scenario 2)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.5	7.5	7.5	7.4	7.4	7.4	7.4	0.0	-0.2
Contributions to pension insurance by employees	7.0	6.9	7.0	7.0	7.0	7.0	7.0	7.0	0.0	0.0
Contributions to pension insurance by self-employed	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	-0.4	-0.1
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.1
Total social security expenditures pension insurance	11.0	11.4	12.7	14.5	15.3	15.9	15.9	15.5	0.5	4.5
Government transfers to pensions insurance system	2.2	2.7	4.0	5.8	6.7	7.2	7.3	6.9	1.7	4.7
Social security contributions health insurance	4.0	4.0	4.1	4.3	4.3	4.4	4.4	4.3	0.1	0.4
Total social security expenditures health insurance	5.0	6.1	6.4	6.8	6.8	6.6	6.5	6.3	0.3	1.3
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
Total social security expenditures accident insurance	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	16.4	16.6	16.8	16.8	16.9	16.9	16.8	0.0	0.2
Transfer expenditures - pensions, health and long term care	16.0	17.0	18.7	21.0	22.1	22.8	22.7	22.1	0.5	6.1
Social expenditures	17.7	20.1	21.7	23.7	24.6	25.3	25.2	24.5	0.5	6.8
	2002=100									
Average real pension per year [1])	100.0	112.5	132.2	155.2	181.0	211.5	247.3	287.1	1.6	
	In percent of GDP, at current prices									
Government expenditures	51.3	50.7	50.8	50.8	50.8	50.8	50.7	50.7		-0.7
Other government expenditures	25.5	25.1	24.2	22.6	22.1	21.6	21.8	22.5		-3.0

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

9.3 Alternative Contribution Rates and Pension Indexation in the Social Security System

9.3.1 A Scenario with a Stable Fiscal Balance of Social Security (Scenario 3A)

In A-LMM the evolution of expenditures of the social security sector is driven to a large extent by demographic developments. The increase in the number of pensions due to the aging of the Austrian population brings about a significant increase in spending relative to GDP. Additionally, demographic trends affect the development of health expenditures. The impact of demography on pensions and health expenditures results in a significant increase in total social security spending relative to nominal GDP.

Revenues of the social security funds depend on the growth rate of the wage bill and the contribution rates. The baseline scenario (scenario 1A) is based on the assumption of no policy change such that contribution rates remain unaltered at their 2002 level. Therefore revenues of the social security funds grow proportional to the wage bill. As the labour share remains constant in A-LMM this implies that the ratio of social security revenues to GDP stays constant over the whole simulation horizon.

Scenario 1A leads to an increasing gap between revenues and expenditures of the social security funds. Consequently, the government transfer to the pension insurance system would climb from 2.2% of GDP to 6.2% in 2060, with a moderate decline afterwards (chart 9.1.4).

In scenario 3A we assume that contribution rates are continuously adjusted in a way that the balance of the social security sector (as a percentage of GDP) remains at the level of the year 2002. This scenario leads to a significant increase in contribution rates. As depicted in chart 9.3.1 contribution rates in the ASVG pension system (the sum of employee and employers rates) would have to be increased from 22.8% of wages up to a maximum rate of 34% in 2055. In order to stabilise the fiscal balance of the social security funds, social contributions as a percentage of nominal GDP have to rise by a maximum amount of about 6.4 percentage points in the year 2050. In A-LMM the adjustment of contribution rates has direct effects on the annual pension adjustment, and the tax wedge (chart 9.3.2).

The increase in contribution rates has a direct effect on pension expenditures. According to current law the indexation of net pensions is linked to the growth in net wages. This implies that the growth rate of average pension benefits is dampened, whenever contributions rates rise. As a result, total expenditures of the pension insurance as a percentage of GDP are slightly below the corresponding values of scenario 1A in the period from 2040 to 2070.

Finally, social security contributions affect the outcome of the wage bargaining process via the tax wedge. In A-LMM part of the increase of social contributions is shifted into higher wage claims, which in turn lead to a decline in labour demand and higher unemployment. Rising contribution rates have a very significant indirect effect on unemployment. The increase in the tax wedge leads to an upward shift of the structural unemployment rate. Consequently, the average unemployment rate would be 8.5% over the simulation period, which is about 3 percentage points above the value obtained in scenario 1A. Chart 9.3.3 describes the evolution of unemployment in this scenario compared to the baseline scenario. Employment and GDP growth are reduced on average by around 0.1 percentage point per year. For the year 2070 this implies that the levels of employment, nominal and real GDP are 4.6% lower as compared to scenario 1A.

Chart 9.3.1: Contribution Rates in Pension Insurance (ASVG) - Stabilising Government Transfers

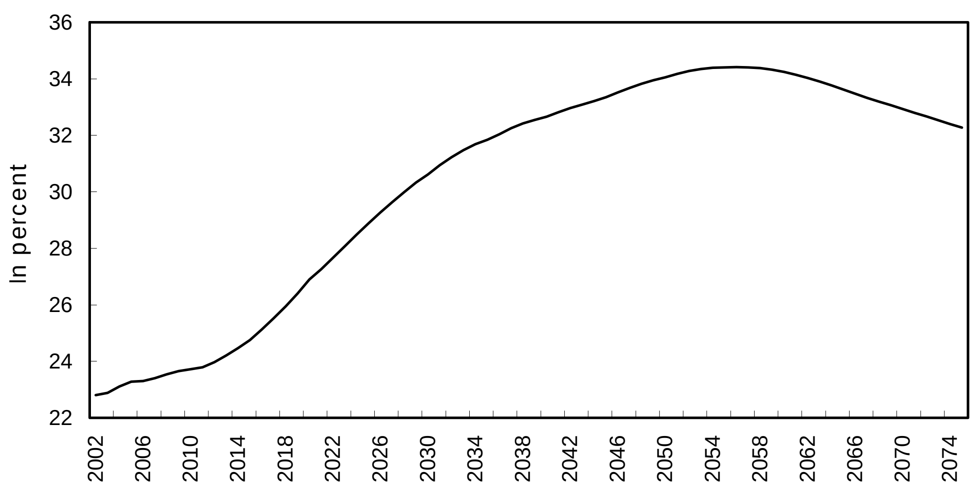


Table 9.3A: Stable Fiscal Balance of Social Security (Scenario 3A)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
					1,000 persons					
Working Age Population (15-64)	5,464.7	5,577.6	5,562.9	5,237.2	4,944.1	4,759.1	4,551.2	4,423.9	-0.3	
Economically active population (Labour force)	3,765.3	3,893.2	3,924.5	3,825.8	3,733.3	3,618.7	3,470.6	3,371.7	-0.2	
Economically active employees in full time equivalents	3,006.8	3,073.2	3,078.1	3,002.8	2,933.7	2,834.1	2,718.6	2,658.4	-0.2	
Number of pensions	1,999.0	2,143.5	2,409.3	2,686.2	2,833.2	2,890.6	2,836.4	2,723.3	0.5	
					In percent					
Participation rate, total	68.9	69.8	70.5	73.1	75.5	76.0	76.3	76.2	0.1	7.3
Women	61.1	61.7	62.1	65.4	69.0	70.1	70.4	70.3	0.2	9.3
Men	76.7	77.9	78.9	80.6	81.9	81.8	82.0	81.9	0.1	5.2
Unemployment rate	6.9	8.2	8.8	8.7	8.6	8.8	8.8	8.3	0.3	1.4
Old age dependency ratio	22.8	26.2	30.2	39.6	47.5	50.6	52.4	51.8	1.2	28.9
Pensions relative to insured persons	62.4	64.5	71.9	82.4	89.3	94.3	96.9	96.1	0.6	33.6
Pensions relative to population aged 65+	1.60	1.46	1.43	1.30	1.21	1.20	1.19	1.19	-0.4	
					Bill. €					
Gross domestic product at constant 1995 prices	201.2	235.5	280.6	327.4	380.4	437.2	499.6	577.0	1.6	
Gross domestic product at current prices	218.3	299.4	434.9	618.6	876.2	1,227.7	1,709.8	2,407.3	3.6	
					1,000 €					
Real GDP per capita	25.0	28.5	33.4	38.9	45.7	53.6	63.2	75.4	1.6	
					2002 = 100					
Real wage per capita, in full time equivalents (MPL)	100.0	114.1	136.7	163.4	194.2	231.5	275.6	325.0	1.7	
					Percentage change against previous year					
Gross domestic product at constant 1995 prices	1.4	2.0	1.5	1.5	1.5	1.4	1.4	1.5	1.6	
Compensation to employees, at current prices	2.2	4.0	3.6	3.5	3.5	3.4	3.4	3.5	3.6	
Real wage per employee	1.3	1.6	2.0	1.7	1.7	1.7	1.7	1.7	1.7	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
					Ratio					
Marginal product of capital	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	-0.1	
Capital-output-ratio	3.62	3.63	3.65	3.70	3.72	3.75	3.78	3.78	0.1	0.2

Table 9.3A (continued): Stable Fiscal Banlance of Social Security (Scenario 3A)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.8	8.8	10.0	10.6	11.1	11.1	10.6	0.5	3.1
Contributions to pension insurance by employees	7.0	7.2	8.2	9.3	10.0	10.4	10.4	10.0	0.5	3.0
Contributions to pension insurance by self-employed	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.6	0.1	0.0
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.1
Total social security expenditures pension insurance	11.0	11.3	12.3	13.6	14.2	14.7	14.7	14.3	0.4	3.3
Government transfers to pensions insurance system	2.2	2.3	2.3	2.3	2.4	2.4	2.4	2.5	0.2	0.3
Social security contributions health insurance	4.0	5.0	5.4	5.9	5.9	5.9	5.7	5.5	0.5	1.5
Total social security expenditures health insurance	5.0	6.1	6.4	6.8	6.8	6.7	6.5	6.3	0.3	1.3
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	-0.2	-0.1
Total social security expenditures accident insurance	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	18.0	19.8	21.7	22.6	23.0	22.8	22.0	0.4	5.4
Transfer expenditures - pensions, health and long term care	16.0	16.9	18.3	20.0	21.0	21.6	21.5	21.0	0.4	4.9
Social expenditures	17.7	20.2	21.8	23.5	24.4	25.0	24.9	24.1	0.5	6.4
	2002=100									
Average real pension per year [1])	100.0	111.7	129.1	148.2	170.9	198.4	231.7	270.5	1.5	
	In percent of GDP, at current prices									
Government expenditures	51.3	52.1	53.6	55.2	56.0	56.3	56.1	55.4		4.0
Other government expenditures	25.5	26.3	26.9	27.2	27.4	27.3	27.4	27.5		2.1

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

Chart 9.3.2: Tax Wedge

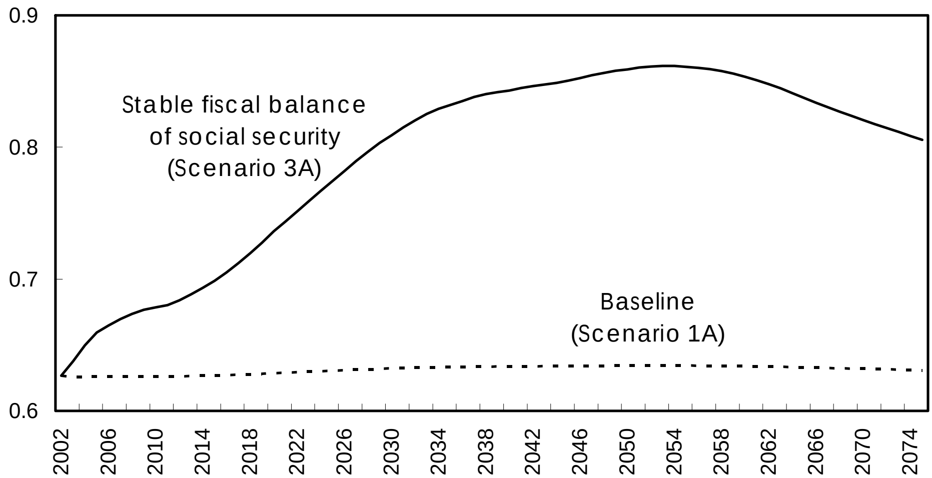
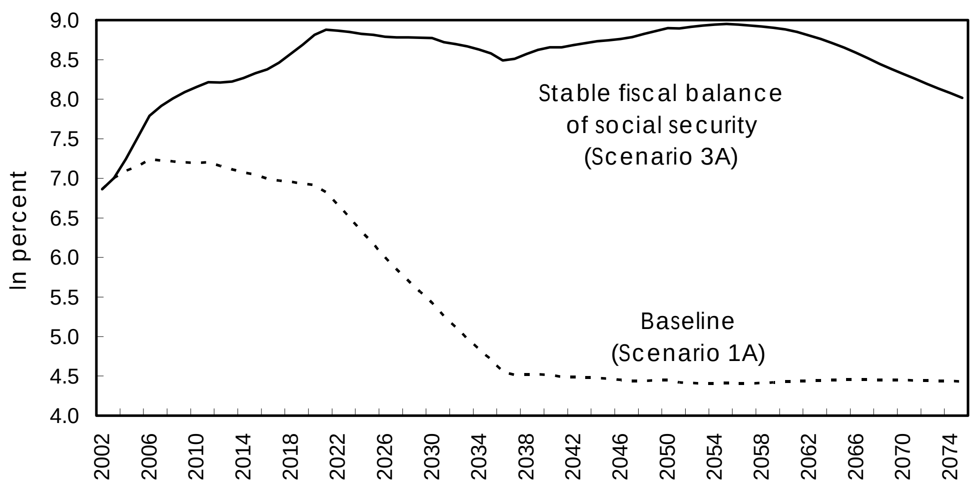


Chart 9.3.3: Unemployment Rate



9.3.2 A Scenario with Alternative Pension Adjustment (Scenario 3B)

As mentioned in section 7.1 the current system of pension indexation implies, that the growth rate of the average pension (which is the sum of average new and existing pension benefits) net of social contributions corresponds to the growth of net wages. This rule makes any measures that modify the generosity of pension benefits ineffective with respect to total transfer expenditures of the pension insurance. Therefore the very recently enacted pension reform in Austria, which causes a continuous decline in pension benefits for new pensioners by 10% until 2009, would lead to no reductions in overall spending, as this effect would be completely compensated by automatically higher growth of existing pension benefits.

In scenario 3B we assume an alternative rule for indexing existing pensions. Specifically we assume that benefits of existing pensioners rise in line with the inflation rate (refer to appendix 1 for details). The growth rate of average pension benefits (the sum of new and average pension benefits) that follows from this rule will be different from the inflation rate because of two effects:

- pension benefits of new pensioners are in general higher than existing benefits, and
- pensioners that die have on average lower pension benefits than those who survive.

The size of both effects depends on changes in the generosity of the pension system, the difference in growth rates of new pension benefits (which will be in the long-term the growth rate of wages) versus the growth rate of existing benefits (the pension indexation), the average duration of receiving a pension, the average duration of receiving a pension of those pensioners who die and the relative size of the three groups of pensioners. In the year 2000 the first effect amounted to about 1 percentage point and the second effect caused an increase of the average pension of about 0.5 percent.

In scenario 3B this alternative rule of pension indexation implies that the growth rate of average pension benefits will fall significantly below the corresponding growth rates under current legislation until 2030. This is a consequence of the decline in pension benefits for new pensioners in the period from 2004 to 2009 implied by the most recent pension reform. Over time, however, the dampening effect of lower pension benefits for new pensioners vanishes and growth rates of average pensions climb to levels comparable to those obtained under current legislation after 2030.

The moderate growth in average pensions leads to a significant reduction in total transfer expenditures of pension insurance. Over the whole projection period transfer expenditures and similarly the government transfer to the pension system decline on average by about 1.3 percentage point of GDP (see chart 9.3.4). Alternative pension indexation has practically no effect on other variables in the A-LMM model. Employment, wages, investment and GDP growth are nearly identical to the baseline scenario.

Table 9.3B: Alternative Pension Adjustment (Scenario 3B)

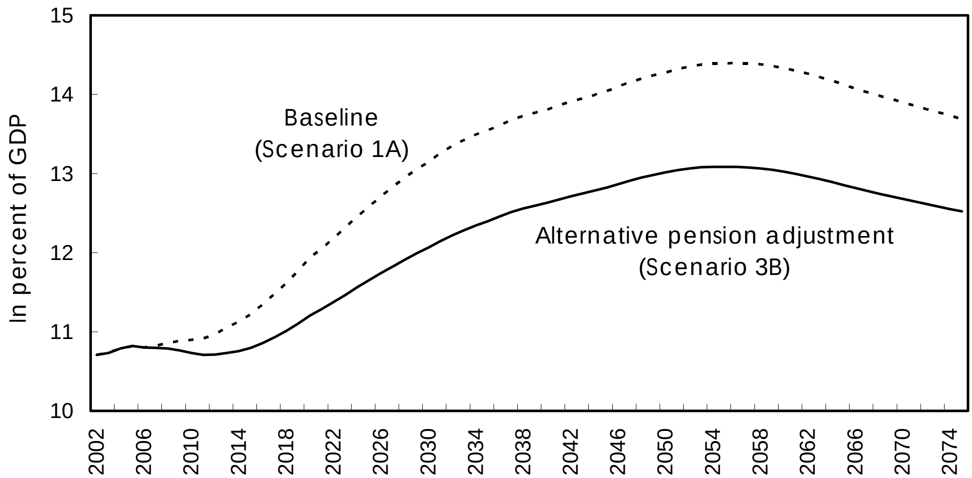
	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
				1,000 persons						
Working Age Population (15-64)	5,464.7	5,577.6	5,562.9	5,237.2	4,944.1	4,759.1	4,551.2	4,423.9	-0.3	
Economically active population (Labour force)	3,765.3	3,895.9	3,931.2	3,838.9	3,751.1	3,638.7	3,491.3	3,390.7	-0.2	
Economically active employees in full time equivalents	3,006.8	3,108.6	3,150.6	3,128.2	3,086.4	2,994.2	2,873.6	2,790.8	-0.1	
Number of pensions	1,999.0	2,142.8	2,407.3	2,682.2	2,827.8	2,884.2	2,829.8	2,717.3	0.5	
				In percent						
Participation rate, total	68.9	69.8	70.7	73.3	75.9	76.5	76.7	76.6	0.2	7.7
Women	61.1	61.7	62.3	65.6	69.4	70.6	70.9	70.8	0.2	9.7
Men	76.7	77.9	79.0	80.9	82.2	82.2	82.4	82.3	0.1	5.6
Unemployment rate	6.9	7.2	6.9	5.4	4.4	4.4	4.3	4.4	-0.7	-2.5
Old age dependency ratio	22.8	26.2	30.2	39.6	47.5	50.6	52.4	51.8	1.2	28.9
Pensions relative to insured persons	62.4	64.5	71.7	82.0	88.7	93.5	96.0	95.2	0.6	32.8
Pensions relative to population aged 65+	1.60	1.46	1.43	1.29	1.20	1.20	1.19	1.19	-0.4	
				Bill. €						
Gross domestic product at constant 1995 prices	201.2	237.5	286.1	338.8	397.6	459.7	526.3	605.7	1.6	
Gross domestic product at current prices	218.3	302.0	443.5	640.2	915.8	1,290.7	1,801.3	2,526.9	3.7	
				1,000 €						
Real GDP per capita	25.0	28.8	34.1	40.2	47.7	56.3	66.6	79.2	1.7	
				2002 = 100						
Real wage per capita, in full time equivalents (MPL)	100.0	113.7	136.0	162.0	192.9	230.3	274.8	325.2	1.7	
				Percentage change against previous year						
Gross domestic product at constant 1995 prices	1.4	2.1	1.7	1.7	1.6	1.4	1.4	1.4	1.6	
Compensation to employees, at current prices	2.2	4.2	3.8	3.7	3.6	3.4	3.4	3.5	3.7	
Real wage per employee	1.3	1.6	1.9	1.7	1.7	1.8	1.7	1.7	1.7	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	

Table 9.3B (continued): Alternative Pension Adjustment (Scenario 3B)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.5	7.5	7.4	7.4	7.4	7.4	7.4	0.0	-0.2
Contributions to pension insurance by employees	7.0	6.9	7.0	7.0	7.0	7.0	7.0	7.0	0.0	0.0
Contributions to pension insurance by self-employed	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	-0.4	-0.2
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.1
Total social security expenditures pension insurance	11.0	11.1	11.6	12.5	13.0	13.4	13.4	13.1	0.3	2.1
Government transfers to pensions insurance system	2.2	2.4	2.9	3.8	4.4	4.8	4.8	4.5	1.1	2.3
Social security contributions health insurance	4.0	3.9	4.0	4.1	4.1	4.2	4.2	4.1	0.1	0.2
Total social security expenditures health insurance	5.0	6.0	6.3	6.6	6.7	6.5	6.4	6.2	0.3	1.3
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
Total social security expenditures accident insurance	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	16.4	16.5	16.6	16.6	16.6	16.6	16.5	0.0	0.0
Transfer expenditures - pensions, health and long term care	16.0	16.6	17.5	18.9	19.7	20.3	20.2	19.7	0.3	3.7
Social expenditures	17.7	19.7	20.5	21.6	22.2	22.7	22.6	22.1	0.3	4.3
	2002=100									
Average real pension per year [1])	100.0	110.3	123.4	141.0	164.0	191.2	222.9	259.9	1.4	
	In percent of GDP, at current prices									
Government expenditures	51.3	50.6	50.7	50.7	50.7	50.6	50.5	50.5		-0.9
Other government expenditures	25.5	25.4	25.3	24.6	24.3	24.0	24.2	24.8		-0.7

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

Chart 9.3.4: Transfer Expenditures of Pension Insurance



9.4 A Scenario with Higher Productivity Growth (Scenario 4)

The average growth rate of the economy is determined by the growth rates of employment, the capital stock, and total factor productivity. Out of these three factors we already showed the implication of a change in the participation rate on employment and GDP-growth. In this section we will discuss the effects of a higher growth rate in total factor productivity. In the base scenario the growth rate of total factor productivity is set constant at an annual rate of 0.85 percent. Under the assumption of constant employment and a constant capital-output ratio this implies a constant annual rate of growth of GDP of 1.6 percent. The alternative scenario assumes a growth rate of total factor productivity of 1.15 percent.

The underlying population projection corresponds to the main variant of Hanika et al. (2004). The higher growth rate provides a moderate stimulus to the labour supply. For this reason all variables relating labour market to population or the number of pensions change as well. For example, the ratio of pensions to the number of insured persons falls by 6.3 percentage points by 2070 compared to baseline. In the model a higher total factor productivity growth feeds through to higher real wages. The average growth of real wages per capita rises by 0.6 percentage point relative to the baseline.

The resulting GDP growth is higher than in the baseline case, although less than to be expected from a TFP-shock of this size. As has been mentioned in section 2, a 0.5 percent growth rate in total factor productivity corresponds to an increase in labour augmented technical progress by 1 percent. Thus we would expect a long-run GDP-growth of around 2.3 percent. However, the constraint imposed by demography slows down the economy. Investment adjusts such that the marginal productivity of capital remains optimal and the capital output ratio drops towards a level of 3.6. Since inflation is assumed constant at 2 percent, the nominal GDP grows by 2 percentage points in excess of real GDP.

By design of the social security block, we do not expect major changes in the key figures as the result of a change in the average growth rate of the economy. Contribution rates are proportional up to the upper earnings threshold, and the upper earnings threshold itself grows in line with nominal wages. The simulation results live up to these expectations. Revenues from contributions by each of the four branches do not deviate by more then 0.1 percentage point of nominal GDP from the baseline. The expenditure side, on the other hand, shows a more pronounced reaction to a high-growth environment. Social expenditures increase less steeply and reach a lower peak value of 24.2 percent of GDP in 2054. The savings occur mainly in the health insurance system. The size of savings in pension expenditures is about half as large as in the health insurance branch. The other two branches do not react visibly. Consequently, public transfers to the social security system are lower in a high growth scenario, although the decrease of transfers to the pension system is less pronounced.

The higher growth rate in GDP is associated with higher tax revenues as a share of GDP. Since we require full balance of the public budget in each year of the simulation this allows for higher government spending as well.

Table 9.4: Higher Productivity Growth (Scenario 4)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	1,000 persons									
Working Age Population (15-64)	5,464.7	5,577.6	5,562.9	5,237.2	4,944.1	4,759.1	4,551.2	4,423.9	-0.3	
Economically active population (Labour force)	3,765.3	3,908.9	3,966.8	3,899.2	3,837.0	3,749.3	3,624.1	3,544.8	-0.1	
Economically active employees in full time equivalents	3,006.8	3,118.1	3,177.1	3,174.9	3,155.1	3,083.8	2,982.2	2,917.7	0.0	
Number of pensions	1,999.0	2,139.7	2,397.3	2,663.8	2,801.4	2,849.0	2,787.9	2,669.1	0.4	
	In percent									
Participation rate, total	68.9	70.1	71.3	74.5	77.6	78.8	79.6	80.1	0.2	11.2
Women	61.1	62.0	62.9	66.8	71.2	73.0	73.9	74.4	0.3	13.3
Men	76.7	78.1	79.6	82.0	83.9	84.4	85.2	85.7	0.2	9.0
Unemployment rate	6.9	7.2	6.9	5.4	4.5	4.4	4.4	4.4	-0.6	-2.5
Old age dependency ratio	22.8	26.2	30.2	39.6	47.5	50.6	52.4	51.8	1.2	28.9
Pensions relative to insured persons	62.4	64.2	70.7	80.1	85.7	89.4	90.8	89.1	0.5	26.6
Pensions relative to population aged 65+	1.60	1.46	1.43	1.29	1.19	1.18	1.17	1.17	-0.5	
	Bill. €									
Gross domestic product at constant 1995 prices	201.2	246.3	312.7	392.3	489.3	602.4	735.3	902.8	2.2	
Gross domestic product at current prices	218.3	313.2	484.7	741.2	1,127.0	1,691.3	2,516.5	3,766.5	4.3	
	1,000 €									
Real GDP per capita	25.0	29.8	37.2	46.6	58.7	73.8	93.0	118.0	2.3	
	2002 = 100									
Real wage per capita, in full time equivalents (MPL)	100.0	117.4	147.3	184.7	232.1	292.8	369.6	463.4	2.3	
	Percentage change against previous year									
Gross domestic product at constant 1995 prices	1.4	2.6	2.3	2.3	2.2	2.1	2.0	2.1	2.2	
Compensation to employees, at current prices	2.2	4.7	4.4	4.3	4.2	4.1	4.0	4.1	4.3	
Real wage per employee	1.3	2.1	2.4	2.3	2.3	2.3	2.3	2.3	2.3	
GDP deflator	1.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
	Ratio									
Marginal product of capital	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.0	
Capital-output-ratio	3.62	3.56	3.54	3.55	3.55	3.57	3.60	3.60	0.0	0.0

Table 9.4 (continued): Higher Productivity Growth (Scenario 4)

	2002	2010	2020	2030	2040	2050	2060	2070	Avg. change (in %) 2002/2070	Cum. change (in % points) 2002/2070
	In percent of GDP, at current prices									
Social security contributions pension insurance	7.6	7.5	7.5	7.4	7.4	7.4	7.4	7.4	0.0	-0.2
Contributions to pension insurance by employees	7.0	6.9	7.0	7.0	7.0	7.0	7.0	7.0	0.0	0.0
Contributions to pension insurance by self-employed	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	-0.5	-0.2
Contributions to pension insurance by others	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-0.1	-0.1
Total social security expenditures pension insurance	11.0	11.1	12.1	13.1	13.6	13.9	13.7	13.1	0.3	2.1
Government transfers to pensions insurance system	2.2	2.4	3.4	4.5	5.0	5.3	5.1	4.6	1.1	2.4
Social security contributions health insurance	4.0	3.9	4.0	4.1	4.2	4.2	4.2	4.1	0.1	0.2
Total social security expenditures health insurance	5.0	5.9	5.9	6.1	6.0	5.8	5.6	5.4	0.1	0.5
Social security contributions accident insurance	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0
Total social security expenditures accident insurance	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	-0.2	-0.1
Social contributions	16.6	16.4	16.6	16.6	16.7	16.7	16.7	16.6	0.0	0.0
Transfer expenditures - pensions, health and long term care	16.0	16.5	17.7	19.1	19.8	20.2	20.0	19.3	0.3	3.3
Social expenditures	17.7	19.6	20.7	21.7	22.1	22.5	22.2	21.4	0.3	3.7
	2002=100									
Average real pension per year [1]	100.0	115.6	141.9	174.2	214.3	264.6	326.9	401.2	2.1	
	In percent of GDP, at current prices									
Government expenditures	51.3	50.7	50.9	50.9	50.9	50.9	50.8	50.7		-0.6
Other government expenditures	25.5	25.6	25.4	24.9	24.8	24.6	25.0	25.8		0.3

1) Average transfer expenditures deflated by GDP-deflator to facilitate comparison with real wage.

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Appendix 1: Modelling Alternative Adjustment of Pension Benefits

A-LMM describes the development of the average pension benefit. Average pension benefits comprise the benefits for new pensions as well as benefits of already existing pensioners. According to current legislation, average net pension benefits grow in line with net wages. The corresponding equation in A-LMM has been described in section 7. If an alternative rule for the revaluation of pension benefits would be introduced the task of modelling pension benefits would be more complicated. This section explains how pension benefits are modelled in A-LMM, if an alternative adjustment of pension benefits, as in scenario 3b, is assumed.

Modelling pension benefits may be described in a number of steps:

Step 1: If existing pension benefits remain unaltered between two periods, the average pension benefit of existing pensioners will rise by a factor *d*. This is due to the fact, that benefits of dying pensioners are usually lower than benefits of surviving pensioners.

$$B_{t-1} = \theta\, BB + (1-\theta) BD\,.$$

$$B_t = BB\,.$$

$$d = \frac{B_t}{B_{t-1}} - 1 = \frac{1}{\theta + (1-\theta)\dfrac{BD}{BB}} - 1\,.$$

Here B_t average pension benefit;
BB average pension benefit of those who survive;
BD average pension benefit of those who die;
θ the share of pensioners that survive.

The parameter d is determined by the difference between benefit levels of surviving to dead pensioners and the share of surviving pensioners. In the year 2000 the growth of average pensions that is attributable to this effect amounted to 0.5 percent.

Step 2: If existing pension benefits remain unaltered the average pension benefit (new pension benefits plus existing pension benefits) will rise by a factor *n*. This is due to the fact, that benefits of new pensioners are usually higher than benefits of existing pensioners.

$$B_t = \psi\, BN + (1-\psi) BB\ .$$

$$B_{t-1} = BB\ .$$

$$n = \frac{B_t}{B_{t-1}} - 1 = \psi\left(\frac{BN}{BB} - 1\right).$$

Here BN average pension benefit of new pensioners;
ψ the share of new pensioners.

The reasoning is the same as in step 1. In the year 2000 the growth of average pension benefits attributable to this effect amounted to about 1.0 percent.

Step 3: The total increase in average pension benefits consists of the sum of the effects *n* + *d* and the adjustment of existing pension benefits. In order to project the increase in average pensions assumptions about the differences in benefit levels of the different groups and the corresponding shares have to be made.

The determinants of differences in benefit levels are:

- changes in the generosity of the pension system;
- differences in labour market histories;
- differences in the growth of new pensions vs. existing pensions.

In our approach we only consider the latter effect. We assume that new pensions rise with the average wage, whereas existing pensions are indexed by the rate of inflation. In this case differences in the benefit levels between new, existing pensions and benefits of dying pensioners are determined by the difference between growth rates of new and existing pension benefits.

If a person retires in *t*, in *t* + *1* she will receive a pension benefit that has grown by the adjustment factor (inflation rate, *Δlog(P)*). A person that retires in *t* + *1* with the same replacement rate as the former person will have a pension benefit which is higher by the factor *(1 + Δlog(W))*:

$$\frac{BN}{BB} = D_{BB}^{\;1+\Delta\log(W)-\Delta\log(P)}\ .$$

Here D_{BB} denotes the duration of the average pension benefit claim.

The above equation implies, that existing pension benefits fall compared to new pension benefits, if the pension adjustment factor *Δlog(P)*, is below the average wage growth, $\Delta log(W)$. The same will be true for the difference between benefits of dying and surviving pensioners.

$$\frac{BB}{BD} = (D_{BB} - D_{BD})^{1+\Delta \log(W) - \Delta \log(P)},$$

where D_{BD} is the duration of the average pension claim of dead pensioners.

In scenario 3b we use this methodology to model the growth of average pension benefits. Equation 7.4 (see section 7) is replaced by the following one:

$$\Delta \log\left(\frac{TRP_t}{PEN_t}\right) = NPS_t(NPB_t - 1) + d_t + \Delta \log(P_t).$$

Following the approach described above, the growth of average pension benefits, TRP_t/PEN_t, consists of three components. The first one comprises the effect of new pension benefits described by the relative share of the number of new benefits in total benefits, NPS_t, and the relationship between new pension benefits and the benefits of existing pensioners (NPB_t corresponds to BN/BB as defined above). The effect of dying pensioners is captured by the parameter d_t. Finally, it is assumed that existing pension benefits are indexed to inflation.

We expect a rather stable development of the relevant parameters. In the A-LMM model we assume that the effect due to dying pensioners, d_t, amounts to 0.5 percent and remains constant over time. The share of new pensions, NPS_t, is set to 4.5 percent. Finally, it is assumed that in the steady state the new pension will be 23 percent above the average pension benefit of existing pension benefits, i.e. $NPB_t = 1.23$. As the pension reform of 2003 implies that pension benefits for new pensioners fall by 10 percent until 2009 we gradually decrease NPB_t by 10 percent. In the period 2009 to 2030 NPB_t reverts gradually to its steady state value.

Appendix 2: *Table A2: List of Variables*

Exogenous Variables

New	English	German	Type	Sec.
QSB	Ratio of business savings to investment	Verhältnis von Sparen im Unternehmenssektor zu den Investitionen	exo	2
RD	Rate of physical depreciation	Ökonomische Abschreibung, Durchschnittssatz	exo	2
RTD	Rate of tax depreciation allowance	Steuerliche Abschreibung, Durchschnittssatz	exo	2
TFP	Total factor productivity, rate of change	Veränderungsrate d. Gesamtfaktorproduktivität	exo	2
PRD	Probability of death (Inverse of life - expectancy), private households	Sterbewahrscheinlichkeit (Kehrwert d. Lebenserwartung) d. priv. Haushalts	exo	3
RTP	Rate of time preference	Zeitpräferenzrate	exo	3
GRR	Gross replacement rate	Ersatzrate d. Arbeitslosenversicherung	exo	4
POP	Population, Austria, in million persons	Bevölkerung von Österreich, Mio. Personen	exo	4
POP0	Population, age group 0 to 14, in million persons	Bevölkerung im Alter von 0 bis 14	exo	4
POP1_3	Population, age group15 to 55, in million persons	Bevölkerung im Alter von 15 bis 55	exo	4
POP4_5	Population, age group 55 to 65, in million persons	Bevölkerung im Alter von 55 bis 65	exo	4
POP6	Population, age group 65 and older, in million persons	Bevölkerung im Alter von 65+	exo	4
POPC	Population, age group 0 to 4, in million persons	Bevölkerung im Alter von 0 bis 4	exo	4
POPE	Population, age group 15 to 65, in million persons	Erwerbsfähige Wohnbevölkerung im Alter von 15 bis 65	exo	4
POPF	Population, Austria, females, in million persons	Gesamtbevölkerung von Österreich, Frauen	exo	4
POPF0	Population, females, age group 0 to 14, in million persons	Bevölkerung Frauen im Alter von 0 bis 14	exo	4
POPF1	Population, females, age group 15 to 24, in million persons	Bevölkerung Frauen im Alter von 15 bis 24	exo	4
POPF2	Population, females, age group 25 to 49, in million persons	Bevölkerung Frauen im Alter von 25 bis 49	exo	4
POPF3	Population, females, age group 50 to 54, in million persons	Bevölkerung Frauen im Alter von 50 bis 54	exo	4
POPF4	Population, females, age group 55 to 59, in million persons	Bevölkerung Frauen im Alter von 55 bis 59	exo	4
POPF5	Population, females, age group 60 to 64, in million persons	Bevölkerung Frauen im Alter von 60 bis 64	exo	4
POPF6	Population, females, age group 65 and older, in million persons	Bevölkerung Frauen im Alter von 65+	exo	4
POPM	Population, Austria, males, in million persons	Gesamtbevölkerung von Österreich, Männer	exo	4
POPM0	Population, males, age group 0 to 14, in million persons	Bevölkerung Männer im Alter von 0 bis 14	exo	4
POPM1	Population, males, age group 15 to 24, in million persons	Bevölkerung Männer im Alter von 15 bis 24	exo	4
POPM2	Population, males, age group 25 to 49, in million persons	Bevölkerung Männer im Alter von 25 bis 49	exo	4
POPM3	Population, males, age group 50 to 54, in million persons	Bevölkerung Männer im Alter von 50 bis 54	exo	4
POPM4	Population, males, age group 55 to 59, in million persons	Bevölkerung Männer im Alter von 55 bis 59	exo	4
POPM5	Population, males, age group 60 to 64, in million persons	Bevölkerung Männer im Alter von 60 bis 64	exo	4
POPM6	Population, males, age group 65 and older, in million persons	Bevölkerung Männer im Alter von 65+	exo	4
ELS	Labour supply elasticity	Arbeitsangebotselastizität	exo	4
PRT	Trend-participation rate	Trend Erwerbsquote	exo	4
PRTF1	Trend participation rate, females, age group 15 to 24	Trend Erwerbsquote Frauen im Alter von 15 bis 24	exo	4
PRTF2	Trend participation rate, females, age group 25 to 49	Trend Erwerbsquote Frauen im Alter von 25 bis 49	exo	4
PRTF3	Trend participation rate, females, age group 50 to 55	Trend Erwerbsquote Frauen im Alter von 50 bis 54	exo	4
PRTF4	Trend participation rate, females, age group 55 to 59	Trend Erwerbsquote Frauen im Alter von 55 bis 59	exo	4
PRTF5	Trend participation rate, females, age group 60 to 64	Trend Erwerbsquote Frauen im Alter von 60 bis 64	exo	4
PRTF6	Trend participation rate, females, age group 65 and older	Trend Erwerbsquote Frauen im Alter von 65+	exo	4

RSA	Contribution rate, accident insurance	Beitragssatz, Unfallversicherung	exo	8
RSH	Contribution rate, health insurance	Beitragssatz, Krankenversicherung	exo	8
RSHR	Contribution rate, health insurance, for retirees	Beitragssatz, Krankenversicherung für Pensionisten	exo	8
RSPC	Contribution rate, pension insurance, for employers	Beitragssatz, Pensionsversicherung, Arbeitgeber	exo	8
RSPE	Contribution rate, pension insurance, for employees	Beitragssatz, Pensionsversicherung, Arbeitnehmer	exo	8
RSPF	Contribution rates of the pension insurance funds	Beitragssatz, Krankenversicherung d. PV Träger	exo	8
RSPS	Contribution rate, pension insurance, for self-employed	Beitragssatz, Pensionsversicherung, Selbständige	exo	8
RSU	Contribution rate, unemployment insurance	Beitragssatz, Arbeitslosenversicherung	exo	8
UTH	Upper threshold health insurance contributions, at current prices	Höchstbeitragsgrundlage d. Krankenversicherung	exo	8
UTPA	Upper threshold pension and accident insurance contributions, at current	Höchstbeitragsgrundlage d. Pensions u. Unfallversicherung	exo	8
UTU	Upper threshold unemployment insurance contributions, at current prices	Höchstbeitragsgrundlage d. Arbeitslosenversicherung	exo	8
QCAY	Adjustment factor, balance in income	Anpassungsfaktor für d. Einkommensbilanz	exo	9
PW	Deflator, imports	Deflator, Importe	exo	9
R	Real long term interest rate	Realer Zinssatz, Sekundärmarktrendite Bund	exo	9
YW	Gross domestic product, 25 OECD countries, in billion US dollars, at constant 1995 prices	Bruttoinlandsprodukt von 25 OECD-Länder*, Mrd. USD, zu Preisen von 1995	exo	9

Alternative population scenarios:

Scenario 1B: High life expectancy

POPH	Population, Austria, in million persons	Bevölkerung von Österreich, Mio. Personen	exo	4
POPCH	Population, age group 0 to 4, in million persons	Bevölkerung im Alter von 0 bis 4	exo	4
POP0H	Population, age group 0 to 14, in million persons	Bevölkerung im Alter von 0 bis 14	exo	4
POP1_3H	Population, age group15 to 55, in million persons	Bevölkerung im Alter von 15 bis 55	exo	4
POP4_5H	Population, age group 55 to 65, in million persons	Bevölkerung im Alter von 55 bis 65	exo	4
POP6H	Population, age group 65 and older, in million persons	Bevölkerung im Alter von 65+	exo	4
POPEH	Population, age group 15 to 65, in million persons	Erwerbsfähige Wohnbevölkerung im Alter von 15 bis 65	exo	4
POPFH	Population, Austria, females, in million persons	Gesamtbevölkerung von Österreich, Frauen	exo	4
POPF0H	Population, females, age group 0 to 14, in million persons	Bevölkerung Frauen im Alter von 0 bis 14	exo	4
POPF1H	Population, females, age group 15 to 24, in million persons	Bevölkerung Frauen im Alter von 15 bis 24	exo	4
POPF2H	Population, females, age group 25 to 49, in million persons	Bevölkerung Frauen im Alter von 25 bis 49	exo	4
POPF3H	Population, females, age group 50 to 54, in million persons	Bevölkerung Frauen im Alter von 50 bis 54	exo	4
POPF4H	Population, females, age group 55 to 59, in million persons	Bevölkerung Frauen im Alter von 55 bis 59	exo	4
POPF5H	Population, females, age group 60 to 64, in million persons	Bevölkerung Frauen im Alter von 60 bis 64	exo	4
POPF6H	Population, females, age group 65 and older, in million persons	Bevölkerung Frauen im Alter von 65+	exo	4
POPMH	Population, Austria, males, in million persons	Gesamtbevölkerung von Österreich, Männer	exo	4
POPM0H	Population, males, age group 0 to 14, in million persons	Bevölkerung Männer im Alter von 0 bis 14	exo	4
POPM1H	Population, males, age group 15 to 24, in million persons	Bevölkerung Männer im Alter von 15 bis 24	exo	4
POPM2H	Population, males, age group 25 to 49, in million persons	Bevölkerung Männer im Alter von 25 bis 49	exo	4
POPM3H	Population, males, age group 50 to 54, in million persons	Bevölkerung Männer im Alter von 50 bis 54	exo	4
POPM4H	Population, males, age group 55 to 59, in million persons	Bevölkerung Männer im Alter von 55 bis 59	exo	4
POPM5H	Population, males, age group 60 to 64, in million persons	Bevölkerung Männer im Alter von 60 bis 64	exo	4
POPM6H	Population, males, age group 65 and older, in million persons	Bevölkerung Männer im Alter von 65+	exo	4

Scenario 1C: Low fertility

POPL	Population, Austria, in million persons	Bevölkerung von Österreich, Mio. Personen	exo	4
POPCL	Population, age group 0 to 4, in million persons	Bevölkerung im Alter von 0 bis 4	exo	4
POP0L	Population, age group 0 to 14, in million persons	Bevölkerung im Alter von 0 bis 14	exo	4
POP1_3L	Population, age group15 to 55, in million persons	Bevölkerung im Alter von 15 bis 55	exo	4
POP4_5L	Population, age group 55 to 65, in million persons	Bevölkerung im Alter von 55 bis 65	exo	4
POP6L	Population, age group 65 and older, in million persons	Bevölkerung im Alter von 65+	exo	4
POPEL	Population, age group 15 to 65, in million persons	Erwerbsfähige Wohnbevölkerung im Alter von 15 bis 65	exo	4
POPFL	Population, Austria, females, in million persons	Gesamtbevölkerung von Österreich, Frauen	exo	4
POPF0L	Population, females, age group 0 to 14, in million persons	Bevölkerung Frauen im Alter von 0 bis 14	exo	4
POPF1L	Population, females, age group 15 to 24, in million persons	Bevölkerung Frauen im Alter von 15 bis 24	exo	4
POPF2L	Population, females, age group 25 to 49, in million persons	Bevölkerung Frauen im Alter von 25 bis 49	exo	4
POPF3L	Population, females, age group 50 to 54, in million persons	Bevölkerung Frauen im Alter von 50 bis 54	exo	4
POPF4L	Population, females, age group 55 to 59, in million persons	Bevölkerung Frauen im Alter von 55 bis 59	exo	4
POPF5L	Population, females, age group 60 to 64, in million persons	Bevölkerung Frauen im Alter von 60 bis 64	exo	4
POPF6L	Population, females, age group 65 and older, in million persons	Bevölkerung Frauen im Alter von 65+	exo	4
POPML	Population, Austria, males, in million persons	Gesamtbevölkerung von Österreich, Männer	exo	4
POPM0L	Population, males, age group 0 to 14, in million persons	Bevölkerung Männer im Alter von 0 bis 14	exo	4
POPM1L	Population, males, age group 15 to 24, in million persons	Bevölkerung Männer im Alter von 15 bis 24	exo	4
POPM2L	Population, males, age group 25 to 49, in million persons	Bevölkerung Männer im Alter von 25 bis 49	exo	4
POPM3L	Population, males, age group 50 to 54, in million persons	Bevölkerung Männer im Alter von 50 bis 54	exo	4
POPM4L	Population, males, age group 55 to 59, in million persons	Bevölkerung Männer im Alter von 55 bis 59	exo	4
POPM5L	Population, males, age group 60 to 64, in million persons	Bevölkerung Männer im Alter von 60 bis 64	exo	4
POPM6L	Population, males, age group 65 and older, in million persons	Bevölkerung Männer im Alter von 65+	exo	4

Scenario 2: Dynamic activity rates

PRT2	Trend-participation rate	Trend Erwerbsquote	exo	4
PRT2F1	Trend participation rate, females, age group 15 to 24	Trend Erwerbsquote Frauen im Alter von 15 bis 24	exo	4
PRT2F2	Trend participation rate, females, age group 25 to 49	Trend Erwerbsquote Frauen im Alter von 25 bis 49	exo	4
PRT2F3	Trend participation rate, females, age group 50 to 55	Trend Erwerbsquote Frauen im Alter von 50 bis 54	exo	4
PRT2F4	Trend participation rate, females, age group 55 to 59	Trend Erwerbsquote Frauen im Alter von 55 bis 59	exo	4
PRT2F5	Trend participation rate, females, age group 60 to 64	Trend Erwerbsquote Frauen im Alter von 60 bis 64	exo	4
PRT2F6	Trend participation rate, females, age group 65 and older	Trend Erwerbsquote Frauen im Alter von 65+	exo	4
PRT2M1	Trend participation rate, males, age group 15 to 24	Trend Erwerbsquote Männer im Alter von 15 bis 24	exo	4
PRT2M2	Trend participation rate, males, age group 25 to 49	Trend Erwerbsquote Männer im Alter von 25 bis 49	exo	4
PRT2M3	Trend participation rate, males, age group 50 to 54	Trend Erwerbsquote Männer im Alter von 50 bis 54	exo	4
PRT2M4	Trend participation rate, males, age group 55 to 59	Trend Erwerbsquote Männer im Alter von 55 bis 59	exo	4
PRT2M5	Trend participation rate, males, age group 60 to 64	Trend Erwerbsquote Männer im Alter von 60 bis 64	exo	4
PRT2M6	Trend participation rate, males, age group 65 and older	Trend Erwerbsquote Männer im Alter von 65+	exo	4

Scenario 3B: Alternative pension indexation

NPS	Share of new pensions of total pensions	Anteil der Neupensionen	exo	8
NPB	Ratio of new pension benefits to average pension benefit	Verhältnis der Höhe der Neupensionen zum Durchschnittspensionsbezug	exo	8

Endogenus variables

DPN	Consumption of fixed capital, at current prices	Abschreibungen, laufende Preise	end	2
I	Gross capital formation, at constant 1995 prices	Bruttoinvestitionen, zu Preisen von 1995	end	2
K	Physical capital stock, at constant 1995 prices	Nettokapitalstock, zu Preisen von 1995	end	2
MPL	Marginal product of labour	Grenzprodukt der Arbeit	end	2
Q	Tobin's Q	Tobinsches Q	end	2
Y	Gross domestic product, at constant 1995 prices	Bruttoinlandsprodukt, zu Preisen von 1995	end	2
YN	Gross domestic product, at current prices	Bruttoinlandsprodukt, laufende Preise	end	2
CP	Private consumption, at constant 1995 prices	Privater Konsum, zu Preisen von 1995	end	3
HWF	Financial wealth of private households, at constant 1995 prices	Finanzvermögen der priv. Haushalte, zu Preisen von 1995	end	3
HWH	Human wealth of private households, at constant 1995 prices	Humanvermögen der priv. Haushalte, zu Preisen von 1995	end	3
NFA	Net foreign assets, at current prices	Netto-Auslandsvermögensposition, laufende Preise	end	3
LD	Economically active employees in full time equivalents, in million persons	Unselbständig (Aktiv)Beschäftigte in Vollzeitäquivalente, Mio. Personen	end	4
LE	Employees (incl. LENA), in million persons	Unselbständig Beschäftigte (inkl. KUG), Mio. Personen	end	4
LEA	Economically active employees (LE - LENA), in million persons	(Aktiv)Beschäftigte	end	4
LENA	Persons on maternity leave and persons in military services, in million persons	Kindergeldbezieher und Präsenzdiener, Mio. Personen	end	4
LF	Economically active population (Labour force), in million persons	Realisierte Erwerbspersonen	end	4
LFF	Economically active population, females, in million persons	Erwerbspersonen, Frauen	end	4
LFM	Economically active population, males, in million persons	Erwerbspersonen, Männer	end	4
LFT	Labour force, trend, in million persons	Erwerbspersonen Trend	end	4
LS	Dependent labour supply, in million persons	Arbeitsangebot unselbständig, Mio. Personen	end	4
LSS	Self employed, in million persons	Selbständig Beschäftigte, Mio. Personen	end	4
LSSA	Self employed, farmers, in million persons	Selbständig Beschäftigte Landwirtschaft, Mio. Personen	end	4
LSSNA	Self employed, non-farmers, in million persons	Selbständig Beschäftigte Gewerbe, Mio. Personen	end	4
LST	Labour supply, trend, in million persons	Trend unselbständiges Arbeitsangebot, Mio. Personen	end	4
LU	Unemployed, in million persons	Arbeitslose, Mio. Personen	end	4
QWT	Working time index	Arbeitszeitindex	end	4
PR	Participation rate	Erwerbsquote	end	4
PR4_5	Participation rate, age group 50 to 64	Erwerbsquote im Alter von 50 bis 64	end	4
PR6	Participation rate, age group 65 and older	Erwerbsquote im Alter von 65+	end	4
PRF1	Participation rate, females, age group 15 to 24	Erwerbsquote Frauen im Alter von 15 bis 24	end	4
PRF2	Participation rate, females, age group 25 to 49	Erwerbsquote Frauen im Alter von 25 bis 49	end	4
PRF3	Participation rate, females, age group 50 to 55	Erwerbsquote Frauen im Alter von 50 bis 54	end	4
PRF4	Participation rate, females, age group 55 to 59	Erwerbsquote Frauen im Alter von 55 bis 59	end	4
PRF5	Participation rate, females, age group 60 to 64	Erwerbsquote Frauen im Alter von 60 bis 64	end	4
PRF6	Participation rate, females, age group 65 and older	Erwerbsquote Frauen im Alter von 65+	end	4
PRM1	Participation rate, males, age group 15 to 24	Erwerbsquote Männer im Alter von 15 bis 24	end	4
PRM2	Participation rate, males, age group 25 to 49	Erwerbsquote Männer im Alter von 25 bis 49	end	4
PRM3	Participation rate, males, age group 50 to 54	Erwerbsquote Männer im Alter von 50 bis 54	end	4
PRM4	Participation rate, males, age group 55 to 59	Erwerbsquote Männer im Alter von 55 bis 59	end	4
PRM5	Participation rate, males, age group 60 to 64	Erwerbsquote Männer im Alter von 60 bis 64	end	4
PRM6	Participation rate, males, age group 65 and older	Erwerbsquote Männer im Alter von 65+	end	4
TWED	Tax wedge	Lohnschere	end	4
U	Unemployment rate	Arbeitslosenquote	end	4
W	Real wage per capita, in full time equivalents	Realer Lohn in Vollzeitäquivalenten	end	4
WA	Alternative wage path index	Index des Alternativlohns	end	4
YLN	Compensation to employees, at current prices, net wage taxes and social security contributions	Arbeitnehmerentgelt, laufende Preise, abzüglich Lohnsteuer u. Sozialversicherungsbeiträge	end	4

GOS	Gross operating surplus and gross mixed income, at current prices	Bruttobetriebsüberschuss u. Selbständigeneinkommen, laufende Preise	end	6
HSC	Social contributions, payable, private households, at current prices	Sozialbeiträge, priv. Haushalte, gezahlt, laufende Preise	end	6
HTRM	Social benefits other than social transfers in kind, receivable, private households, at current prices	Monetäre Sozialleistungen, priv. Haushalte, erhalten, laufende Preise	end	6
HTRO	Balance of other current transfers, private households, at current prices	Sonstige laufende Transfers, Saldo, priv. Haushalte, laufende Preise	end	6
HYI	Balance of property income, private households, at current prices	Vermögenseinkommen, Saldo, priv. Haushalte, laufende Preise	end	6
HYL	Compensation of employees, receivable, private households, at current pr	Arbeitnehmerentgelt, priv. Haushalte, erhalten, laufende Preise	end	6
HYNSI	Non-entrepreneurial disposable income of private households, at current p	Verfügbares Einkommen d. priv. Haushalte ohne Selbständigeneinkommen, laufende Preise	end	6
HYS	Mixed income, net, private households, at current prices	Selbständigeneinkommen, priv. Haushalte, erhalten, laufende Preise	end	6
S	Domestic savings	Inländisches Sparen	end	6
YDN	Disposable income of private households, at current prices	Verfügbares Einkommen d. priv. Haushalte, laufende Preise	end	6
YL	Compensation to employees, at current prices	Arbeitnehmerentgelt, laufende Preise	end	6
GC	Government consumption, at current prices	Konsumausgaben des Staates, zu laufenden Preisen	end	7
GD	Government debt, at current prices	Staatsschuld, laufende Preise	end	7
GDMV	Government debt management and valuation changes, at current prices	Staatsschuldenverwaltung und Bewertungsänderungen, laufende Preise	end	7
GE	Government expenditures, at current prices	Staatsausgaben, laufende Preise	end	7
GEC	Government expenditures under constant spending ratio rule, at current pı	Staatsausgaben unter Regel konst. Staatsausgabenquote, laufende Preise	end	7
GEI	Government expenditures on interest, at current prices	Zinsen für die Staatsschuld, Staat konsolidiert, laufende Preise	end	7
GEIC	Government expenditures on interest under constant spending ratio rule, at current prices	Zinsen für die Staatsschuld unter Regel konst. Staatsausgabenquote, laufende Preise	end	7
GELTC	Government expenditures on long term care, at current prices	Ausgaben für Pflegegeld (Bundespflegeld), laufende Preise	end	8
GEO	Other government expenditures, at current prices	Sonstige staatliche Ausgaben, laufende Preise	end	7
GEOC	Other government expenditures under constant spending ratio rule, at curı	Sonst. Staatl. Ausg. unter Regel konst. Staatsausgabenquote, laufende Preise	end	7
GR	Government revenues, at current prices	Staatseinnahmen, laufende Preise	end	7
HTDIR	Current taxes on income and wealth, payable, private households, at current prices	Einkommen u. Vermögensteuern, priv. Haushalte, gezahlt, laufende Preise	end	7
RGD	Implicit average interest rate on government debt	Impliziter durchschnittlicher Zinssatz der Staatsschuld	end	7
RN	Nominal long term interest rate	Nominaler Zinssatz, Sekundärmarktrendite Bund	end	7
SC	Social contributions, at current prices	Sozialbeiträge, laufende Preise	end	7
SUB	Subsidies, at current prices	Subventionen, laufende Preise	end	7
TDIR	Current taxes on income and wealth, receivable, at current prices	Einkommen u. Vermögensteuern, Aufkommen, laufende Preise	end	7
TIND	Taxes on production and imports, at current prices	Produktions- u. Importabgaben, laufende Preise	end	7
PEN	Number of pensions, in million	Anzahl d. Pensionsbezüge (Direktpensionen+Hinterbliebenenpensionen)	end	8
SCA	Social security contributions - accident insurance, at current prices	Beitragseinnahmen d. Unfallversicherung, laufende Preise	end	8
SCH	Social security contributions - health insurance, at current prices	Beitragseinnahmen d. Krankenversicherung, laufende Preise	end	8
SCHE	Social security contributions - health insurance, employees, at current prices	Beitragseinnahmen d. Krankenversicherung, Arbeitnehmer, laufende Preise	end	8
SCHR	Social security contributions - health insurance, retirees, at current prices	Beitragseinnahmen d. Krankenversicherung, Beiträge für Pensionisten, laufende Preise	end	8
SCP	Social security contributions - pension insurance, at current prices	Beitragseinnahmen d. Pensionsversicherung, laufende Preise	end	8
SCPE	Social security contributions - pension insurance, employees, at current prices	Beitragseinnahmen d. Pensionsversicherung, Unselbständige, laufende Preise	end	8
SCPS	Social security contributions - pension insurance, self-employed, at current prices	Beitragseinnahmen d. Pensionsversicherung, Selbständige, laufende Preise	end	8
SCU	Social security contributions - unemployment insurance, at current prices	Beitragseinnahmen, Arbeitslosenversicherung	end	8

SE	Social security expenditures and long term care payments, at current price	Sozialversicherungsausgaben u. Plegegeld, laufende Preise	end	8
SEA	Total social security expenditures, accident insurance, at current prices	Gesamte Ausgaben, Unfallversicherung	end	8
SEAO	Other social security expenditures, accident insurance, at current prices	Sonstige Ausgaben, Unfallversicherung	end	8
SEH	Total social security expenditures, health insurance, at current prices	Gesamte Ausgaben, Krankenversicherung	end	8
SEHO	Other expenditures - health insurance, at current prices	Sonstige Ausgaben d. Krankenversicherung	end	8
SEP	Total social security expenditures, pension insurance, at current prices	Gesamte Ausgaben, Pensionsversicherung	end	8
SEPO	Other expenditures - pension insurance, at current prices	Sonstige Ausgaben d. Pensionsversicherung	end	8
STR	Social security and long term care transfers, at current prices	Transferausgaben Sozial u. Arbeitslosenversicherung sowie Pflegegeld, laufende Preise	end	8
TRA	Transfer expenditures, accident insurance, at current prices	Leistungsausgaben d. Unfallversicherung	end	8
TRH	Transfer expenditures, health insurance, at current prices	Leistungsausgaben d. Krankenversicherung	end	8
TRP	Transfer expenditures, pension insurance, at current prices	Leistungsausgaben d. Pensionsversicherung	end	8
TRU	Transfer expenditures, unemployment insurance, at current prices	Leistungsausgaben d. Arbeitslosenversicherung	end	8
CA	Current account balance, at current prices	Saldo d. Leistungsbilanz, laufende Preise	end	9
CAXM	Balance in goods and services trade, at current prices	Saldo d. Waren- u. Dienstleistungsbilanz, laufende Preise	end	9
CAT	Balance in transfers, at current prices	Saldo d. Transferbilanz, laufende Preise	end	9
CAY	Balance in income, at current prices	Saldo d. Einkommensbilanz, laufende Preise	end	9
M	Goods and services imports, at constant 1995 prices	Güter und Dienstleistungsimporte, zu Preisen von 1995	end	9
P	Deflator, GDP	Deflator, Bruttoinlandsprodukt	end	9
PC	Deflator, private consumption	Deflator, privater Konsum	end	9
PGC	Deflator, government consumption	Deflator, öffentlicher Konsum	end	9
PI	Deflator, gross capital formation	Deflator, Bruttoinvestitionen	end	9
PX	Deflator, exports	Deflator, Exporte	end	9
SDIFFN	Changes in inventory, acquisition less disposition of valuables, and statistical discrepancy, at current prices	Vorratsveränderungen, Nettozugang an Wertsachen und Statistischer Differenz, laufende Preise	end	9
X	Goods and services exports, at constant 1995 prices	Güter und Dienstleistungsexporte, zu Preisen von 1995	end	9
YDEN	Disposable income, at current prices	Verfügbares Einkommen, laufende Preise	end	9
YNPN	Gross national product, at current prices	Brutto Nationalprodukt, laufende Preise	end	9

Comment on "A Long-run Macroeconomic Model of the Austrian Economy (A-LMM)"

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A-LMM seems to be remarkable for at least two reasons. First, to my knowledge, it is the first joint modelling effort by the Austrian Institute of Economic Research (WIFO) and the Institute for Advanced Studies (IHS), and, second, its long-term character integrates it closely into the present discussions in modelling theory. The necessity to overlook very long periods emanates not only from the problems of social security systems which are dealt with in this paper, but the inclusion of long-term components into short-term forecasting models has proven essential to warrant their stability and consistency. Macromodels as currently in use are not able to solve the conflict between theoretical and empirical coherence in a satisfactory way, as they do not succeed in coordinating the interaction of stable long-term and cointegrated relations with the demands of short-term forecasting.

Recently, to overcome these problems, "hybrid-models" have been proposed which – following a two-step approach – define a theoretically consistent and long-run stable core and then arrange a system of short-term equations around it. Discrepancies between these two blocs of equations will be corrected for by equation correction mechanisms. In some central banks models of this kind are currently intensively investigated.

By these remarks, I want to draw attention to the fact that modelling theory is currently assigning new importance to long-term aspects after having forgotten the endeavours of Kondratieff, Schumpeter and others over the last decades. Thus, A-LMM is a valuable contribution. It is, of course, designed predominantly to deal with problems of the Austrian social security system. This task is fulfilled very well; some questions and comments regarding the current version and possible further developments seem appropriate, however.

I feel that the adjustment processes to exogenous shocks should be modelled in more detail. Currently, these aspects of the model seem to be driven mainly by the desire to achieve convergence and stability as quickly as possible. This is understandable, but there is a danger of simplifying the structure too much. Thus, in the present version, adjustment is brought about seemingly exclusively by the currently favoured approach of using the current account as the main channel.

Deficits/ surpluses are fed via the net foreign assets directly into the wealth variable which in turn influences consumption. It would be interesting to know whether adjustment is brought about then by a strong propensity to consume out of wealth (which should have corresponding effects on GDP) or whether it will need extreme oscillations of the net foreign assets.

Also the fiscal policy rule – although very rigorous in securing a permanently balanced budget – does not contribute to adjustment. It achieves its goal by corresponding changes of „other government expenditures", which by assumption, however, have no influence on output. This may not seem very plausible, as „other government expenditures" include variables like purchases from the private sector und public investment. The more obvious adjustment via price relations is excluded (see below), though this would be more consistent with the neoclassical paradigm.

To determine investment, Tobin's Q is used; without doubt, this is an interesting concept. However, there is wide agreement that its empirical performance is weak, because, for instance, valuations by managers meeting the investment decision may differ from valuations by markets, or these valuations may be distorted by speculative bubbles and may diverge from fundamentals over long periods.

Capital and money markets are not modelled in the current version. For further developments this would be of great interest, because, among other reasons, this sector can cause severe disturbances especially with regard to old age pensions, as is well known.

Over the very long-run, it is certainly difficult to decide which variables are to be regarded as exogenous or endogenous. Over the course of decades, for instance, also demographic developments will finally become endogenous. It may be regarded as problematic, however, to assume prices as exogenous but wages as endogenous. It probably cannot be excluded that an implausible divergence between these two variables might develop which is especially against the traditional Austrian feeling and experience that wages and prices have to be regarded as closely interlinked.

For future developments, another important step would be to provide for some aspects of endogenous growth.

Lacking expertise in this field, I am not in a position to comment in detail on the scenarios concerning the social security problems. In any case, an impressive amount of institutional and other detail is taken into account; thus, we can rely on a very competent and broad insight into these issues from the side of the modellers. Results seem to be plausible and, given the circumstances described above, a high degree of stability of the model is warranted. It is remarkable and reassuring that in practically all scenarios – in whatever direction the assumptions are changed and despite of a shrinking active population and an increasing number of pensions – real per capita income will be more than tripled until 2070. High employment will prevail, except in the case of rising social security contributions. In public discussion, however, it is often argued that social security systems may turn out to be unsustainable. Thus, it would be interesting to know where the critical values for A-LMM lie in this respect.

Summing up, I would like to point out that A-LMM provides a solid base for further research on long-term models which may be helpful to deal with issues beyond the usual forecast horizons.

Forecasting Austrian Inflation[1]

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Abstract

In this paper we apply factor models proposed by Stock and Watson (1999) and VAR and ARIMA models to generate 12-month out of sample forecasts of Austrian HICP inflation and its sub-indices processed food, unprocessed food, energy, industrial goods and services price inflation. A sequential forecast model selection procedure tailored to this specific task is applied. It turns out that factor models possess the highest predictive accuracy for several sub-indices and that predictive accuracy can be further improved by combining the information contained in factor and VAR models for some indices. With respect to forecasting HICP inflation, our analysis suggests to favor the aggregation of sub-indices forecasts. Furthermore, the sub-indices forecasts are used as a tool to give a more detailed picture of the determinants of HICP inflation from both an ex-ante and ex-post perspective.

JEL Classification: C52, C53, E31
Keywords: Inflation Forecasting, Forecast Model Selection, Aggregation

1. Introduction

The inflation rate is often seen as an important indicator for the performance of a central bank. Inflation forecasts are therefore an important element in the set of variables on which forward looking monetary policy decisions are based. Apart from the role of inflation forecasts as an input to monetary policy deliberations there is also an additional role for inflation forecasts in the national macroeconomic policy debate. By informing the public about likely trends in inflation the forecast can influence inflationary expectations and therefore can serve as a nominal anchor

[1] We would like to thank Sylvia Kaufmann, Ricardo Mestre, the workshop participants at the Banque de France Workshop on Inflation Forecasting and an anonymous referee for helpful comments.

for example in the wage bargaining process or for other nominally fixed contracts like housing rents, interest rates. Furthermore, since the appropriate reaction of monetary policy to inflationary pressures depends among other things on the sources of inflation, it is useful to monitor, analyze and forecast sub-indices of headline inflation that are defined according to the type of product contained in the Harmonized Index of Consumer Prices (HICP). The incorporation of information on developments in the sub-indices helps to give a more detailed picture on the sources of inflation and the propagation of shocks to inflation across product categories and time. The sub-indices covered in our analysis comprise processed food, unprocessed food, energy, non-energy industrial goods and services. In the case of the Eurosystem, a forecast of area-wide inflation is required as an input to monetary policy decisions. As area-wide inflation is an aggregation of the inflation rates prevailing in the countries of the monetary union, one way to meet this requirement is to produce inflation forecasts for the member states (for each sub index) and aggregate them to an area-wide inflation forecast.[2]

This paper compares the performance of factor models and VAR and ARIMA models for forecasting the rate of change of the Austrian HICP and its sub-indices. Furthermore, we compare the performance of HICP inflation forecasts based on “direct" modeling of the HICP with a forecast based on an aggregation of forecasts for the sub-indices.[3] The forecasts of the models with the highest predictive accuracy are then evaluated using a range of criteria that characterize *optimal* forecasts. Finally, the sub-indices forecasts with the highest predictive accuracy are used as a tool to obtain a more detailed picture of the sources of future (forecasted) inflation and past inflation forecast errors for the period 1990 to 2002.

Starting with the contribution of Stock and Watson (1999a), various authors have applied factor models to forecasting inflation. Stock and Watson (1999b) use factor models to forecast U.S. inflation. Marcellino, Stock and Watson (2000) and Angelini, Henry and Mestre (2001) evaluate the usefulness of factor models for forecasting euro area inflation. Tkacz and Gosselin (2001) evaluate factor models for forecasting inflation in Canada.

Factor models offer a convenient way to incorporate the informational content of a wide range of time series. The underlying assumption is that a small number of unobservable factors is the driving force behind the series under consideration. This is an appealing feature for forecasting purposes since it allows us to concentrate on a few common factors instead of a potentially large number of

[2] This is the approach that is currently followed in the quarterly narrow inflation projection exercises (NIPE) conducted by the Eurosystem. For a comparison of this approach with a “direct" forecast of area-wide inflation both at the level of the aggregate HICP and the sub-indices see Benalal et al. (2004).

[3] In related papers, Hubrich (2003) analyses euro area HICP sub-indices and Fritzer, Moser and Scharler (2002) consider forecasting the Austrian HICP sub-indices using time series methods.

explanatory variables. In particular, for forecasting HICP sub-indices factor models appear to be a promising tool since economic theory provides only little guidance for variable selection in this case. Hence, using factor models allows us to avoid arbitrary assumptions necessary to preserve degrees of freedom when standard time series methods are employed. On the other hand, the usefulness of other time series models, in particular VAR and ARIMA models, in forecasting inflation has been widely documented in the literature, see e.g. Hubrich (2003) and the references therein.

We find that factor models appear to possess the highest predictive accuracy for the unprocessed food, energy and industrial goods price indices. However, a check for forecastability of these variables reveals that they are close to being unforecastable which helps to explain the forecast errors made in forecasting the HICP. For processed food and the services index, the highest predictive accuracy is obtained using a combined forecast of factor and VAR models. Here the excess persistence in the forecast errors for the service price inflation forecasts stands out as a main departure from an optimal forecast. Furthermore, we find that forecasts for Austrian HICP inflation based on an aggregation of the sub-indices forecasts appears to be somewhat more accurate than the best available forecast for the HICP itself. This “indirect" approach to forecasting inflation has the additional advantage that it avoids inconsistencies between forecasts of the sub-indices inflation and headline inflation and at the same time allows a more detailed analysis of trends in inflation.

The remainder of the paper is organized as follows: Section 2 briefly discusses factor models along with the other techniques used in the forecasts and describes the forecasting procedure. Section 3 compares the forecasting performance of the models and evaluates the resulting models with the highest predictive accuracy. Section 4 concludes the paper.

2. Forecasting Models and Procedures

2.1 Forecasting Models

The goal of this paper is to evaluate forecasts for the year-on-year growth rate of the HICP index and its sub-indices. These growth rates are defined as

$$\Delta P_{i,t} = \log(P_{i,t}) - \log(P_{i,t-12}), \tag{1}$$

where $P_{i,t}$, $i = 0,...,5$, denotes the date t observations of the headline HICP $i = 0$ and the sub-indices for processed food $i = 1$, unprocessed food $i = 2$, energy $i = 3$, industrial goods $i = 4$ and services $i = 5$.

The forecasting performance of the models under consideration is evaluated by comparing simulated out-of-sample forecasts. The rolling out-of-sample forecasts are carried out recursively, i.e. the models are re-estimated every period taking into account only data up to that period, as will be explained below. The out-of-sample forecast error is given by

$$u_{i,t+12} = \Delta P_{i,t+12} - \widehat{\Delta P}_{i,t+12}, \tag{2}$$

where $\widehat{\Delta P}_{i,t+12}$ is the predicted value for the year-on-year increase of index i.

In the case of the factor model forecasts are generated for each inflation rate as a linear projection of the change of the log price index over the next 12 months on a set of predictor variables:

$$\Delta P_{i,t+12} = \alpha_i + \sum_{h=0}^{n} \beta_{i,h} \Delta P_{i,t-h} + \sum_{l=1}^{m} \sum_{h=0}^{k} \gamma_{i,l,h} f_{l,t-h} + \varepsilon_{i,t+12}. \tag{3}$$

The change in each index over the next 12 months is explained by n of its own lags plus at most k lags of m common factors denoted by f_t, ε_{t+12} is an $i.i.d.$ disturbance term. In order to generate forecasts from equation (3), the factors have to be estimated. Stock and Watson show that f_t can be consistently estimated by the method of principal components. Concerning the choice of the number of factors, we apply the selection criteria of Bai and Ng who specify that the number of factors, m, is set equal to the mode of the optimal number of factors over the estimation sample.

The second class of models considered are VAR models. In the selection of the specific VARs used in our analysis we take mainly a statistical approach. The models are selected according to pure statistical criteria instead of being derived from any theory of inflation determination. The reason is – besides the fact that the focus of the paper is not to test different models of inflation determination – a rather practical one, namely that theoretical models do not really exist for the inflation processes of the HICP sub-indices. In particular, specifying the VARs requires two decisions. First, the variables entering the VAR have to be selected. Second, the appropriate lag specification of the model has to be determined. The variables entering the six VARs for the sub-indices and the HICP are selected according to a procedure which investigates the leading indicator properties of all 179 time series in our database for the HICP sub index under consideration.[4] This

[4] The leading indicator property is assessed by the explanatory power of any of the series for the respective HICP sub index in a large number of bivariate regressions (for 1, 3, 6,

procedure is only a first step in selecting the variables because usually a larger number of variables than what is feasible to include in a VAR qualify according to our procedure. This implies that some judgment to reduce the variables to a feasible number is required which prohibits an automatic reformulation of the VAR in every period of the rolling estimations[5]. For this reason and also for the fact that using VARs with changing variables from period to period would render our forecasts rather unstable, we decided to keep the formulation of the VARs in terms of variables constant over all periods,[6] whereas the lag specification is re-optimized every period. The variables included in the VARs for the five sub-indices and the HICP aggregate which have been selected according to the procedure just described are listed in table 1[7].

As a third model class, we use ARIMA models. The specification of the ARIMA models for the five sub-indices and headline inflation, i.e. the selection of AR and MA terms as well as seasonal AR and MA terms, is also re-optimized in every period of our rolling estimation procedure. All ARIMAs are estimated in first-difference form implying that no unit root specification for the ARIMAs is required, as all indices are difference-stationary.

9, and 12 months ahead). This procedure is described in more detail in Fritzer, Moser and Scharler (2002).

[5] For example, the judgment comes into play when a few variables that are equally correlated with the sub index under consideration and which are strongly correlated among each other, one of them is selected by judgment to enter the VAR.

[6] This, however, in a strict sense violates the principle of full recursiveness of our forecasts as information of the whole sample is used in the formulation of the VARs also for the earlier periods.

[7] All VARs are estimated in first differences and all variables are in logs except the interest rate series.

Table 1: Variables in the VAR Models (in Addition to the Respective Indices)

ΔP_0	ΔP_1
OeNB/ECB base rate, bank deposits up to 2 years, M3	OeNB/ECB base rate, bank deposits up to 2 years, negotiated wages in agro-forestry, price index of foreign tourist demand, wholesale price index for food and beverage
ΔP_2	ΔP_3
total orders in manufacturing, unemployment in building and construction, wholesale price index for feed barley, negotiated wages in agro-forestry	OeNB/ECB base rate, industrial production, bank deposits up to 2 years, M3, exports of intermediate goods
ΔP_4	ΔP_5
M3, demand deposits, producer price index for pulp wood, exports of final goods	total credit, bank deposits up to 2 years, M3, wholesale price index for mineral oil

2.2 Data and Forecast Procedure

Our data set consists of 179 macroeconomic and financial time series of monthly frequency, beginning in 1980:1 and ending in 2002:12. This yields a total of 276 observations for each series. The data are seasonally adjusted and outliers are removed. For the estimation the series are differenced in order to induce stationarity. Since the HICP and its sub-indices are only available from 1987:1 on, we extrapolate the series backwards until 1980:1 in order to increase the number of observations (see Appendix A). Furthermore, we remove breaks from the processed food and the industrial goods index together with the corresponding breaks in the HICP before we forecast those series (see Appendix B). The HICP and its sub-indices are also seasonally adjusted.

For the evaluation and comparison of the different model classes we construct a series of 12-step-ahead out-of-sample forecasts where the models are estimated with a rolling split of the estimation and forecasting periods. In moving forward the rolling procedure the models are not only re-estimated each period but also their lag specifications are re-optimized after each step. This is done by estimating a large number of possible lag combinations for each VAR, ARIMA and factor model out of which the model with the best fit according to the Schwarz information criterion is selected.[8] The selected model is then used to produce a 12-step-ahead forecast where only the last forecast value, i.e. the 12th-step-ahead forecast, is used for the forecast evaluation. In the next step the estimation sample is moved one period forward, again a large number of different lag specifications are estimated, the optimal model is selected and used to produce another 12-step-ahead forecast where again only the last value is stored for the forecast evaluation.[9] The procedure continues until the last 12-step-ahead forecast has reached the end of the sample range.

Specifically, we start with the estimation period 1980:1 to 1989:1 and forecast the values for the period 1989:2 to 1990:1. The forecast for 1990:1 is the first to be used for the evaluation.[10] Next, the models are estimated for the period 1980:1 to 1989:2 to produce a forecast for 1989:3 to 1990:2 where only the last value is stored for later evaluation, and so on. By stacking all the stored values we obtain a series of 12-step-ahead forecasts for HICP inflation and its sub-indices ranging from 1990:1 to 2002:12 – each derived from a different forecast – which are then compared with the true values and the forecasts of the other models.

3. Forecasting Model Selection and Evaluation

This section has three goals: first, the forecasts of factor models and VAR and ARIMA models of the HICP and its sub-indices are compared. Based on this

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[8] Concerning the VARs, a total of 451 specifications are estimated each period which include (not all possible but most relevant) lag combinations from a minimum of 4 up to a maximum of 14 lags. In the case of the ARIMAs a total number of 676 specifications are estimated each period including all possible combinations of AR and MA terms up to 12 lags as well as seasonal AR and MA terms at the 12th lag.

[9] The fact that the specifications are re-optimized after each period also implies that two consecutive forecasts may be based on different models, which has the potential to make the series of forecasts more variable. However, in our estimations – except for only a few periods – this did not turn out to be a major problem.

[10] We chose the minimum estimation sample to range from 1980:1 to 1989:1 because, given the large number of coefficients to be estimated for some specifications, a fairly large number of observations is required to deliver reliable estimates. Furthermore, as noted by Ashley (2003), a sufficient number of observations in the validation period, preferably above 100, is necessary to establish significant differences in predictive accuracy.

comparison possibilities for forecast combination are considered. Second, a distinct approach to generate forecasts of the HICP is examined namely a “indirect" forecast based on an aggregation of forecasts of the HICP sub-indices. Both steps are conducted with the goal of arriving at a specification for forecasting Austrian inflation that is characterized by highest predictive accuracy. Third, this specification to forecast the HICP and its sub-indices is evaluated and the minimized forecast errors are used for an ex-ante and ex-post assessment of Austrian inflation during the period 1990–2002.

3.1 Forecast Comparison and Forecast Combination

The comparisons are based on a common descriptive statistic for predictive accuracy, the mean squared error (MSE), a test for differences in predictive accuracy and a test for forecast encompassing. As the latter testing principle is related to the concept of forecast combination we also compute the MSE for combined forecasts where appropriate. Factor models are used as benchmark for comparing predictive accuracy. This choice appears inconsequential, i.e. does not appear to prevent efficient forecasting model selection, as it only entails that we do not compare the VAR and the ARIMA model with respect to their relative predictive accuracy.

As a descriptive statistic for the gain of using factor models we compute

$$Gain_{1,j} = 100 * (\frac{MSE_j - MSE_1}{MSE_j}) \tag{4}$$

where MSE_1 is the mean squared error of the factor model forecast and MSE_j the competing models forecast ($j = 2$ denotes the VAR model and $j = 3$ denotes the ARIMA model). As a “rule of thumb" a model is considered to possess higher predictive accuracy if the gain is above 10%, a choice that can be found in the literature on forecast comparisons (see e.g. Marcellino et al., 2000).

Furthermore, as formal statistical testing for relative predictive accuracy is usually recommended (see Fildes and Stekler, 2002) we make use of the test statistic of Harvey, Leybourne and Newbold (1997) which is a modified version of the widely used statistic of Diebold and Mariano (1995). This statistic is applied to test the null hypothesis of equal predictive accuracy between the factor model forecast as the benchmark model and the VAR and the ARIMA model forecast. The modification proposed by Harvey, Leybourne and Newbold should reduce somewhat the size distortion of the Diebold-Mariano test that is present when long horizon multi-step forecasts are compared.

The distribution of this statistic is an issue of debate. Harvey, Leybourne and Newbold suggest to use the Student distribution with $N-1$ degrees of freedom. Clark and McCracken (2002) show for the case of multi-step forecasts that this is no longer appropriate when forecasts are derived from nested models. We follow the suggestion of Harvey, Leybourne and Newbold and compare the values of this statistic with the critical values of a Student distribution with 155 degrees of freedom associated with a 10% and 5% confidence level. The critical values are 1.66 and 1.98.

The decision rule based on the descriptive and the test statistic should ideally lead to one model with higher predictive accuracy than all competing models for each index. The next step consists of determining whether these models also encompass their competitors. Forecast encompassing is given when a forecast already incorporates all the relevant information of a competing forecast. The concept of forecast encompassing is related to the idea of forecast combination. If a forecast does not encompass the competing forecast then there might exist a linear combination of the two forecasts with further improved predictive accuracy.

We make use of the encompassing test statistic of Harvey, Leybourne and Newbold (1997). With respect to the distribution of this statistic the same issue arises as in the case of tests for equal predictive accuracy (see Clark and McCracken, 2002). We again follwow Harvey, Leybourne and Newbold and compare the values of this statistic with the critical values of a Student distribution with 155 degrees of freedom associated with a 10% and 5% confidence level. As this is a one-sided test the critical values are 1.29 and 1.66.[11]

Based on the results of the encompassing tests we then employ the variance-covariance approach to forecast combination proposed by Bates and Granger [4]. This approach applies the logic of portfolio optimization to forecast combination. Consider the following linear combination of the forecast of the model with higher predictive accuracy $\widehat{\Delta P}_{i,s,t+12}$ and a competing forecast $\widehat{\Delta P}_{i,j,t+12}$ for the inflation rate of index i:

$$\widehat{\Delta P}^{c}_{i,s,j,t+12} = \omega \widehat{\Delta P}_{i,s,t+12} + (1-\omega)\widehat{\Delta P}_{i,j,t+12}. \tag{5}$$

Given that both the forecast of the model with higher predictive accuracy and the competing forecast are unbiased one can show that the weight ω^* which minimizes the forecast error variance of the combined forecast $\widehat{\Delta P}^{c}_{i,s,j,t+12}$ is given by

[11] Details on the definition and application of the tests for comparing predictive accuracy and forecast encompassing can be found in Appendix C.

$$\omega_i^* = \frac{var(u_{i,j,t+12}) - cov(u_{i,s,t+12}, u_{i,j,t+12})}{var(u_{i,j,t+12}) + var(u_{i,s,t+12}) - 2cov(u_{i,s,t+12}, u_{i,j,t+12})}, \tag{6}$$

where $u_{i,j,t+12}$ and $u_{i,s,t+12}$ are the forecast errors of the two model. The mean squared error of the combined forecast associated with the optimal combining weight ω_i^* is denoted as $MSE_{i,s,j}^C$. This measure has the property that $MSE_{i,s,j}^C \leq min(MSE_{i,s}, MSE_{i,j})$.

3.1.1 Comparing Factor Models with VAR and ARIMA Models

We begin with computing the MSEs for all indices and for each forecasting model and the corresponding gains in using factor models. After verifying the stationarity of the loss differential sequences the null hypothesis of equal predictive accuracy of the factor model compared to the VAR and ARIMA models and the null hypothesis that the resulting models with higher predictive accuracy encompass the competing forecasts are tested. Finally, if encompassing can be rejected, optimal combining weights, the corresponding combined forecasts, its MSE and the associated gain in predictive accuracy of a combined forecast compared to the forecast of the model with higher predictive accuracy are computed. The results are shown in table 2.

One immediate result is that ARIMA models do not appear to possess higher predictive accuracy for any of the indices. Furthermore, encompassing of the ARIMA model by the factor model or the VAR model cannot be rejected for any of the indices. Therefore ARIMA models do not appear to perform well relative to the two other models, leaving the choice of using factor model forecasts, VAR model forecasts or combined forecasts of these two models.

The factor model for the HICP inflation rate ΔP_0 seems to work somewhat better than the VAR model with a gain of 19%. This gain is not significant, however. Encompassing of the VAR model forecast by the factor model forecast cannot be rejected.

Table 2: Forecast Performance of the Factor, VAR and ARIMA Models

	ΔP_0	ΔP_1	ΔP_2	ΔP_3	ΔP_4	ΔP_5
MSE_1	0.35	0.76	9.67	21.2	0.35	0.42
MSE_2	0.43	0.70	11.4	26.7	0.56	0.48
MSE_3	0.80	1.55	11.3	38.2	0.49	0.80
$Gain_{1,2}$	19	–8	16	21	38	12
$Gain_{1,3}$	56	51	15	45	29	47
$DM_{1,2}^{mod}$	1.29	–0.3	2.07**	2.00**	2.34**	1.14
$DM_{1,3}^{mod}$	1.92*	1.74*	1.28	3.07**	2.07**	2.86**
$HLN_{s,j}$	0.69	1.95**	0.18	0.33	–1.84	2.07**
$HLN_{s,3}$	–1.94	–2.10	0.79	–0.51	–1.28	–2.11
$MSE_{s,j}^{C}$	- -	0.62	- -	- -	- -	0.37
$Gain_{s,j}^{C}$	- -	12	- -	- -	- -	13

*Notes: $DM_{1,j}^{mod}$ denotes the modified Diebold-Mariano test statistic. $HLN_{s,j}$ denotes the encompassing statistic of Harvey, Leybourne and Newbold. ** and * indicate rejection of the null at the 5% and 10% level.*
Source: Authors' calculations.

For the processed food price inflation rate, ΔP_1, the VAR model produces the smallest MSE of all models. However, the gain compared to the factor model is only 8% and not significant. This is an example for two models being within a "demilitarized zone" (see Kunst, 2003) within it is not possible to discriminate between models due to their high degree of similarity in performance. Nevertheless, we test whether the VAR model does encompass the factor model. As encompassing can be rejected we compute a combined forecast that appears to improve predictive accuracy compared to the VAR model, with a gain of 12%. The factor model for the unprocessed food price inflation rate, ΔP_2, outperforms the VAR model significantly with a gain of 16%. Encompassing cannot be rejected. The inflation rates of energy prices, ΔP_3, and industrial goods prices, ΔP_4, are also forecast best by the factor model with large and significant gains compared to the VAR models. Encompassing cannot be rejected. Finally, the factor model forecasts of the inflation rate of services prices, ΔP_5, seem to outperform the VAR forecast. However, the difference in the MSE is not significant. Encompassing can be rejected for the VAR model and the corresponding combined forecast of the factor model forecast and the forecast of the VAR appears to improve predictive accuracy with a gain of 13%.

Overall, the factor model appears to produce highest predictive accuracy in terms of a lower MSE for forecasting unprocessed food, energy and industrial goods. Encompassing can be rejected for the processed food price and the services price index. The combination of the two models forecasts for these indices seem to produce forecasts with further improved predictive accuracy.

Therefore, the specification for forecasting the sub-indices of the Austrian HICP with highest predictive accuracy consists of factor models for forecasting unprocessed food price inflation, energy price inflation and industrial goods price inflation and a combined forecast of the factor model and the VAR model for forecasting processed food and service price inflation. With respect to forecasting the HICP, the factor model displays higher predictive accuracy. However, there exists another approach to forecast the HICP that can potentially produce forecasts with still higher predictive accuracy. This approach consists of a contemporaneous aggregation of forecasts of the sub-indices to a forecast of the HICP, an issue that will be addressed in the next subsection.

3.1.2 Comparing the Direct and the Indirect Approach to Forecasting the HICP

The fact that the HICP is a weighted average of its sub-indices opens up another possibility to arrive at forecasts for the HICP, namely the contemporaneous aggregation of the forecasts of the sub-indices to a forecast of the HICP. Following the terminology in Hubrich (2003) this approach is referred to as the indirect approach while forecasting the HICP itself is considered the direct approach. Theoretically, if the data generating processes of the sub-indices are known, the indirect approach should yield a lower MSE since it is based on a larger information set. However, if the data generating process is not known, as is the case in this study, there are no reasons based on statistical theory to favor either approach (for a survey on the theoretical aspects of forecast aggregation see the paper of Hubrich). The following equation relates the HICP to its sub-indices:[12]

$$P_{0,t} = \sum_{i=1}^{5} w_{i,t} P_{i,t}. \tag{7}$$

[12] Due to the method of aggregation there may be small deviations between the weighted sum of the sub-indices and the HICP as provided by the statistical office of Austria. During the period 1990–2002 the average discrepancy is 0.03 percentage points.

The weights $w_{i,t}$ add up to unity and represent expenditure shares of the representative consumers consumption basket as measured by the statistical office of Austria. Under the assumption of constant weights this translates into

$$\hat{u}^{agg}_{0,t+12} = \sum_{i=1}^{5} w_i \hat{u}^{*}_{i,t+12}. \tag{8}$$

The forecast error of the indirect approach $\hat{u}^{agg}_{0,t+12}$ is equal to the weighted sum of the forecast errors $\hat{u}^{*}_{i,t+12}$ of the sub-indices forecasts with highest predictive accuracy determined in the previous section.

In our application the weights are time varying which implies that the weighted sum of the first differences of the components of the HICP is not necessarily equal to the first difference of the HICP. As the future weights are in general not known, we use a random walk forecast for the weights twelve months ahead. Since year-on-year changes in the weights are usually small, this method does not affect the forecast and therefore the comparison in a major way, indicating that time variation in the weights is not an important factor for indirect HICP forecasting at the 12-month horizon. Given the forecast of the future values of the weights we generate the HICP forecasts based on the indirect approach and calculate the associated forecast errors. This forecast is compared to the direct HICP forecasting model with higher predictive accuracy determined in the previous section (the factor model) by computing their MSEs, the gain and the test statistics for comparing predictive accuracy and encompassing. Note however, that in this case it is unclear whether there exists a nesting relationship between the direct and the indirect approach. Nevertheless, we report the DM^{mod} and HNL statistics and compare them with the same critical values as in the previous section. table 3 shows the results.

Table 3: Forecast Performance of the Direct and the Indirect Approach

	ΔP_0
MSE_1	0.35
MSE_{agg}	0.31
$\text{Gain}_{1,agg}$	–11
$\text{DM}^{mod}_{1,agg}$	–0.98
$\text{HNL}_{1,agg}$	–0.29

Notes: $DM^{mod}_{1,j}$ denotes the modified Diebold-Mariano test statistic. $HLN_{s,j}$ denotes the encompassing statistic of Harvey, Leybourne and Newbold. ** and * indicate rejection of the null at the 5% and 10% level.
Source: Authors' calculations.

Based on the descriptive statistic it appears that the indirect approach to forecasting the Austrian HICP produces forecasts with higher predictive accuracy, with a gain of 11%. However, according to the modified Diebold-Mariano test the difference of the MSEs is not significant. Furthermore, the null hypothesis that the indirect approach encompasses the direct approach cannot be rejected which renders forecast combination between the two approaches irrelevant. Therefore, a decision rule based on statistical criteria would tend to select the indirect approach as it produces highest predictive accuracy.

A further non-statistical reason to select this approach to forecasting HICP inflation is that the direct and the indirect approaches will usually give different forecasts at any given point in time. If the direct approach is used it is likely that the forecast of the HICP and the forecasts of the sub-indices are inconsistent. This natural disadvantage of the direct approach would have to be compensated by visible gains to predictive accuracy, something which does not appear to be the case for the sample under study. However, the corresponding natural advantage of the indirect approach is based on the presumption that forecasts of the sub-indices of the HICP have an intrinsic value beyond being instrumental for forecasting the HICP.

This intrinsic value consists of a more detailed picture of expected trends in inflation which can be useful for a forward looking monetary policy. Such an ex-ante assessment of HICP inflation requires sub-indices forecasts with a high degree of predictive accuracy. Furthermore, the disaggregated approach can also help to identify the sources of past shocks to HICP inflation. An example for the use of sub-indices for an ex-post evaluation of shocks to Euro Area HICP inflation since the beginning of stage III of EMU is given in ECB (2002), p. 34.

3.2 Evaluating the Models with Highest Predictive Accuracy

In the previous two sections a specification for forecasting the sub-indices and the HICP has been determined that is characterized by highest predictive accuracy. It consists of factor models for unprocessed food, energy and industrial goods price inflation and combined forecasts of factor and VAR models for processed food and services price inflation. The preferred forecast for the HICP is obtained using the indirect approach. The forecasts along with the actual inflation rates are shown in charts 17–22.

The next step is to check whether the resulting forecasts with highest predictive accuracy satisfy a range of criteria which characterize *optimal* forecasts, as listed in Diebold and Lopez (1996). If departures from optimality are detected, it may be possible to improve these forecasts accordingly. The first two evaluation criteria are whether the forecasts are efficient and unbiased. This can be checked by running the regression $\hat{u}^*_{t+12} = \beta_1 + \beta_2 \Delta \hat{P}^*_{t+12} + \varepsilon_{t+12}$, where $\hat{u}^*_{t+12}$ is the forecast error of the model with the highest predictive accuracy, $\Delta\hat{p}^{*}_{t+12}$ the corresponding forecast and ε_{t+12} an $i.i.d.$ error term. If β_1 is insignificant this indicates unbiasedness, while an insignificant β_2 coefficient indicates efficiency as the forecast error is unrelated to the forecast itself. Furthermore, optimal k-step forecasts errors should display at most $(k-1)$-dependence. For our application this implies that there should be no significant autocorrelation at any lag greater than lag 11. This can be checked by examining the autocorrelation function of the forecast error series and comparing the autocorrelations with the confidence bound +/-$2/\sqrt{N}$. It is also of interest to test for normality of the distribution of the forecast errors which can be done with the Jarque-Bera test.[13]

Another evaluation criterion of interest is whether the inflation rates of the sub-indices and the HICP are actually forecastable conditional on our dataset and our models with highest predictive accuracy. Determining the degree of forecastability in particular of the sub-indices is useful as it helps to explain the errors in forecasting HICP inflation. A common measure of forecastability which is mentioned by Diebold and Lopez (1996) is the statistic $G = 1-(var(\hat{u}_t)/var(y_t))$ where $\hat{u}_t$ is the forecast error and y_t is the actual value of the series to be forecast. This statistic has the form of the R^2 of a linear regression, i.e. it indicates the proportion of the variance explained by the model of the total variance of the series. A low value indicates a low degree of forecastability. The results of the checks for unbiasedness, efficiency, departure from $(k-1)$-dependence, normality and forecastability are shown in table 4.

[13] This test does not account for the serial correlation present in the forecast error series.

Table 4: Criteria for an Optimal Forecast

	ΔP_0	ΔP_1	ΔP_2	ΔP_3	ΔP_4	ΔP_5
Unbiasedness	√	√	√			
Efficiency	√	√	√		√	
(k-1) independence		√	√		√	
Normality	√	√	√	√		√
Forecastability	0.31	0.39	0.02	–0.01	0.04	0.67

Note: √ indicates fulfillment of the criteria.
Source: Authors' calculations.

The estimates for β_1 and β_2 indicate that the forecasts for energy, industrial goods and services price inflation rates are biased. As the sample means of the corresponding forecast errors are 0.8, 0.2 and 0.1 percentage points, it appears that with the exception of the energy index the biases are minor. The test for efficiency indicates that the forecasts of the services index and of the energy index are not efficient. The inspection of the autocorrelation functions of the forecast error series show that the acf of the processed food, energy and services indices indicate substantial serial correlation beyond lag 11. The other indices' acf dies out smoothly until lag 11 with no substantial autocorrelation thereafter (see charts 5 to 10). Since the services index has the largest weight in the HICP, it could be useful to try to exploit this regularity in the forecast error for improving predictive accuracy. The tests for normality of the distribution of the forecast errors indicate that with the exception of the industrial goods price inflation forecast error all forecast error distributions are normal at the 5% confidence level (see charts 11 to 16 for the forecast error distributions and their moments).

The check for forecastability shows that the indices for unprocessed food and energy prices are essentially unforecastable with the methods and data employed in this paper. Industrial goods price inflation also appears very difficult to forecast. Forecasting processed food prices is considerably more successful. The highest degree of forecastability is found for the services price index with a value of 0.67. As the forecast of the HICP is produced using the indirect approach, the medium degree of forecastability of the HICP inflation rate also reflects the different degrees of forecastability of the sub-indices.

A further important method to assess the quality of a forecast is a visual inspection against the actual series and a visual inspection of the forecast error. Since the forecasts display considerable short run variation, a centered three month moving average of the actual series, the forecasts and the forecast errors is used in order to facilitate the identification of patterns (see charts 17 to 22 and 23 to 28). In the interest of brevity, only the HICP forecast inspection is described here.

The HICP inflation forecast underpredicts inflation considerably from mid 1990 to 1993, followed by a period of very good forecasting performance from 1994 to 1997. The following period is characterized by a considerable overprediction of inflation in 1999 followed by an underprediction in 2000 and 2001. The visual inspection of the actual series suggests major shifts in the trend of inflation in 1993, 1999 and 2001. The model appears to predict those turning points in inflation well, albeit with a lag. The graph of the HICP forecast error shows the same information in a different representation. Note that the forecast error series crosses the zero line often, which is considered a desirable property of a forecast error.

It was mentioned that forecasts of the sub-indices of the HICP can help to identify the sources of HICP inflation both from an ex-ante and ex-post perspective. As the forecast of the HICP is based on an aggregation of sub-indices forecasts, a decomposition of the forecast as well as a decomposition of the forecast errors can be obtained using equations (7) and (8).[14] A visual representation of the decomposition of the HICP forecast and the HICP forecast errors at annual frequency is given in charts 29 and 30.

For the HICP forecast decomposition the following picture emerges: Until 1994 the models predicted a rather stable HICP inflation at close to 2% with the exception of 1992 where forecasted inflation was lower. Throughout, forecasted inflation was mainly driven by increases in services prices, a feature that is also maintained in the years after 1994, where forecasted HICP inflation receded to around 1.5%. The stability in the contribution of service sector inflation to forecasted headline inflation can be attributed to offsetting tendencies of a trend decline in forecasted services inflation and a trend increase in the weight of services in the consumer basket (from 36% in 1990 to 45% in 2002). The other indices did not contribute much to forecasted inflation, either due to their small weight and/or due to a small forecasted inflation. The year-to-year variation in forecasted inflation can be mainly attributed to the contribution of the forecast of energy price inflation.

Turning to the HICP forecast error decomposition, the higher than expected inflation during the period from 1990 to 1993 was broadly based across goods categories, with large contributions of unprocessed food in 1990–91 and of services and industrial goods throughout. The unexpectedly low inflation between 1997 and 1999 was related to unexpectedly low industrial goods price inflation and unexpectedly low energy price inflation. The unexpectedly high inflation in 2000 emanated almost exclusively from the energy category, while in the following year inflation rates in almost all categories were underestimated. In the years 1995 to

[14] Note that this exercise is stylized in the sense that the adjustments to the processed food and industrial goods indices described in appendix B are not taken into account.

1996 a considerable underprediction of energy prices did offset overpredictions of inflation in other components. Recalling the result that energy price inflation is essentially unforecastable this indicates that a low degree of forecastability is not a sufficient condition for dismissing the attempt to forecast a variable.

To sum up, the ex-ante analysis of expected trends in Austrian inflation revealed that based on the models selected, a forward-looking decision-maker would have attributed most of inflation to increases in services prices, and she would have predicted a significant shift in the level of inflation in 1994 and 1995, partly explained by lower forecast energy and industrial goods price inflation. The errors implied by that ex-ante assessment were widely spread across goods categories at the beginning of the nineties while a strongly oscillating oil price was the dominating cause of over- and underpredictions of Austrian HICP inflation at the turn of the century.

Note that this is a stylized analysis designed to give an example for the use of HICP sub-indices for obtaining a more detailed picture of trends in inflation and not a description of the information available to decision makers in the past. The reason is that the sequential forecast model selection procedure applied above (and the variable selection procedure for the VARs) uses information from the whole period from 1990 to 2002. A more realistic exercise would require recursive forecasting together with recursive forecasting model selection. This is beyond the scope of this paper.

4. Conclusions

In this paper we take a comprehensive approach to forecast Austrian inflation at the 12-month horizon by forecasting aggregate HICP as well as 5 sub-indices. The simulated recursive out-of-sample forecasting exercise together with the forecasting model selection procedure suggest that factor models are useful for forecasting the sub-indices of the HICP. In two cases, predictive accuracy can be further improved by combining factor models with VAR models. An aggregation of sub-indices forecasts yields a somewhat higher predictive accuracy than a forecast of the HICP, with the additional advantage of consistency between the forecast of the HICP and the forecasts of the sub-indices. Furthermore, those forecasts can be used to give a more detailed picture of the determinants of HICP inflation both from an ex-ante and ex-post perspective. The analysis of the degree of optimality of the forecasts with highest predictive accuracy reveals some departures from optimality along several dimensions. The analysis of the forecastablity of the indices suggests that the specification with highest predictive accuracy obtainable from the models considered is still not able to forecast energy prices and unprocessed food prices. Industrial goods price inflation also appears difficult to forecast. However, in the case of energy price inflation the forecast errors tended to reduce the error of the HICP forecast by offsetting errors in other sub-indices.

The recursive out-of sample forecasting procedure is designed to simulate the problem of a forecaster of Austrian inflation in real time. However, this situation is far more complex than can be replicated in such an exercise. Conducting a real time forecast usually entails, besides selecting the optimal model, the use of personal judgment of the forecaster which is based on her expertise and experience. Apart from that, it is not guaranteed that the models, even with the highest predictive accuracy, use the information available in the data in an optimal way. Hence, the difference between our exercise and the job of forecasting inflation in real time is that in the latter case, the numeric results of the models, the judgment of the forecaster and additional information on future likely events affecting inflation, such as planned fiscal measures by the government or likely developments of raw material prices, interest rates and exchange rates derived from financial market prices, all combine to produce a more accurate forecast. This implies that predictive accuracy which has been the focus of this paper, although being vital, is not the only determinant for selecting the type of models to be used in forecasting Austrian inflation.

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Appendix

A. “Backcasting” the HICP Using the CPI

The HICP and its sub-indices are available from Statistik Austria beginning in January 1987. As noted by Ashley (2003), a sufficient number of observations in the validation period, preferably above 100, is necessary to establish significant differences in predictive accuracy. This implies that estimation has to start at an earlier date than 1987. The problem therefore is to “backcast" the HICP and its sub-indices.

We chose the following approach: First, based on qualitative information for each subindex and the HICP, those CPI sub-indices are identified that are related to the corresponding HICP indices. Then these indices are used together with all other available CPI indices in the regression $\Delta P_{i,t} = c + \sum_{j=0}^{N} \theta_j \Delta CPI_{j,t} + \varepsilon_{i,t}$. In that regression the annual increase of the HICP or HICP subindex, $\Delta P_{i,t}$, is regressed on the annual increases of N sub-indices of the CPI and the CPI itself and a constant. The next step is to exclude sequentially all CPI components that are not significant, except those that are already identified to be related to the HICP or a subindex of the HICP based on qualitative information. The result is a parsimonious representation of the HICP or HICP subindex in terms of the CPI and/or CPI sub-indices. This procedure reflects the hypothesis that the set of prices of individual goods contained in the HICP and CPI is largely similar but aggregated in different fashions.

The results of these regressions (available from the authors on request) display several common features: First, the adjusted R^2 is very high, between 88 and 96%. Second, in all equations there is considerable serial correlation, with DW-statistics ranging from 0.32 to 0.71. The good fit is evidence that the HICP sub-indices are well approximated by the CPI sub-indices. However, the low DW-statistic in conjunction with the high R^2 points to a possible spurious relationship. The next step consists of using the estimated coefficients $\hat{\theta}_j$ to generate predicted values for the HICP and the HICP sub-indices for the period from January 1980 to December 1986. This increases the number of observations by 43%.

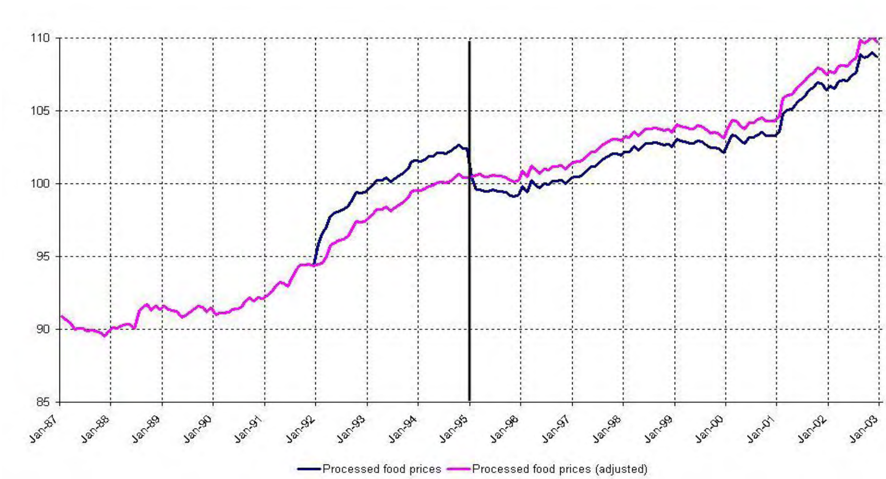
The expanded series are then subjected to two quality checks: First, a visual inspection of the series does not suggest the presence of major breaks in January 1987. Furthermore, for some indices also the seasonal pattern is clearly maintained. Second, the HICP sub-indices predicted by the above models are aggregated using the HICP weights of January 1987. The resulting backcasted aggregated HICP is compared to the backcasted aggregate HICP. Here it turns out that the discrepancy between the two series in the pre-1987 period is comparable to this discrepancy in the post-1987 period (mentioned in footnote 9). Overall, it seems that the approximation of the HICP and the HICP sub-indices works fairly well. This suggests that the costs given by any approximation errors are outweighed by the gains in terms of increased discriminatory power across forecasting models mentioned above.

B. Removing Breaks from the Price Index Series

A visual inspection of the monthly differences and the level of the seasonally adjusted price index series of the processed food and the industrial goods price index reveal that both series contain breaks. The processed food index displays an upward jump in the price level in January and February 1992 and a sharp fall in the price level in January and February 1995. The sizes of these shifts suggest that some event caused a temporary increase in the price level of processed food in Austria in the period from 1992 to 1994, followed by a permanent fall since then. A similar pattern is visible in the wholesale price index of food, but not in the index for unprocessed food or world market prices of food measured by the corresponding HWWA index. This points to a sectoral cause, possibly related to Austria's accession to the EU in January 1995. In order to remove the two breaks from the series a dummy variable is defined as shown in chart 1, which is then subtracted from the original series to obtain the adjusted series as displayed in chart 2.

Chart 1: Dummy for the Shift in the Processed Food Index[15]

Chart 2: Processed Food Price Level



[15] All data used in charts originate from authors' calculations.

Chart 3: Dummy Variable for the Industrial Goods Index

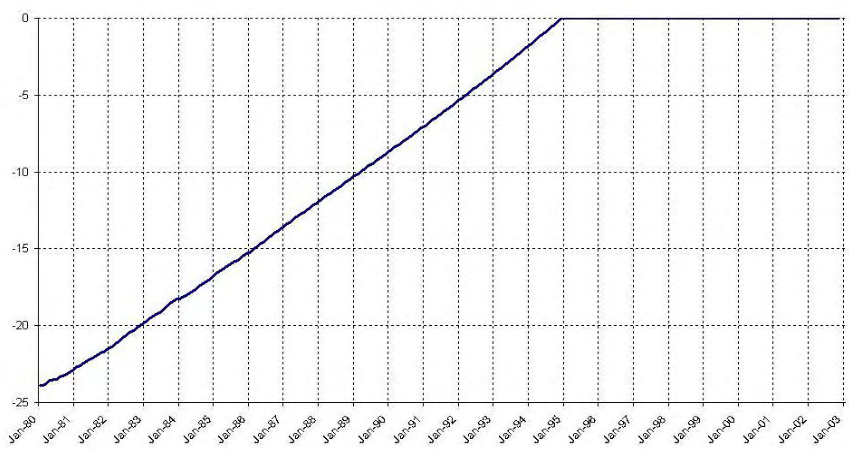
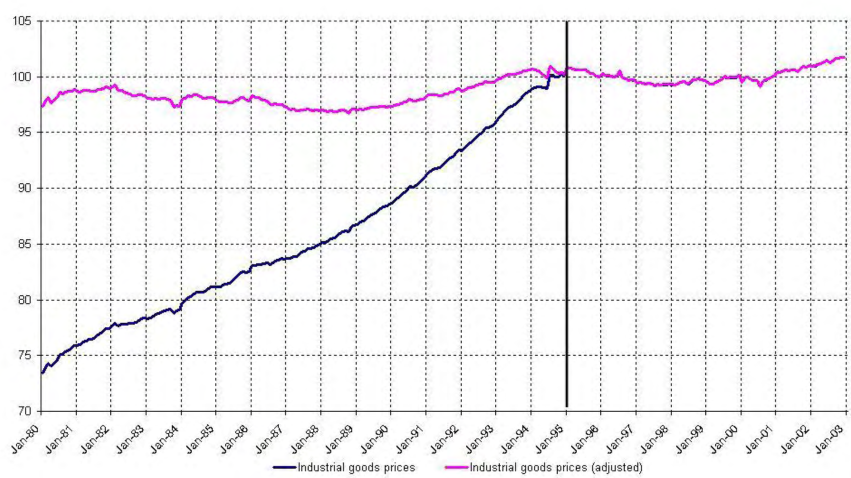


Chart 4: Industrial Goods Price Level



The level and monthly differences of the industrial goods index suggest a break in January 1995, possibly related to increased competitive pressure induced by EU entry. The break is dealt with by calculating the mean growth rates for the pre- and post-1995 periods and subtract the difference between the two means from the pre-1995 data. This removes the strong upward trend visible in the pre-1995 data (see charts 3 and 4). The remaining variation in the manipulated series reflects short run changes in inflation, the focus of our forecasting efforts.

The headline HICP is also affected by the two breaks. They are removed from the index by multiplying the dummies for the two indices with the weights of these indices in the HICP and subtracting it from the HICP.

C. Test Statistics for Comparing Predictive Accuracy and Encompassing

Calculating the modified Diebold-Mariano statistic of Harvey, Leybourne and Newbold proceeds as follows. A loss differential sequence, $d_{1,j,t+12} = \hat{u}^2_{j,t+12} - \hat{u}^2_{1,t+12}$ is computed where $\hat{u}_{1,t+12}$ and $\hat{u}_{j,t+12}$ denote the 12-step out-of-sample forecast errors of the factor model forecasts and the forecasts of the competing model. The mean of this sequence is given by $\bar{d}_{1,j} = N^{-1}\sum_{t=1}^{N} d_{1,j,t+12}$. Note that $\bar{d}_{1,j} = MSE_j - MSE_1$. Furthermore, let $\hat{S}_{1,j}^{DM^{mod}} = \gamma_{1,j,0} + 2\sum_{k=1}^{n} \gamma_{1,j,k}$ be a consistent estimate of the long-run covariance of the sequence $d_{1,j,t+12}$, where $\gamma_{1,j,k} = N^{-1}\sum_{t=1}^{N}(d_{1,j,t+12} - \bar{d}_{1,j})(d_{1,j,t+12-k} - \bar{d}_{1,j})$. Following Diebold and Mariano, our choice of the truncation lag n is motivated by the fact that optimal k-step forecasts should display at most $(k-1)$-dependence. Since our forecasts are 12-step we choose a truncation lag of 14 to account for deviations from optimality. Only those autocovariances of the sequence $d_{1,j,t+12}$ enter the long-run covariance with a non-zero value which are at lags with a significant autocorrelation coefficient. Significance is given if the absolute value of an autocorrelation coefficient is greater than $2/\sqrt{N}$. Note that $d_{1,j,t+12}$ has to be stationary which is checked using the augmented Dickey-Fuller test. The test statistic

$$DM_{1,j}^{mod} = \left[\frac{N+1-2k+N^{-1}k(k-1)}{N}\right]^{0.5} \frac{\bar{d}_{1,j}}{\sqrt{\hat{S}_{1,j}^{DM^{mod}}/N}} \tag{9}$$

is given by the difference between the mean squared errors of the two models, scaled by the standard deviation of the sequence $d_{1,j,t+12}$. The expression in square brackets is the size correction proposed by Harvey, Leybourne and Newbold. They note that this test still has the tendency to reject a true null somewhat to often. The measure of the standard deviation accounts for the autocorrelation in the loss differential sequence which may be present due to our multi-step forecasting framework.

Calculating the encompassing test statistic of Harvey, Leybourne and Newbold proceeds as follows. Let $\hat{c}_{s,j,t+12} = \hat{u}^2_{s,t+12} - \hat{u}_{j,t+12}\hat{u}_{s,t+12}$ and $\bar{c}_{s,j} = N^{-1}\sum_{t=1}^{N} \hat{c}_{s,j,t+12}$. The index s denotes the forecast with higher predictive accuracy as established by the modified Diebold Mariano test and/or the descriptive statistics and j denotes the competing forecast. Note that $\bar{c}_{s,j} = MSE_s - cov(\hat{u}_{j,t+12}, \hat{u}_{s,t+12})$. The statistic is given by

$$HLN_{s,j} = \frac{\bar{c}_{s,j}}{\sqrt{\hat{S}^{ENC}_{s,j}/N}}, \tag{10}$$

where $\hat{S}^{ENC}_{s,j} = \delta_{s,j,0} + 2\sum_{k=1}^{n} \delta_{s,j,k}$ and $\delta_{s,j,k} = N^{-1}\sum_{t=1}^{N} (\hat{c}_{s,j,t+12} - \bar{c}_{s,j})$ $(\hat{c}_{s,j,t+12-k} - \bar{c}_{s,j})$. The truncation lag n is again set to 14. Under the null hypothesis that the forecast with higher predictive accuracy encompasses the forecast of the competing model, the difference between the MSE of the model with higher predictive accuracy and the covariance between the forecast errors will be less than or equal to zero. Under the alternative that the competing model contains additional information, the difference should be positive and large compared to the standard deviation of the sequence $\hat{c}_{s,j,t+12}$. This condition is more likely to be fulfilled if the forecast errors of the two models are negatively correlated.

D. List of Data

Labor market

1. Unemployment, total
2. Unemployment, female
3. Unemployment, male
4. Unemployment, construction sector
5. Unemployment rate, total
6. Unemployment rate, female
7. Unemployment rate, male
8. Employment, total
9. Employment, female
10. Employment, male
11. Employment, total, blue collar
12. Employment, female, blue collar
13. Employment, male, blue collar
14. Employment, total, white collar
15. Employment, male, white collar
16. Employment, female, white collar
17. Employment, foreigners
18. Vacancies

Trade balance

1. Imports, food
2. Imports, raw materials
3. Imports, intermediate goods
4. Imports, finished goods
5. Imports, finished goods, investment goods
6. Imports, finished goods, consumption goods
7. Imports, finished goods, miscellaneous
8. Imports, machinery, vehicles
9. Imports, total, excluding intra euro area dispatches
10. Imports, total
11. Imports, total, unit values
12. Exports, food
13. Exports, raw materials
14. Exports, intermediate goods
15. Exports, finished goods
16. Exports, finished goods, investment goods
17. Exports, finished goods, consumption goods
18. Exports, finished goods, misc.

19. Exports, machinery, vehicles
20. Exports, total, excluding intra euro area dispatches
21. Exports, total
22. Exports, total, unit values

Money and credit

1. Deposits with maturity up to two years
2. Demand deposits
3. M1
4. M2
5. M3
6. Loans to the private sector
7. Collateralized loans
8. Foreign currency loans
9. Private sector demand deposits
10. Private sector time deposits
11. Cash in stock at banks
12. Deposits of banks at central bank
13. Liquidity of banks

Wholesale prices

1. Wholesale prices (total)
2. Consumer goods (total)
3. Consumer goods (durable)
4. Consumer goods (non-durable)
5. Consumption goods
6. Intermediate goods
7. Construction goods
8. Investment goods
9. Iron and steel
10. Non-steel metals
11. Solid Fuels
12. Food
13. Electrical appliances
14. Paper and paper products
15. Seasonal food
16. Feed barley
17. Soy grits
18. Utility calfs
19. Calf breed
20. Chicken
21. Pork chop

22. Beef
23. Veal
24. Pulp wood (Styria)
25. Pulp wood (Upper Austria)
26. Energy

Aggregate demand

1. Industrial production (total)
2. Industrial production excluding energy and construction
3. Industrial orders
4. Industrial sales price expectations
5. Car registration and sales

Negotiated monthly wages

1. All employees, total,
2. All employees, excluding public services
3. All employees, public services
4. All employees, public services, transportation
5. All employees, industry
6. All employees, manufacturing
7. All employees, construction
8. All employees, trade
9. All employees, transportation
10. All employees, tourism
11. All employees, agriculture and forestry
12. Blue collar, total
13. Blue collar, industry
14. Blue collar, construction
15. Blue collar, manufacturing
16. Blue collar, trade
17. Blue collar, transportation
18. Blue collar, tourism
19 Blue collar, agriculture and forestry
20 White collar, total
21. White collar, industry
22. White collar, construction
23. White collar, manufacturing
24. White collar, trade
25. White collar, transportation
26. White collar, tourism
27. White collar, banking
28. White collar, agriculture and forestry

Raw materials

1. Import prices, coal
2. Import prices, electricity
3. Import prices, crude oil, including components for processing
4. Import prices, crude oil
5. Import prices, liquid gas
6. Import prices, gasoline
7. Import prices, heating oil
8. HWWA index, total
9. HWWA index, total, excluding energy
10. HWWA index, food and tobacco
11. HWWA index, materials used in manufacturing
12. HWWA index, materials used in agriculture
13. HWWA index, non-steel metals
14. HWWA index, iron ore and scrap
15. HWWA index, energy
16. HWWA index, coal
17. HWWA index, crude oil
18. Brent crude oil

Tourism

1. Price index for foreigners in Austria
2. Price index for domestic residents in foreign countries
3. Price index for domestic residents in Austria
4. Bednights, total
5. Foreign tourist bednights
6. Domestic tourist bednights

Exchange rates

1. Austrian Schilling to the U.S. dollar
2. Austrian Schilling to the Canadian dollar
3. Austrian Schilling to the pound sterling
4. Austrian Schilling to the Swiss francs
5. Austrian Schilling to the Norwegian krone
6. Austrian Schilling to the Swedish krone
7. Austrian Schilling to the Japanese yen
8. Austrian Schilling to the Australian dollar
9. Austrian Schilling to the Korean won
10. Austrian Schilling to the Indonesian rupiah
11. Austrian Schilling to the Thai baht
12. Austrian Schilling to the Malaysian ringgit
13. Austrian Schilling to the Philippine peso

14. Effective exchange rate, nominal
15. Effective exchange rate, real, CPI based
16. Effective exchange rate, real, Ulc-mfg based
17. Terms of trade index, domestic currency

Interest rates

1. Yield on German government bond, one year residual maturity
2. Yield on German government bond, two years residual maturity
3. Yield on German government bond, three years residual maturity
4. Yield on German government bond, four years residual maturity
5. Yield on German government bond, five years residual maturity
6. Yield on German government bond, six years residual maturity
7. Yield on German government bond, seven years residual maturity
8. Yield on German government bond, eight years residual maturity
9. Yield on German government bond, nine years residual maturity
10. Yield on German government bond, ten years residual maturity
11. Base rate of the Oesterreichische Nationalbank
12. Reference rate of the Oesterreichische Nationalbank
13. Yield on Austrian government bond, ten years residual maturity
14. Vienna stock exchange, index
15. Overnight interest rate, Frankfurt
16. Three months deposit interest rate, Zurich
17. Three months deposit, Eurodollar
18. Federal Funds rate
19. Yield, secondary market government bonds, bond basket, other maturities.
20. Yield, private sector bonds, including bank and mortgage bonds.
21. Interest rate, euro-currency, 1-month bid rate
22. Interest rate, euro-currency, 3-month bid rate
23. Interest rate, euro-currency, 6-month bid rate
24. Interest rate, euro-currency, 12-month bid rate
25. 3-month VIBOR

CPI and CPI components

1. CPI
2. CPI excluding unprocessed food
3. Food and beverages
4. Unprocessed food
5. Food
6. Services
7. Rents
8. Tobacco
9. Rents and maintenance of flats

10. Lighting und heating
11. Clothing and personal equipment
12. Cleaning of clothing
13. Personal hygiene
14. Leisure and education
15. Transport

HICP and HICP components

1. HICP
2. Processed food
3. Unprocessed food
4. Energy
5. Industrial goods
6. Services

Chart 5: Acf of the HICP Inflation Forecast Error

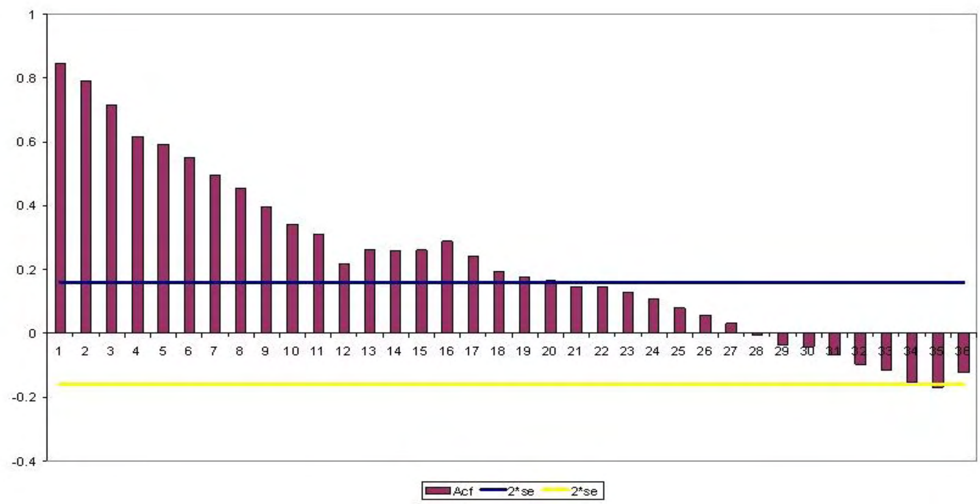


Chart 6: Acf of the Processed Food Price Inflation Forecast Error

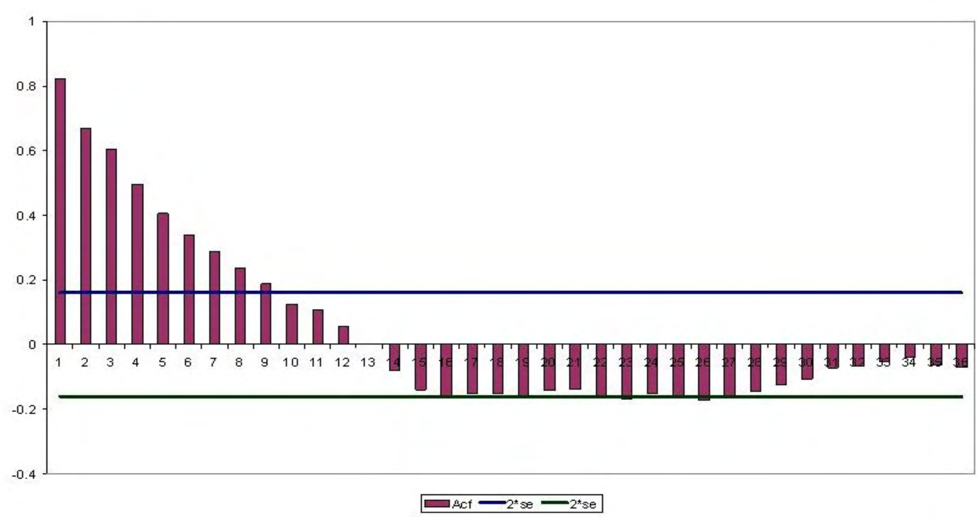


Chart 7: Acf of the Unprocessed Food Price Inflation Forecast Error

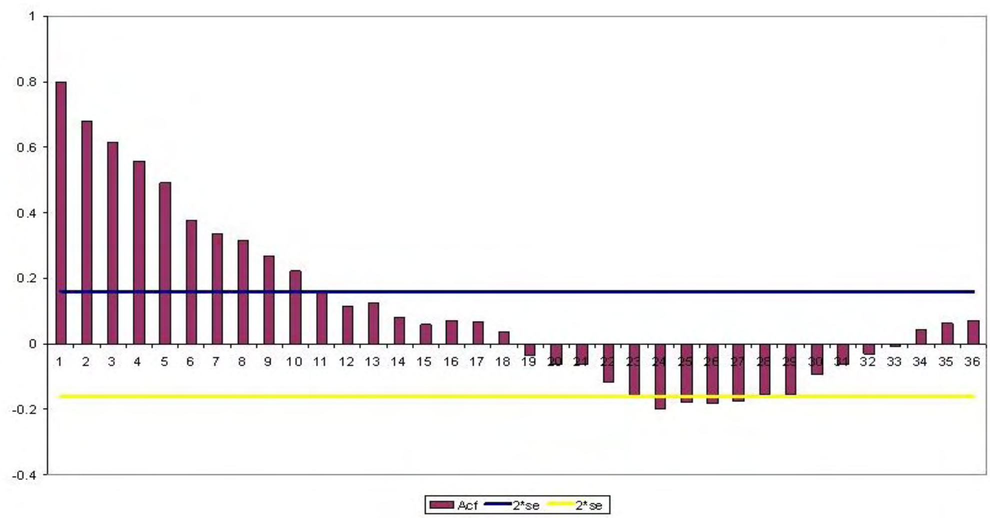


Chart 8: Acf of the Energy Price Inflation Forecast Error

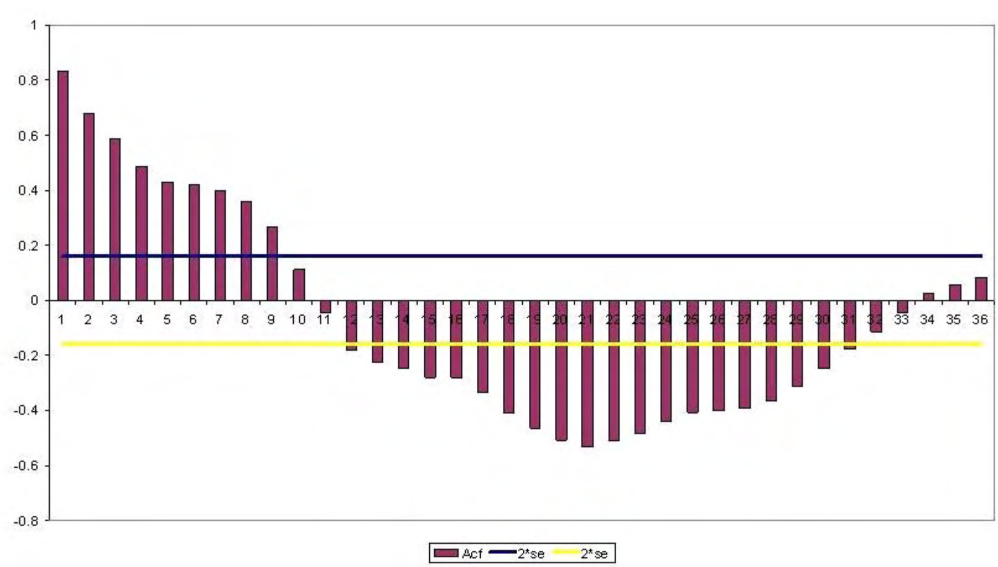


Chart 9: Acf of the Industrial Goods Price Inflation Forecast Error

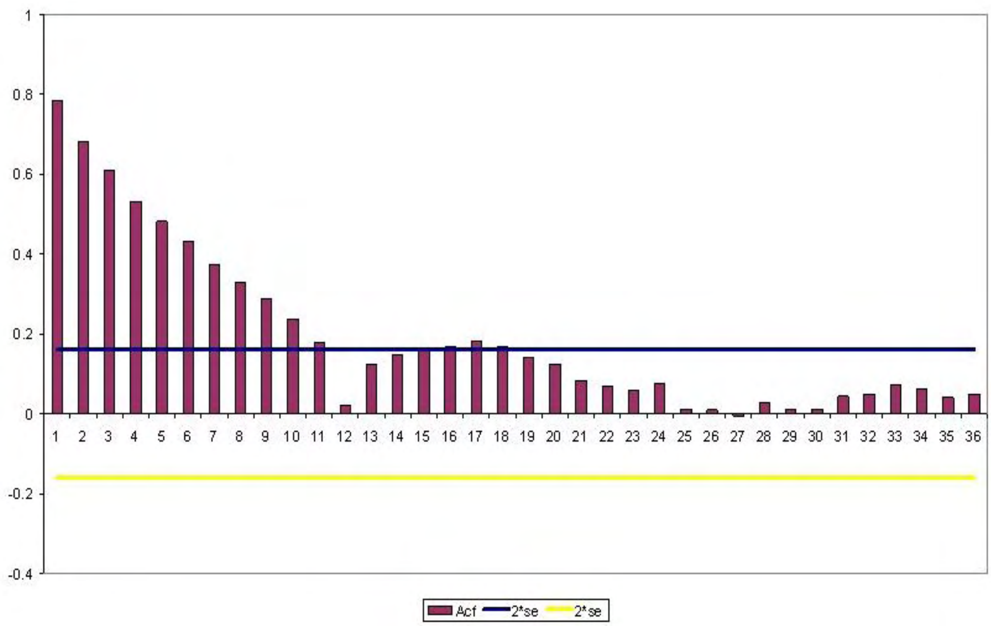


Chart 10: Acf of the Services Price Inflation Forecast Error

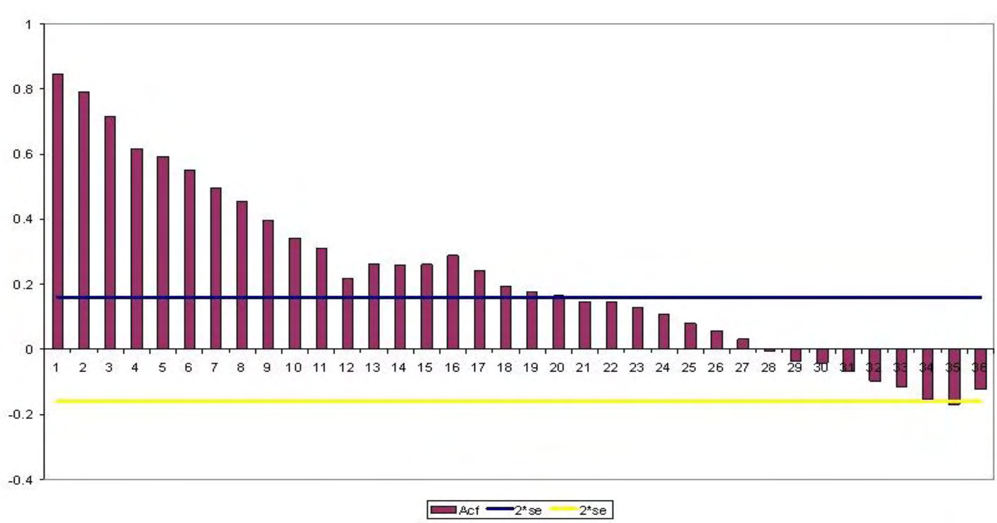


Chart 11: Forecast Error – HICP

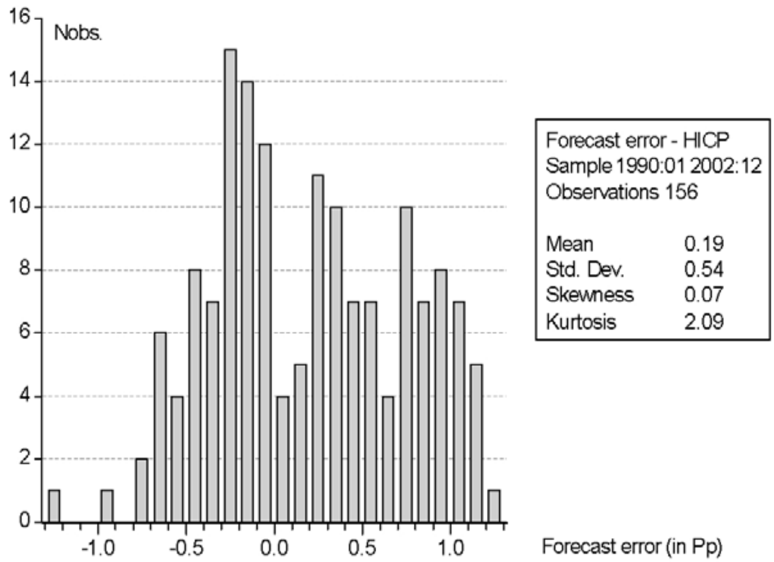


Chart 12: Forecast Error – Processed Food

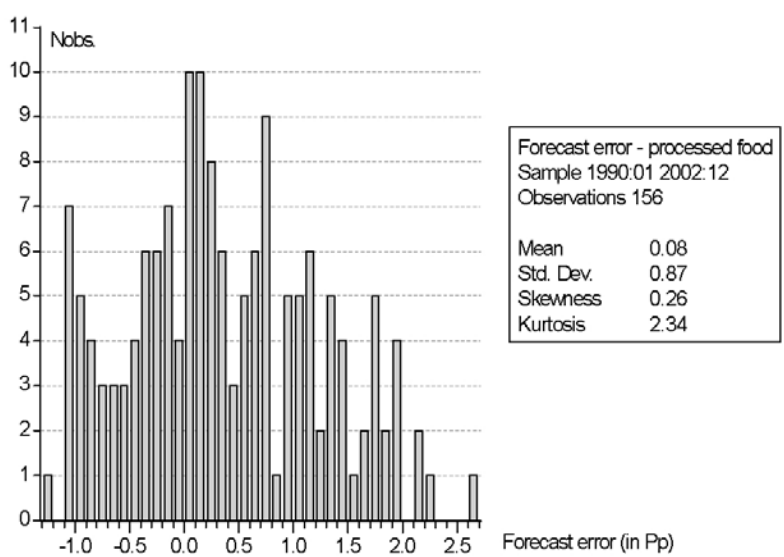


Chart 13: Forecast Error – Unprocessed Food

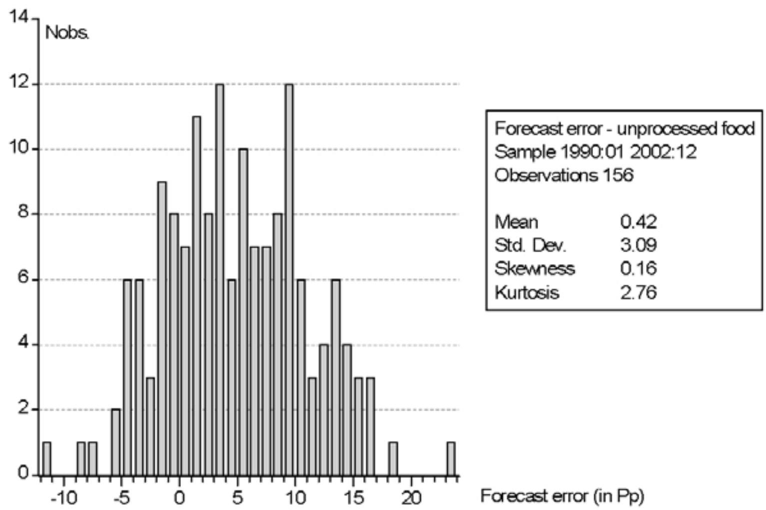


Chart 14: Forecast Error – Energy

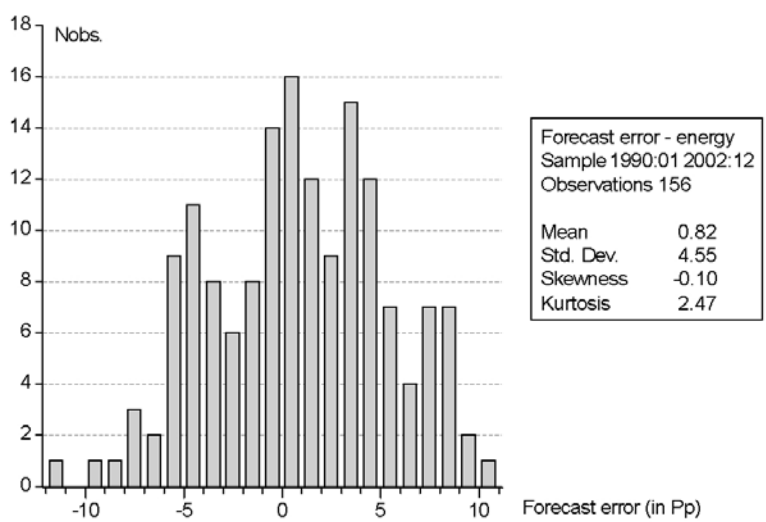


Chart 15: Forecast Error – Industrial Goods

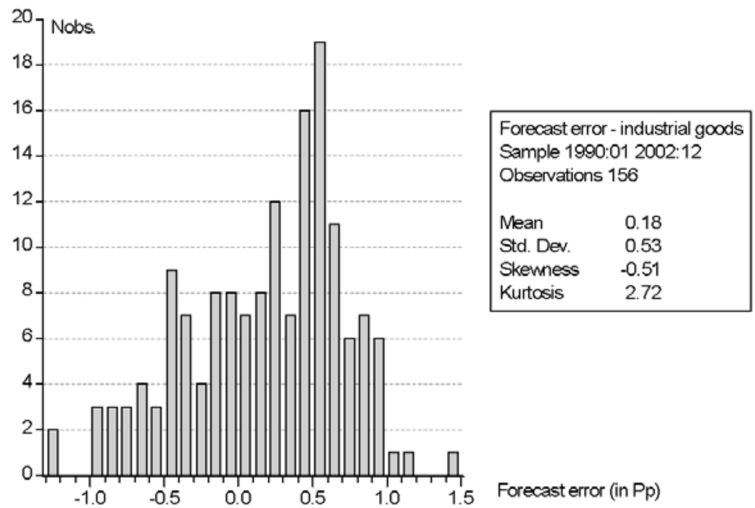


Chart 16: Forecast Error – Services

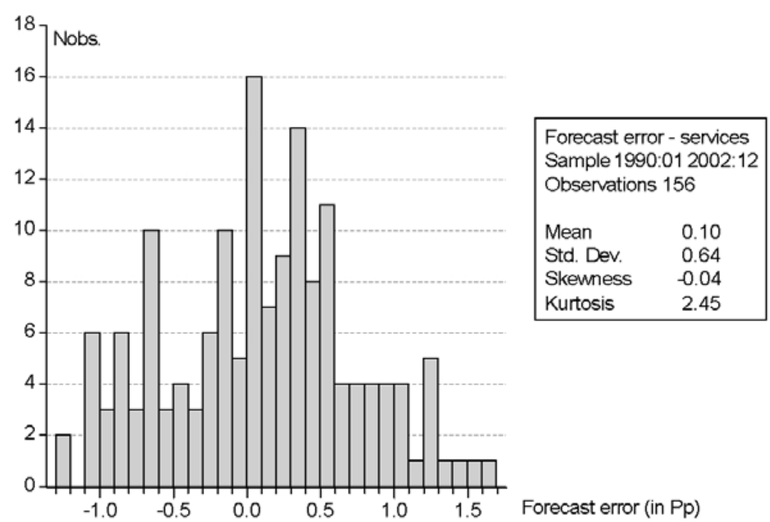


Chart 17: HICP Inflation

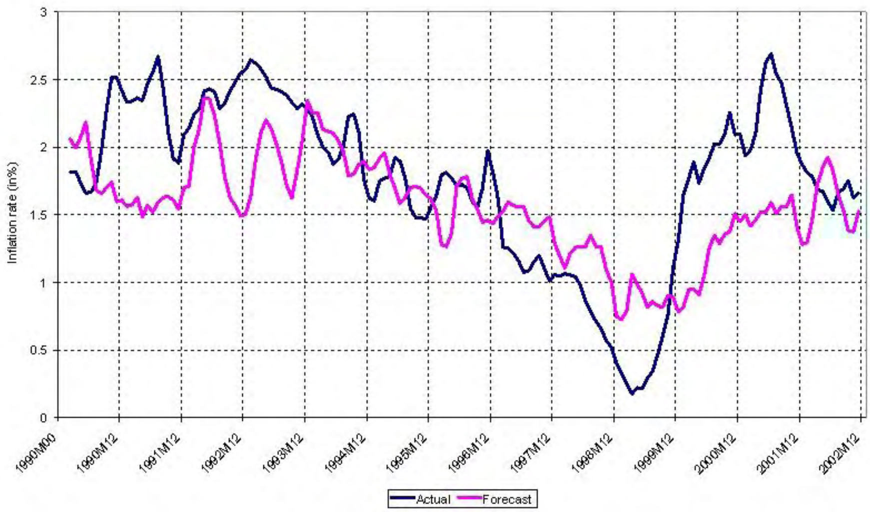


Chart 18: Processed Food Price Inflation

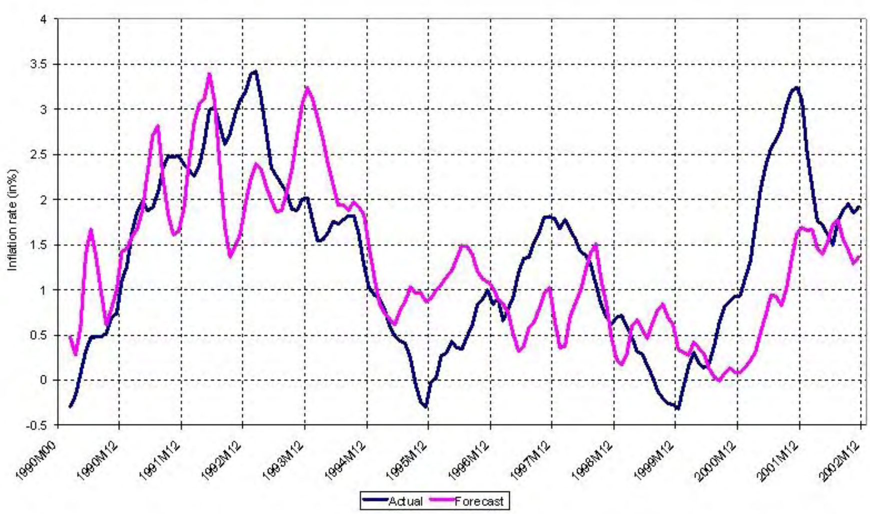


Chart 19: Unprocessed Food Price Inflation

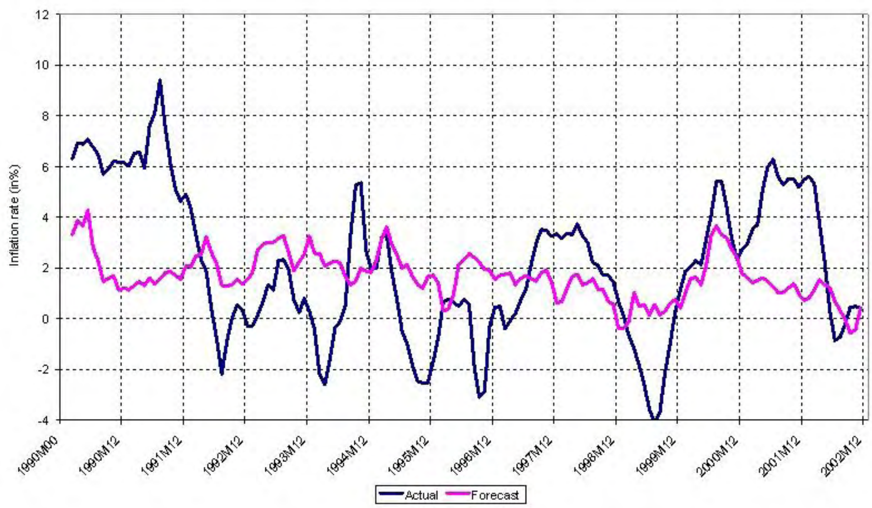


Chart 20: Energy Price Inflation

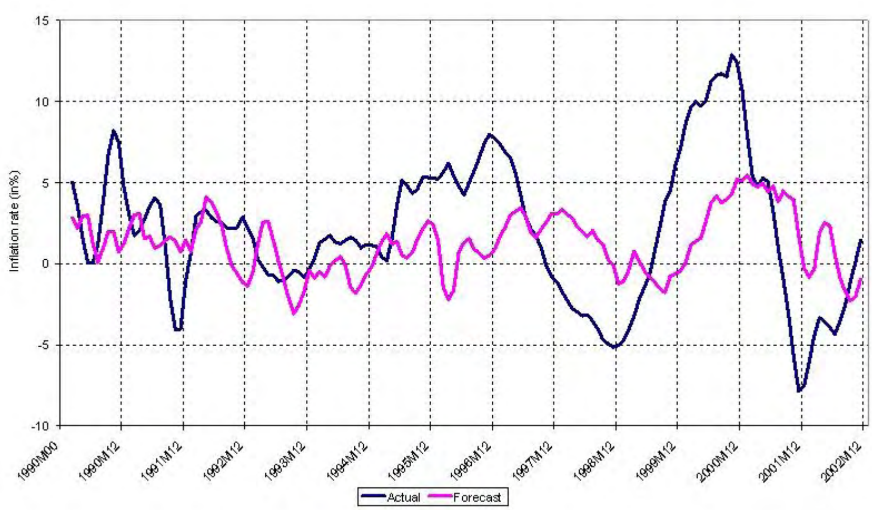


Chart 21: Industrial Goods Price Inflation

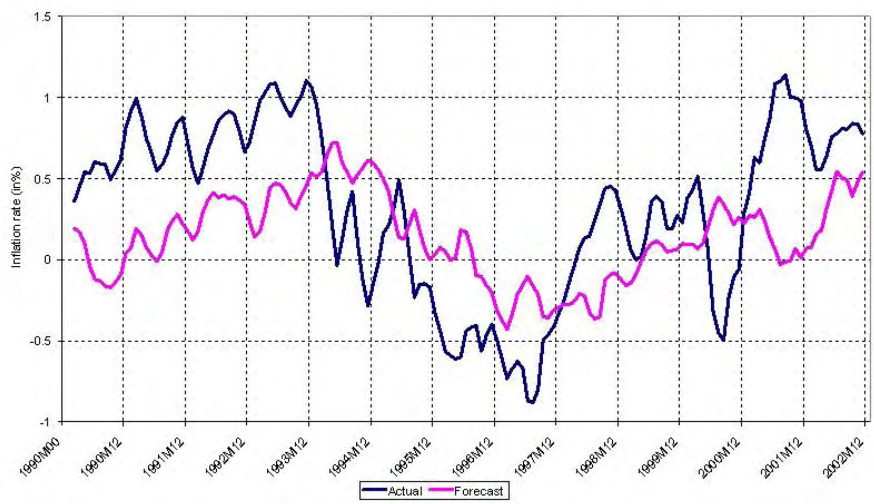


Chart 22: Services Price Inflation

Chart 23: HICP–Forecast Error

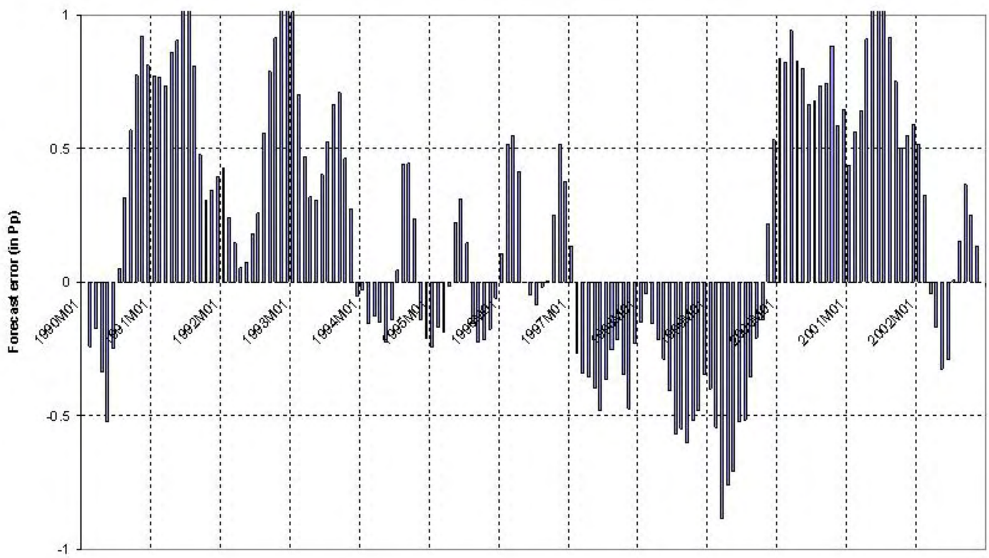


Chart 24: Processed Food – Forecast Error

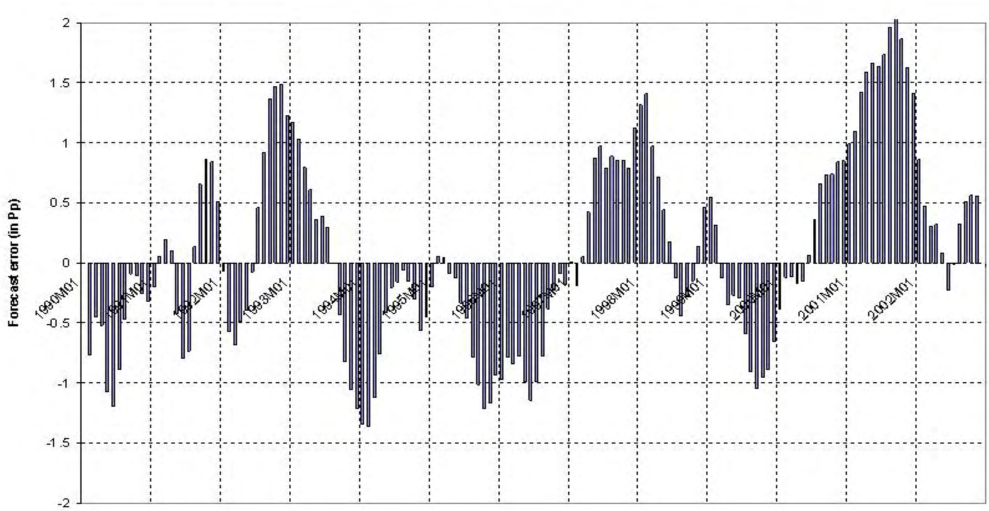


Chart 25: Unprocessed Food – Forecast Error

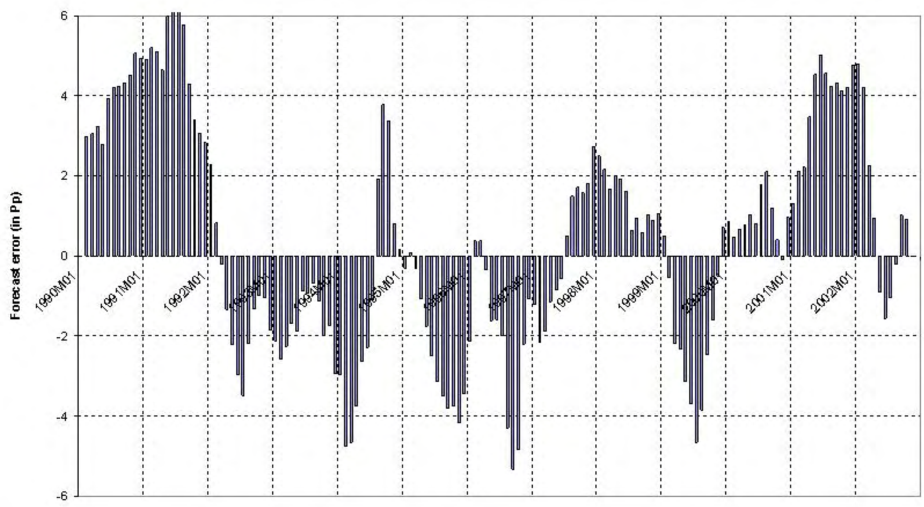


Chart 26: Energy – Forecast Error

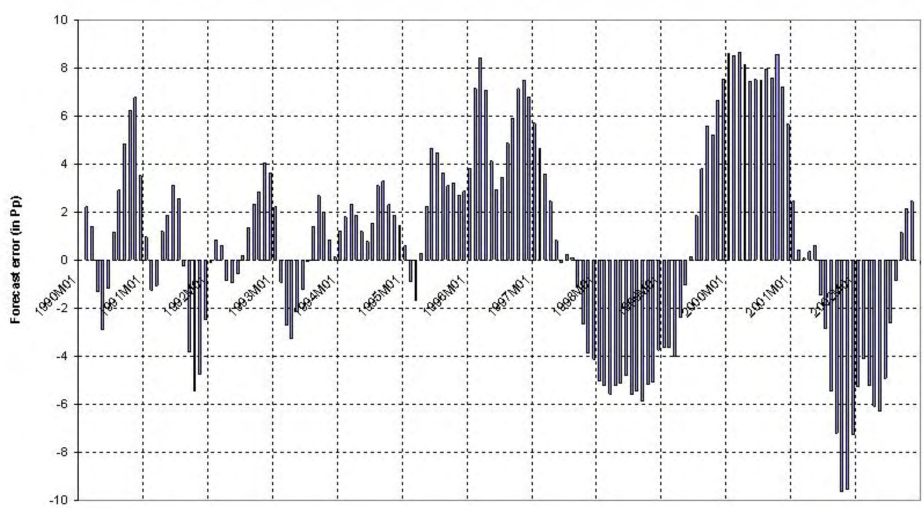


Chart 27: Industrial Goods – Forecast Error

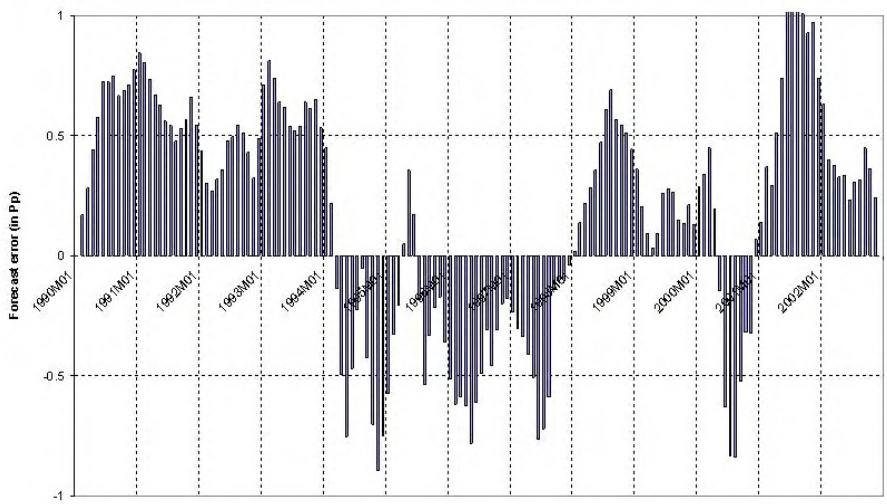


Chart 28: Services – Forecast Error

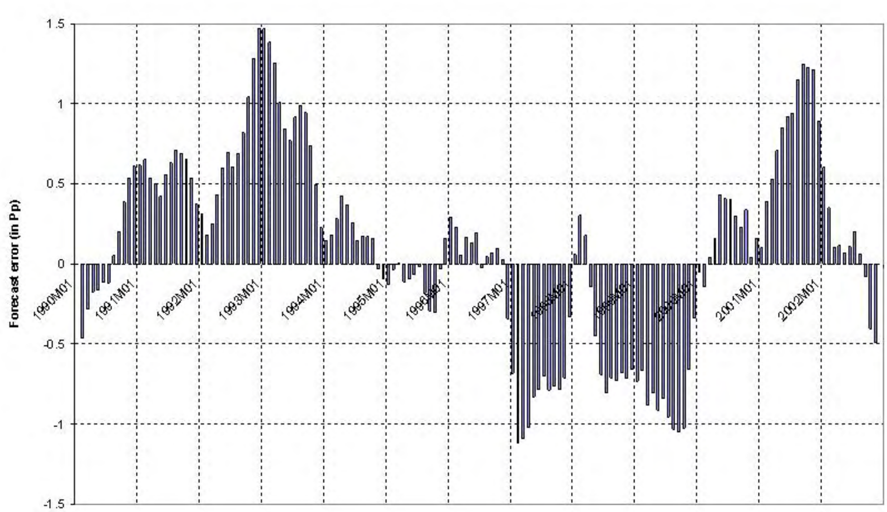


Chart 29: HICP – Forecast Decomposition

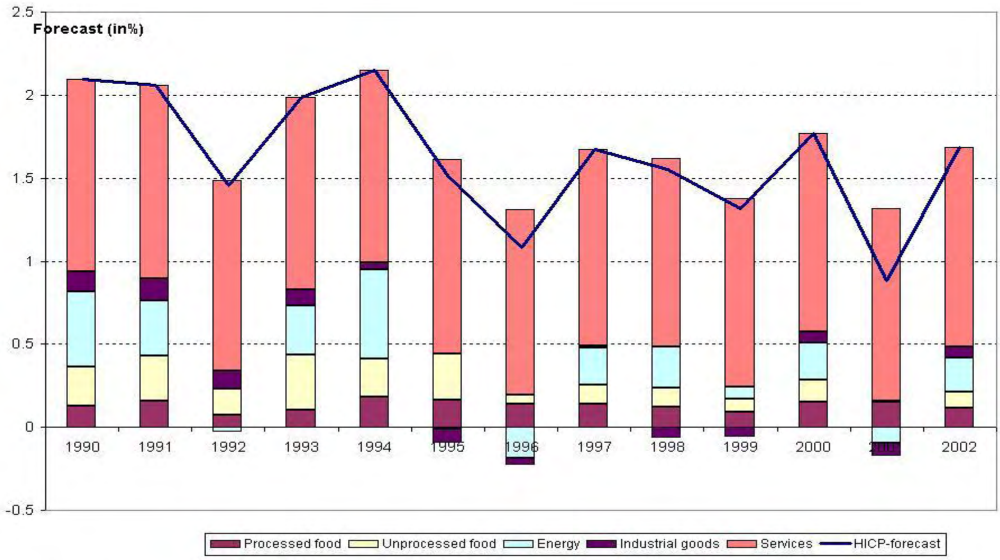
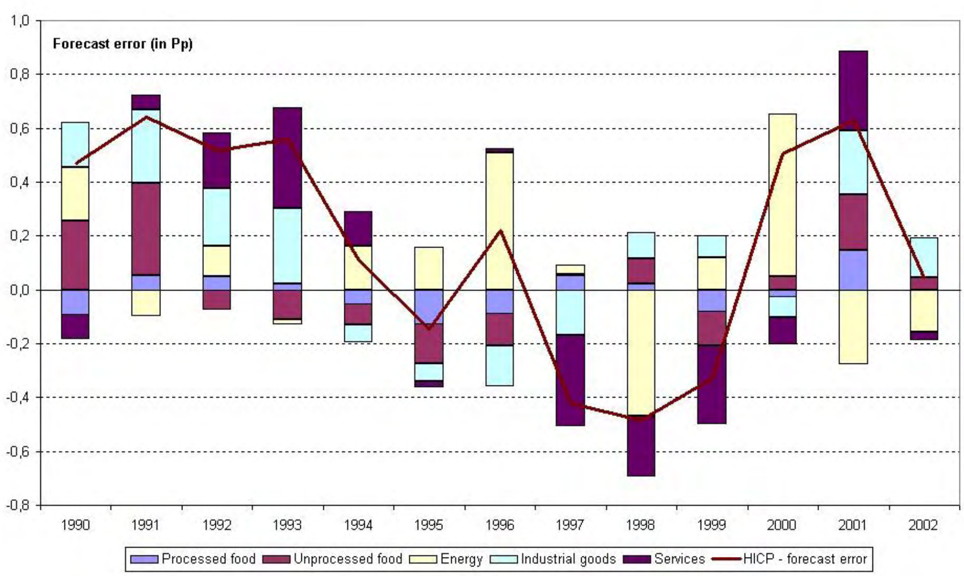


Chart 30: HICP – Forecast Error Decomposition



Comment on “Forecasting Austrian Inflation”

Gerhard Rünstler[1]

European Central Bank

At least since Stock and Watson (1999), the use of composite indicators as derived from factor analysis has become a widely used approach to forecasting. Indeed, the empirical evidence tends to favour factor models as compared, for instance, to the standard VAR or ARIMA models. In this sense, the findings of the paper, which is competently done, stand largely in line with a number of recent studies on inflation forecasting conducted in the Eurosystem central banks.

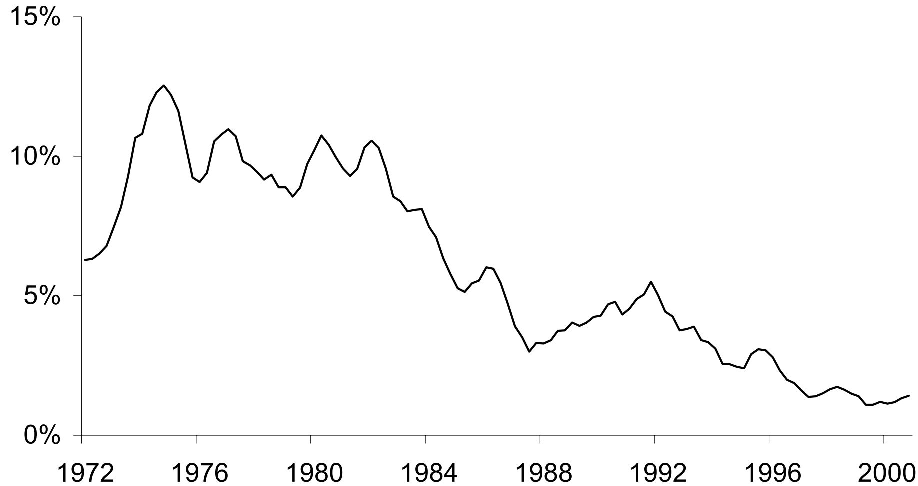
Still, a closer look at tables 2 and 4 reveals that the forecasts of the factor model still fall probably short of what we would like to achieve. According to the forecastability measure presented in table 4 it is only 2 among the 5 subcomponents of HICP, i.e. “Services” and “Processed food”, for which the models produce informative 1-year ahead forecasts. As regards overall annual HICP inflation, the reduction in the standard error of the forecasts amounts to $1-\sqrt{1-0.31}\approx 17\%$.

However, these findings stand in line with the previous studies also in this respect. Inflation data have some undesirable properties and are simply very difficult to forecast. I shall demonstrate some of the difficulties with data for the euro area. I should however say beforehand that these issues may be somewhat less relevant for inflation in Austria, as the historical swings in the 1970s and 1980s are smaller compared to euro area data. However, apparently they apply to a number of euro area countries as well.

Chart 1 shows quarterly data for euro area quarterly and annual inflation, as measured by the consumer price index. The data range from 1970:1 to 2001:4.

[1] The opinions expressed in this contribution are those of the author and do not necessarily reflect the views of the European Central Bank.

Chart 1: Euro Area Annual CPI Inflation



Source: Rünstler (2002).

First of all, is inflation stationary? The graph does not suggest so. The data exhibit a clear downward trend and are far from fluctuating around a constant mean. Augmented Dickey-Fuller tests do not reject non-stationarity. This may stem from insufficient power of the tests. But there exist also unit root tests against stationarity as the null, such as the test due to Leybourne and McCabe (1984). This test clearly rejects stationarity.[2]

Note that a rejection of stationarity does not necessarily imply a unit root in the series. Arguably, such can hardly be a feature of inflation dynamics, as it would imply unbounded variance. However, a deterministic downward trend can hardly be regarded as an admissible model either, which becomes evident if one considers longer-term forecasts from such a model. Instead, some other approach to modelling the non-stationarity of inflation seems required. It has been proposed, for instance, to allow for infrequent jumps in the unconditional mean in time series models for inflation (e.g. Corvoisier and Mojon, 2005). However such infrequent deterministic jumps can be at best an approximation.

[2] The Leybourne-McCabe test statistics for quarterly inflation rates amounts to .278, which exceeds the 1% critical value of .216. The Augmented Dickey-Fuller test statistics, in turn, is found with -1.20, insignificant at the 10% level. Both tests exclude the possibility of a deterministic trend in inflation.

In any case, the level shifts in inflation may generate a good deal of parameter instability in time series models and thereby hamper their forecasting performance. Table 1 aims at demonstrating this for the euro area data (see also Rünstler, 2002). The table shows statistics of 4 and 8 quarters-ahead forecasts for inflation, based on various real activity and monetary indicators x_t. I consider two types of forecasts, i.e. conditional and leading-indicator forecasts.

The *conditional forecasts* for inflation π_{t+h} use the future values of the indicator $x_t,\ldots,x_{t+h}$. They are based on the ARIMAX equation

$$\Delta\pi_{t+1} = \mu + \theta_x(L)x_{t+1} + c(L)\Delta\pi_t + e_t \tag{1}$$

where L denotes the lag operator, $Lx_t = x_{t-1}$, and $\Delta = 1 - L$ is the difference operator. The forecasts for π_{t+h} are obtained from iterating this equation for $i = 1,\ldots,h$.

The *leading indicator (LI) forecasts* (Stock and Watson, 1999) predict π_{t+h} directly from the equation

$$\pi_{t+h} - \pi_t = \mu + \theta_x(L)x_t + c(L)\Delta\pi_t + e_t \tag{2}$$

The major difference between these two is that the LI forecasts use only the current (and past) values $\{x_s\}_{s=1}^{t}$ of the indicator, whereas the conditional forecasts also use future values, $\{x_s\}_{s=1}^{t+h}$. The latter should hence be more precise. While the LI forecast are more relevant in practice, conditional forecasts are of interest as a diagnostic instrument.

Crucially, the forecasts shown in Table 1 are either based on *full-sample* or on *recursive* parameter estimates.[3] In the latter case, parameters are re-estimated at each single point time. They hence, use only the information available to a forecaster in 'real time' and are therefore the relevant ones in practice. Naturally, recursive forecasts are more sensitive to parameter instability.

The table shows the root mean squared error (RMSE) of 4 and 8 quarters-ahead forecasts relative to the RMSE of a naive forecast.[4] A small value indicates good

[3] For full-sample forecasts, in turn, the parameters are estimated once over the entire sample. Lengths of lag polynomials c(L) and θ(L) have been determined from the Schwartz information criterion. Versions of equations (2) and (3) that use inflation in levels instead of first differences yield very similar results.

[4] The naive forecast for π_{t+h} amounts simply to the last observed value π_t.

forecasting performance, while a value of larger than one indicates that the forecast is uninformative (i.e. worse then the naive forecast). In addition, the table contains a test for Granger-causality of the indicator to inflation together with Andrews' (1993) test for stability of constant μ (with unknown breakpoint).

Table 1: Inflation Forecasts from Various Indicators

	GC test	Stability test (μ)	RRMSE Conditional (2) full-sample		RRMSE Conditional (2) recursive		RRMSE LI forecasts (3) recursive	
Forecast horizon			4	8	4	8	4	8
None							0.96	0.84
Capacity utilisation	**17.31	2.33	0.63	0.46	0.75	0.75	0.82	0.92
UR (level)		**16.15	0.92	1.02	1.39	1.81	0.89	0.81
UR (change)	2.20	3.35	0.86	0.91	1.30	1.67	0.83	0.76
GDP (growth)	**8.71	3.26	0.85	0.89	1.36	1.74	0.81	0.86
Long-term rate	**14.49	**8.07	0.72	0.67	1.31	1.76	0.72	0.79
Short-term rate	*7.88	**8.96	0.75	0.64	1.34	1.84	0.88	0.89
Money M3 growth	*8.59	**10.90	1.02	1.31	0.98	1.00	1.10	0.83

*Note: RRMSE denotes the root mean squared error of the forecasts relative to the one of the naive forecast. GC denotes the test for Granger causality of the indicator to inflation. Critical values for Andrews' (1993) stability test for constant μ are 6.05 and 7.51 for 10% and 5% significance levels, respectively * and ** denote significance at 10% and 5% levels, respectively. Estimation period starts in 1973Q1 with the exception of money and interest rates which start in 1981Q1. The forecast evaluation period ranges from 1991Q1 to 2000Q4.*

Source: Rünstler (2002).

The results of table 1 contain a few interesting features. First, a number of indicators, e.g. capacity utilisation, interest rates and to a lesser extent, GDP growth provide good full-sample forecasts.. When it comes to recursive forecasts however, most of the indicators perform worse than the naïve forecast. This strongly suggests parameter instability, which, in some cases, can be attributed to the constant μ as indicated by Andrews' (1993) test.

Second, and somewhat surprisingly, the recursive LI forecasts perform better than the conditional forecasts. This holds despite the smaller information set and the presence of parameter instabilities. Long-term interest rates and money M3 growth are perhaps the most striking examples. The test for Granger-causality of M3 is only significant at the 10% level and for both series, the instability of constant μ leads to values of the RMSE statistics of well above one. However, the LI forecasts show the indicators as those with the highest information content for future inflation, thereby turning the results from conditional forecasts on their head.

Overall, it seems difficult to find leading indicators for inflation that exhibit a stable relationship with the latter and this seems to stem from the pronounced low-frequency shifts in the level of inflation over most of the available data period. Appropriate ways to accounting for these shifts seems a precondition for obtaining reliable forecasts. The results of table 1 also suggest that leading indicator forecasts may be a rather unreliable guide to model selection, given a few technical issues that so far have not been investigated in detail.[5]

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Andrews, D. W. K. (1993), Tests for parameter instability and structural change with unknown change point, Econometrica 6(4), 821–56.

Leybourne, S. J. and P. B. McCabe (1994), A consistent test for a unit root, Journal of Business and Economics Statistics 12(2), 157–66.

[5] One important issue is the overlapping nature of the forecasts obtained from LI regressions. With using π_{t+h} as the dependent variable, the forecasts are necessarily subject to an MA(h) structure. This hampers the precision of parameter estimates and perhaps also of the RMSE statistcs. Such effect may become particularly severe in case of highly persistent series.

Corvoisier, S. and B. Mojon, B. (2005), Breaks in the mean of inflation: how they happen and what to do with them, ECB Working Paper 451.
Rünstler, G. (2002), The information content of real-time output gap estimates, ECB Working Paper 184.
Stock, J. and M. Watson (1999), Forecasting inflation, Journal of Monetary Economics 44(2), 293–335.

Evaluating Euro Exchange Rate Predictions from a Battery of Multivariate Models

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Abstract

We compare the accuracy of vector autoregressive and vector error correction models in forecasting the exchange rates of the euro (EUR) against the U.S. dollar (USD) and the Japanese yen (JPY) when using monetary and capital flows related variables. For the EUR/USD exchange rate monetary and capital flows models tend to outperform the random walk model for long-term predictions (more than six months), but fail to reject the test of equality of forecasting accuracy against the random walk model for all forecasting horizons but one. On the other hand, the best monetary model for the EUR/JPY exchange rate outperforms the random walk model on all horizons, and does so significantly for more than six months ahead. Models based on capital flow variables fail to beat the predictions of the random walk model for all forecasting horizons.
Keywords: Vector Autoregression; Cointegration; Forecasting; Exchange Rates.

1. Introduction

Exchange rate prediction is a subject of major interest for researchers and economic policy actors. The surprising result presented in Meese and Rogoff (1983), namely that exchange rate forecasts based on the random walk model outperform the predictions of theory-based and (both univariate and multivariate) time series models, gave rise to an ever-growing branch of literature aimed at finding econometric models which deliver good out-of-sample exchange rate forecasts. Hoque and Latif (1993), Liu *et al.* (1994), Finn (1986), MacDonald and

Taylor (1993), Boothe and Glassman (1987) or van Aarle *et al.* (2000) are, among many others, examples of this direction of research.

This paper presents the results of a systematic comparison of multivariate time series models in terms of the accuracy of out-of-sample point forecasts for the euro (EUR) against the U.S. dollar (USD) and Japanese yen (JPY) when using monetary and capital flows related variables. We use a collection of linear multivariate models which comprises the most important models used in the literature: unrestricted and restricted vector autoregressions (henceforth, VAR and RVAR, respectively) and vector error correction models (henceforth, VEC). Features of such an exercise are quite appealing, both as a source of knowledge about the insights of exchange rate determination and as a consulting instrument for portfolio choices in the increasingly globalized world economy.[1]

The structure of the paper is the following. Section two presents a brief exposition of the various multivariate specifications used throughout the paper. The results of the forecasting exercise for the euro against the U.S. dollar and the Japanese yen are presented and commented in section three, and section four concludes.

2. Forecasting Euro Exchange Rates

2.1 Analytical Framework

The variables used in the analysis are those suggested by the theoretical framework of the monetary model of exchange rate formation (for the original formulations, see Frenkel, 1976, Dornbusch, 1976 or Hooper and Morton, 1982). In our case, (logged) exchange rates (E_t) are put in relation with their own lagged values, lagged values of domestic and foreign (logged) money supply (M_t^d and M_t^f), domestic and foreign (logged) output − the data actually used is industrial production − (Y_t^d and Y_t^f), domestic and foreign short-term interest rates (R_t^d and R_t^f), and domestic and foreign long-term interest rates (π_t^d and π_t^f) in the form of a VAR model.[2]

Depending on whether relative or country-specific variables are used, we will differentiate between structural or unstructural models. An unstructural VAR (u-VAR) model is specified as

[1] Crespo Cuaresma and Hlouskova (2004) perform a similar exercise involving also Bayesian vector autoregressions for five Central and Eastern European currencies against the U.S. dollar and the euro.

[2] See Appendix for data characteristics and sources.

$$X_t = \psi(0) + \sum_{s=1}^{p} \psi(s) X_{t-s} + \varepsilon_t, \tag{1}$$

$$X_t = \left[E_t, M_t^d, M_t^f, Y_t^d, Y_t^f, R_t^d, R_t^f, \pi_t^d, \pi_t^f\right]',$$

$$\varepsilon_t = \left[\varepsilon_t^1, \varepsilon_t^2, ..., \varepsilon_t^9\right]' \sim NID(\vec{0}, \Sigma)$$

where $\psi(l)$ ($l = 1,..., p$) are (9×9) matrices of coefficients.

The structural VAR model (s-VAR) arises when imposing the restriction that the parameters corresponding to the domestic variables be equal in absolute value and contrary in sign to those of the corresponding foreign variable. The model specified in (1) can then be written as

$$Z_t = \omega(0) + \sum_{s=1}^{p} \omega(s) Z_{t-s} + \mu_t, \tag{2}$$

$$Z_t = \left[E_t, m_t, y_t, r_t, \pi_t\right]',$$

$$\mu_t = \left[\mu_t^1, ..., \mu_t^5\right]' \sim NID(\vec{0}, \Sigma_\mu),$$

where $m_t = M_t^d - M_t^f$, $y_t = Y_t^d - Y_t^f$, $r_t = R_t^d - R_t^f$, $\pi_t = \pi_t^d - \pi_t^f$, and $\omega(l)$ ($l = 1,..., p$) are (5×5) matrices of coefficients. Both the u-VAR and s-VAR models will be specified in levels or in differences (the latter will be denoted u-DVAR and s-DVAR), and the models in differences can be augmented by including one or more error correction terms among variables of the system, giving rise to the u-VEC and s-VEC models.

The monetary model rests on two important simplifying assumptions: (i) domestic and foreign assets are perfect substitutes (implying perfect capital mobility) and (ii) current account effects (surplus or deficit) are negligible. These assumptions could be relaxed if the possible role of capital flows in explaining exchange rate movements is taken into account (see Bailey et al., 2001 or Aliber, 2000). Thus, it might be possible to tie together movements in the exchange rates, the real interest rate, equity prices and current account balance. Rather than explicitly incorporating current account data in the model, we may choose to do so *implicitly* by using productivity figures. Current account dynamics are the result of changes in productivity. For instance, a positive productivity shock raises expected future output in the home country. This will tend to induce capital inflows for at least two reasons. On the one hand, if consumers in the home country expect to be richer in the future, they will want to borrow from abroad to increase their consumption today (in case that consumers are sufficiently forward-looking to smooth their consumption over present and future time periods). On the other hand, the expected increase in future productivity raises expected future profits, increasing equity prices, thereby stimulating investment demand; insofar the additional demand for funds to finance such investment is not available domestically, which causes inflows of capital (FDI and portfolio investment).

The VAR and VEC models with capital flow variables that will be evaluated in terms of forecasting ability include short and long-term interest rates, leading indicators, stock market indices and earnings. The vectors X_t and Z_t above are thus modified accordingly. For the sake of brevity we use the term *capital flows model* to denote this model class.

Unrestricted VAR models are known to forecast poorly due to their overfitting of parameters (see, e.g., Fair, 1979), therefore restricting linear combinations of the parameters in the VAR model to be equal to certain constants may result in improved forecasting features of the VAR model. Such restrictions may be imposed under the light of the available economic theory, as in the case of the structural models of exchange rate described above, or based on empirical grounds (in a similar way as, e.g., Kunst and Neusser, 1986). That is, an unrestricted VAR is estimated and insignificant lags of the endogenous variables are removed from the model specification. The class of estimated models where insignificant parameters have been removed will henceforth be denoted restricted VAR (RVAR).

2.2 Estimation and Forecasting Comparison

The forecasting exercise is carried out following a systematic procedure for all models and countries (see Appendix for the range and characteristics of the datasets).[3] Models in first differences and in levels are estimated for each class. The model selection concerning the number of lags to be included in the VAR specification is done by evaluating the AIC criterion for each lag length $l = 1,\ldots,8$ in the original estimation period and choosing the lag length with a minimum value of the information criterion. For the VEC models, the number of lags and error correction terms to be included is done by choosing the specification with a minimum AIC among all VEC models with lag length l ($l = 1,\ldots,8$) and all possible combinations of cointegration relationships in the original estimation period.

For the case of restricted models, the restrictions are imposed by setting to zero those parameters whose t-test statistic for parameter insignificance falls within the central 80% region of the t-distribution[4] in the estimated VAR specification for the original in-sample period.

The parameters of the model of interest are estimated for the available data up to 2000:12 (the periodicity of the data is monthly, and seasonally unadjusted series are adjusted using additive seasonality filters) and forecasts up to twelve months ahead are drawn from the estimated model. A new observation (the one corresponding to 2001:1) is added to the sample, the model is re-estimated, new forecasts are drawn from it and compared to realized values. This procedure is repeated until no usable observation is left. At this stage two statistics evaluating the forecast accuracy of the point forecasts of the model being studied (Root Mean Squared Error, RMSE, and Mean Absolute Error, MAE) are computed by comparing the forecasts with the actually realized values,

$$\mathrm{RMSE}(k) = \sqrt{\sum_{j=0}^{N_k-1} \frac{[F_{t+j+k} - A_{t+j+k}]^2}{N_k}},$$

[3] For each currency, the following models are estimated: u-VAR, u-RVAR, u-DVAR, u-RDVAR, u-VEC, s-VAR, s-RVAR, s-DVAR, s-RDVAR, s-VEC.

[4] This (unusual) level of significance was chosen after several experiments with lower significance levels lead to equations with too few regressors.

$$\text{MAE}(k) = \sum_{j=0}^{N_k-1} \frac{| F_{t+j+k} - A_{t+j+k} |}{N_k},$$

where $k = 1,...,12$ denotes the forecast step, N_k is the total number of k-steps ahead forecasts in the projection period for which the realized value of the exchange rate A_t is known, and F_t is the forecast value for the exchange rate.

The Diebold-Mariano test (Diebold and Mariano, 1995) will be used to compare the accuracy of forecasts against random walk predictions. When comparing two forecasts, the question arises of whether the predictions of a given model, A, are significantly more accurate, in terms of a loss function $g(\cdot)$, than those of the competing model, B. The Diebold-Mariano test aims to test the null hypothesis of equality of expected forecast accuracy against the alternative of different forecasting ability across models. The null hypothesis of the test can be, thus, written as

$$d_t = E\left[g(e_t^A) - g(e_t^B)\right] = 0 \qquad (3)$$

where e_t^i refers to the forecasting error of model i when performing h-steps ahead forecasts. The Diebold-Mariano test uses the autocorrelation-corrected sample mean of d_t in order to test for (3). If n observations and forecasts are available, the test statistic is, therefore,

$$S = [\hat{V}(\overline{d})]^{-1/2}\overline{d},$$

where

$$\hat{V}(\overline{d}) = \frac{1}{n}\left[\hat{\gamma}_0 + 2\sum_{k=1}^{h-1}\hat{\gamma}_k\right],$$

and

$$\hat{\gamma}_k = \frac{1}{n} \sum_{t=k+1}^{n} (d_t - \overline{d})(d_{t-k} - \overline{d}).$$

Under the null hypothesis of equal forecast accuracy, S is asymptotically normally distributed.

3. Results of the Forecasting Exercise

Tables 1 and 2 show the ratios of RMSE and MAE statistics of the best monetary and capital flows models (in terms of smallest average RMSE and MAE for the out-of-sample period considered) and the benchmark model (the random walk model) for the EUR/USD and EUR/JPY exchange rates. The results of the test of equal forecasting accuracy against the random walk model are included as well. The tables present the ratios of forecasting error for one to twelve months ahead, together with the ratio of the average prediction error for the period ranging from one to twelve months ahead. The column RMSE/RMSE(RW) [MAE/MAE(RW)] refers to the ratio between the root mean squared error (mean absolute error) of the model considered and that of a simple random walk model for the exchange rate. In all cases the best model chosen by minimizing average root mean squared error is the same, namely the restricted structured VAR model on differences (s-RDVAR).

The performance results of the EUR/USD exchange rate (see Table 1) using the monetary variables are not too convincing. The model fails to reject the null of equal forecast accuracy to the benchmark random walk model over all horizons when using both RMSE and MAE as loss functions. The random walk model actually outperforms the best monetary model over the two to six months horizon when using the RMSE as the loss function and over the three to six months horizon when using the MAE as the loss function. The forecasting performance when using the capital flows related variables is marginally better. When the RMSE is used as the loss function, the random walk model outperforms (albeit marginally) the best capital flows model only for five and six months ahead but for the rest the performance of the best model is not significantly better. On the other hand, when the MAE is taken as the loss function, the Diebold-Mariano test for forecasting horizons nine and ten months ahead is rejected at 10%. For the three to five months horizon the random walk model seems to outperform the best capital flows model and for the rest of horizons the best model outperforms the random walk model but not significantly.

The forecast performance of the best monetary model of the EUR/JPY exchange rate is more satisfactory. Taking the RMSE as the loss function, with exception of the one and two months horizon, the best monetary model outperforms the benchmark model significantly. More specifically, for the three and five months horizon the Diebold-Mariano test is rejected at 10%, for the four months horizon and from the six to ten months horizon the test for equal forecast accuracy is rejected at 5%, and for eleven and twelve months ahead the Diebold-Mariano test is rejected at 1%. In contrast, the forecast performance of the best capital flows JPY/EUR model is very poor. The random walk outperforms the best capital flows model on all horizons.

To summarize, the forecasting exercise delivers mixed results concerning the predictability of euro exchange rates. For the EUR/USD exchange rate monetary models tend to outperform the random walk model for long-term predictions (more than six months), but fail to reject the test of equality of forecasting accuracy against the random walk model for all forecasting horizons. On the other hand, the best monetary model for the EUR/JPY exchange rate outperforms the random walk model on all horizons and significantly for more than six months ahead. Models based on capital flow variables, on the other hand, tend to have worse predictive power than simple monetary models.

4. Summary and Conclusions

A battery of multivariate time series models has been compared to the naive random walk model in terms of forecasting accuracy in the prediction of the euro exchange rate against the U.S. dollar and the Japanese yen. The results partly confirm the conclusions in Meese and Rogoff (1983), namely that the random walk model performs as well as more sophisticated models of exchange rate determination for short-term predictions, including in this case VAR, VEC and restricted VAR models in different (structural and unstructural) specifications. For long-term predictions, however, multivariate time series models present clearly better forecasting accuracy than the simple random walk in the case of the monetary model for the EUR/JPY exchange rate, and marginally better forecasting accuracy in the case of the monetary and capital flows models for the EUR/USD exchange rate.

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Appendix: Data Sources and Characteristics

All time series have monthly periodicity (January 1980 to June 2004), and have been extracted from Thomson Financial Datastream. The variables used for EU-11, U.S.A. and Japan are:

- Money supply: M1 aggregate, indexed 1990:1=100. Seasonally unadjusted
- Output: Industrial production index 1990:1=100
- Short-term interest rate: 3-month interbank offered rate
- Long-term interest rate: 10-year rate interest rate on government bonds

- Leading indicator for Germany as a proxy for Europe: IFO Index
- Leading indicator for U.S.A.: ISM Index
- Earnings
- Stock market indices covering at least 80% of market capitalization in the respective country

*Table 1: Out-of-Sample Forecast Performance for USD/EUR: Best Monetary Model (Best Capital Flows Model) – RMSE and MAE. *(**)[***] Indicates Rejection of the Null Hypothesis of Equal Forecasting Accuracy at 10% (5%) [1%]*

U.S. dollar				
	Monetary model, s-RDVAR		Capital flows model, s-RDVAR	
Horizon	RMSE/RMSE(RW)	MAE/MAE(RW)	RMSE/RMSE(RW)	MAE/MAE(RW)
1 month	0.9382	0.9819	0.9642	0.9334
2 months	1.0055	0.9989	0.9856	0.9598
3 months	1.0413	1.0665	0.9967	1.0243
4 months	1.0505	1.0605	0.9935	1.0331
5 months	1.0468	1.0297	1.0018	1.0143
6 months	1.0270	1.0091	1.0015	0.9960
7 months	0.9872	0.9729	0.9748	0.9461
8 months	0.9608	0.9705	0.9467	0.9183
9 months	0.9556	0.9622	0.9363	0.9007*
10 months	0.9572	0.9601	0.9297	0.9082*
11 months	0.9538	0.9726	0.9250	0.9207
12 months	0.9583	0.9733	0.9362	0.9234
Average	0.9902	0.9965	0.9660	0.9565

Source: Authors' calculations.

*Table 2: Out-of-Sample Forecast Performance for JPY/EUR: Best Monetary Model (Best Capital Flows Model) – RMSE and MAE. *(**)[***] Indicates Rejection of the Null Hypothesis of Equal Forecasting Accuracy at 10% (5%) [1%]*

Japanese yen				
	Monetary model, s-RDVAR		Capital flows model, s-RDVAR	
Horizon	RMSE/RMSE(RW)	MAE/MAE(RW)	RMSE/RMSE(RW)	MAE/MAE(RW)
1 month	0.9865	0.9977	1.0114	1.0062
2 months	0.9540	0.9365	1.0388	1.0410
3 months	0.8763*	0.9086	1.0325	1.0535
4 months	0.8402**	0.8588	1.0699	1.0572
5 months	0.8218*	0.8453	1.1151	1.1215
6 months	0.7646**	0.8006	1.1401	1.1661
7 months	0.7198**	0.7378*	1.1486	1.1952
8 months	0.7112**	0.6888**	1.1629	1.1914
9 months	0.6632**	0.6176***	1.1675	1.1860
10 months	0.6346**	0.5794***	1.1794	1.1932
11 months	0.5930***	0.5179***	1.1984	1.1653
12 months	0.5522***	0.4789***	1.2077	1.1957
Average	0.7598	0.7473	1.1227	1.1310

Source: Authors' calculations.

Comment on "Evaluating Euro Exchange Rate Predictions from a Battery of Multivariate Models"

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Forecasting exchange rates – in particular – in the short run is a controversial issue, far from being settled. Various empirical exchange rate models which are dealt with in a huge number of empirical papers are not found to consistently outperform the random walk. So, although researchers occasionally claim that their model can beat the random walk, the scientific consensus today is that the results of the classical paper of Meese and Rogoff (1983) still stand. Another noteworthy conclusion from the empirical literature is that since the breakdown of Bretton Woods, exchange rates in general have become a lot more volatile. There is however no evidence that the fundamentals which are – according to the theoretical models – deemed to determine the value of the exchange rates have become more volatile during the same period. This is clearly the opposite to the predictions of the various models, indicating that exchange rate variability can only increase if the underlying fundamental volatility has also increased. Obviously, exchange rate volatility is – at least to a great extent – separated from the variability of the fundamentals, see for instance de Grauwe (2000). Obstfeld and Rogoff (2000) refer to this perception as one of the six major puzzles in international finance.

The economic theory behind the exchange rate forecasting exercise of the Institute for Advanced Studies, Vienna, is the monetary model of exchange rate determination (MM-model). The empirical methods are various forms of vector-auto-regressions (VARs). The theoretical framework and the empirical methods are extensively described in two papers, namely "Forecasting the Euro Exchange Rate Using Vector Error Correction Models" by van Arle et al. (2000) and "Forecasting Exchange Rates in Transition Economies: A comparison of multivariate time series models" by Cuaresma and Hlouskova (2004).Van Arle et al. (2000) estimate a sticky-price monetary exchange rate model in the form of a Vector Error Correction Model (VEC) of the Euro (EUR) against the U.S. dollar (USD), the British pound (GBP), the Japanese yen (JPY) and the Swiss franc (CHF). The variables used in the empirical analyses are nominal money balances, real output, nominal short-term interest rates and nominal long-term interest rates, serving as a proxy for inflation expectations. The authors furthermore produce out-of-sample exchange rate forecasts, investigating periods from January 1994 to February 1999, with the forecasting horizons from one to twelve months. The performance of the various forecasts is measured by the ratio of the Root Mean Squared Error (RMSE) and the Mean Absolute Error (MAE) of the best model against alternative models, including as the "true" benchmark, the random walk (RW). The forecasting model is –to some extent – able to beat the random walk for the EUR/USD and the EUR/GBP exchange rate. For the EUR/JPY and the EUR/CHF spot rate, the best forecasting models do not outperform the RW-model.

Cuaresma and Hlouskova (2004) compare the accuracy of five different VAR-models in forecasting five Central and Eastern European currencies (Czech koruna, Hungarian forint, Polish zloty, Slovak koruna, and Slovenian tolar) against the EUR and the USD. The forecasting horizons range from one to twelve months. The Slovenian tolar/euro rate is the only rate, being able to outperform the random walk model.

Summing up the forecasting results of the two papers: The sticky-price monetary exchange rate model has some out-of-sample forecasting power (in the short run), though not in a consistent way. The results differ from country to country and from forecasting period to forecasting period.

These rather disappointing results may have various reasons. The first may be the time horizon. Forecasting exchange rates for a period of one to twelve months may be too short to obtain (reliably) significant results, given that the MM-model is a long-run exchange rate model. In general, most of the empirical exchange rate studies, investigating the monetary models of exchange rate determination over the floating exchange rate period have found no support for these theoretical models. Opposing to what the long-run MM-models ask for, no evidence for a co-integrating relationship between the exchange rate and various monetary fundamentals could be established. Moreover, even in the minor cases, where co-integration has been found, little support is detected found for the predictions of the MM-model. Coefficients had wrong signs or were simply insignificant. This is not too surprising, since the long-run purchasing power parity, one of the major building blocks performs poorly on a country-by-country basis, in particular at shorter horizons. Furthermore, another important building block, the uncovered interest rate parity (UIP) is typically rejected by empirical evidence, mainly as the forward rate is generally not conceived to be an unbiased predictor of future spot rates.

Moreover, MM-models might suffer from omitted variables. One of these omitted variables could be home and foreign country wealth variables, such as the government debt to GDP ratio or net foreign asset ratios. Such variables typically enter into another kind of exchange models, the "behavioural equilibrium exchange rate" (BEER) approach. Models like the BEER and related models, like the NATREX, have gained considerable importance in the context of policy issues for intermediate horizons. The BEER approach, for instance, is frequently used to determine the long-run value of the euro. Clostermann and Schnatz (2000) for instance, identify four fundamental factors, driving the real exchange rate of the EUR/USD exchange rate, which are the international real interest rate differential, relative prices in the traded and non-traded goods sectors, the real oil price and the relative fiscal position. They also perform forecasts from one to eight quarters, showing that their single equation error correction model is able to outperform the benchmark random walk model.

Other reasons, why the monetary exchange rate models have performed rather poorly in the empirical literature are:

Simultaneity problems. It is questionable, whether all variables on the right hand side of the forecasting equations are exogenous. A change in money supply for instance, is assumed to influence the exchange rate. However, if the central bank intervenes to influence the spot rate without sterilization, the money supply changes. Similarly, real income may also be affected by the exchange rate.

Lack of taking into account nonlinearities. In case, exchange rates are influenced or determined by economic fundamentals and in doing so, in a nonlinear form, the formulation of a linear model would clearly lead to a misspecification of the empirical model.

Parameter instability. Most of the empirical studies cover a long period of investigation and only very few test for structural breaks.

Turning to the econometric method applied, VARs have the distinct advantage that they are not only able to cover the long-run properties of the MM-model but are also able to capture short run exchange rate dynamics. In general it is well known that VARs do a good job in data description and forecasting, see for instance Stock and Watson (2001). Two other tasks, VARs are used for structural inference and policy analysis are much more difficult to fulfil, since they require to solve the identification problem. Solving the identification problem, the researcher is enabled to differentiate between correlation and causation and thereby enabled to interpret correlation causally. What is also well known is that in order to produce good forecasting results, VAR forecasting systems should on the one hand contain at least three or four variables and on the other hand allow for time varying parameters to capture important drifts in the coefficients. An increase in the variables, however, makes it a lot more difficult to obtain reliable estimates of all coefficients without further restrictions. One way to tackle this problem is to impose a common structure on the coefficients by using for example Bayesian methods which, however, is covered by the empirical models, applied by the Institute for Advanced Studies, at least in the paper on the exchange rates of the five transition countries.

One alternative empirical route that could be followed, when forecasting for instance the EUR/USD exchange rate especially for shorter horizons, is to take account of possible nonlinearities between exchange rates and fundamentals and examine the MM-model in a context of time-varying coefficients using a Markov switching approach.

Finally, two further suggestions for forecasting for instance the EUR/USD or EUR/JPY exchange rates could possibly be improved are:

The first suggestion concerns the data, being used in the forecasting exercises: Most of the exchange rate forecasting experiments in the empirical literature are based on revised macroeconomic data. Nevertheless, it is well known that data revisions can have large effects on the fundamentals, for instance on GDP figures. Recently, in particular in the fields of monetary economics, a new growing strand has emerged in literature. It suggests that analysis working with real-time data frequently results in substantially different conclusions than work based on revised data. Indeed, it is conceivable that we would possibly get a much different picture of exchange rate movements, if information or data are used which were actually available to agents at a particular point in time in the past. Faust et al. (2003), for instance, examine the real-time forecasting power of standard exchange rate models of several currencies (JPY, DEM, CAD and CHF) against the USD. The authors conclude that the predictive power of the exchange rate models used is uniformly better using real time data than using ex-post revised data.

The second and last suggestion refers to the estimation technique: As empirical exchange rate models performed rather poorly in forecasting spot rates on a country-by-country basis, why not turn to panel tests that pool data across countries? In this context, I would like to refer for instance to a paper by Rapach and Wohar (2002). The authors show that in contrast to country-by-country analysis, there is substantial support for the monetary model using panel tests. Moreover, comparing forecasts undertaken on a country-by-country basis versus panel forecasts, they show that panel estimates generate superior out-of-sample exchange rate forecasts. This suggests that panel estimates of the monetary model are more reliable than country-by-country analysis.

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MULTIMAC IV: A Disaggregated Econometric Model of the Austrian Economy

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1. Introduction

MULTIMAC IV is the current stage of the input-output based macroeconomic model of WIFO (Austrian Institute of Economic Research). Former versions of the model have been laid down in Kratena (1994) and Kratena and Wüger (1995). This version (MULTIMAC IV) is characterized by a full description of quantity and price interactions at the disaggregated level.

MULTIMAC IV is input – output based at a medium aggregation level of 36 industries and combines econometric functions for goods and factor demand, prices, wages and the labour market with the input-output accounting framework. In that sense MULTIMAC IV is oriented along the same lines as other large scale macroeconomic input-output based models like the INFORUM model family (Almon, 1991) and the European multiregional model E3ME (Barker, et. al. 1999). Compared to these fully specified models MULTIMAC IV has important shortcomings in the modelling of external trade, where exports are fully exogenous and only import functions exist. MULTIMAC IV shares with the two mentioned models the emphasis on econometrics, i.e. on parameter values derived by using historical data in statistical methods opposed to the CGE philosophy of restricting parameters and calibrating for some base year.

On the other hand an important advantage of CGE models is the consistent derivation of functional forms from microeconomic theory, which implies certain restrictions concerning the links between variables. This is for example the case for factor demand and output prices, where CGE models usually start from production or cost functions in a certain market form (usually but not necessarily perfect competition), from which factor demand and output prices can be derived simultaneously.

MULTIMAC IV tries to combine the advantages of econometric techniques with consistent microeconomic functional forms and uses specifications derived from well known microeconomic concepts. In general the functional forms chosen in MULTIMAC IV from microeconomic theory are those with a minimum of necessary *a priori* restrictions.

MULTIMAC IV consists of three main blocks for factor demand, goods demand and the labour market. In between these model blocks some small model elements are built in for the intermediate demand prices and for income generation. Input – output analysis plays an important role at the price side as well as on the goods demand side and in both cases the phenomenon of changing input – output structures is treated with.

Chart 1: The Block Structure of MULTIMAC IV

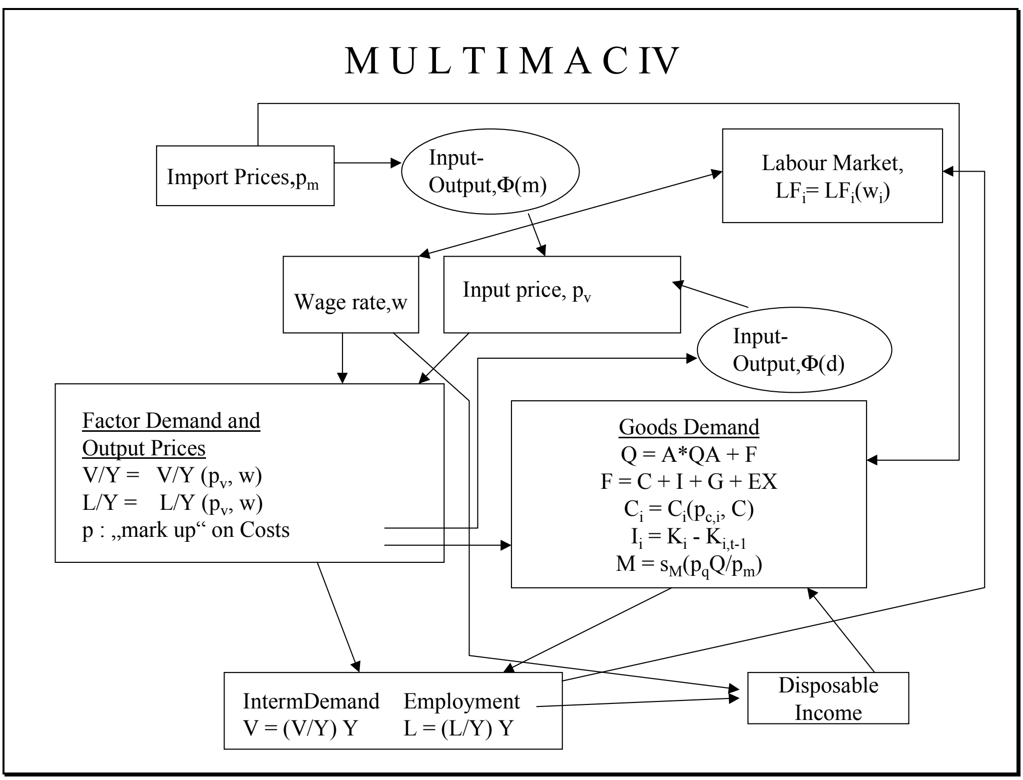

Table 1: The 36 Industry Structure of MULTIMAC IV

	Model Industry	NACE 2-digits
1	Agriculture, Forestry and Fishing	1,2,5
2	Mining of Coal and Lignite	10
3	Extraction of Crude Petroleum and Natural Gas	11
4	Gas Supply	
5	Manufacture of Refined Petroleum Products	23
6	Electricity, Steam and Hot Water Supply	40
7	Collection, Purification and Distribution of Water	41
8	Ferrous & Non Ferrous Metals	27
9	Non-metallic Mineral Products	13, 14, 26
10	Chemicals	24
11	Metal Products	28
12	Agricultural and Industrial Machines	29
13	Office Machines	30
14	Electrical Goods	31, 32
15	Transport Equipment	34,35
16	Food and Tobacco	15, 16
17	Textiles, Clothing & Footwear	17, 18, 19
18	Timber & Wood	20
19	Paper	21
20	Printing Products	22
21	Rubber & Plastic Products	25
22	Recycling	37
23	Other Manufactures	33, 36
24	Construction	45
25	Distribution	50, 51, 52
26	Hotels and Restaurants	55
27	Inland Transport	60
28	Water and Air Transport	61, 62
29	Supporting and Auxiliary Transport	63
30	Communications	64
31	Bank, Finance & Insurance	65, 66, 67
32	Real Estate	70, 71
33	Software & Data Processing	72
34	R&D, Business Services	73, 74
35	Other Market Services	92, 93, 95
36	Non-market Services	75, 80, 85, 90, 91
37	Statistical Differences	

2. The Database of MULTIMAC IV

In order to provide a brief overview of the database of MULTIMAC IV, this section deals with the following three aspects. First the sources and compilation methods for the time series data in the model will be described. This is followed by the introduction of the Input-Output(IO)-table incorporated in the model. And finally the derivation of the devices that link these two data bases, mainly bridge matrices, is outlined. The level of industrial classification adopted in the model comprises 36 sectors plus one sector capturing statistical differences (e.g. between National Accounts and the Input-Output table). The classification along with the corresponding 2-digit NACE industries (respectively ÖNACE, which is the slightly modified NACE classification used by Statistik Austria) can be taken from table 1 below.

2. Time Series Data

A notable difference between MULTIMAC IV and its predecessors is that the data base of the time series in MULTIMAC IV complies with the new standards of the ESA 1995. The first annual data at the industry level satisfying the new standards became available by Statistik Austria (St. At.) (2000b). These time series comprise various economic indicators and run from 1988 through 1999. Most of them are available on a 55 industry level (roughly corresponding to the 2-digits of the NACE classification), although there are some important exceptions, as will be outlined below. Clearly, the compilation of an econometric model such as MULTIMAC would not be feasible with time series featuring only 12 observations. Whenever possible the time series were extended back to 1976, mainly with the help of series from former versions of the model based on National Accounts for Austria according to the concept of ESA 1979.

The variables of interest for MULTIMAC IV, their sources and the various adjustments applied to those series are briefly described in the following subsections.

2.1.1 Data on GDP, Value Added, Intermediate Demand, Wages and Employment

This section will explore the derivation of the most detailed time series available for the computation of MULTIMAC IV. The data on *GDP*, *Value Added* and *Intermediate Demand* that comply with the standards of ESA 1995, all are available on a 55 industry level from 1988 through 1999 for both nominal and real values (at constant prices of 1995). Moreover, for all these variables time series of previous versions of MULTIMAC IV in the old system of ESA 1979 exist over the time period of 1976 to 1997 based on a former data base of National Accounts from St. At. but also in 55 NACE based classification .

The growth rates of new and old data on the series under consideration were used to extend the former back from 1988 to 1976. In order to keep aggregation-biases as low as possible, the computations were undertaken on the 55 industry level and aggregation to the 36 industries of the model was accomplished thereafter. These computations were conducted for both nominal and real values of the series, which in addition enabled the derivation of the respective price indices (with 1995 as their base year).

Time series on *employment* and *wages/salaries* at the industry-level underwent the same procedure that was just outlined as far as enlargement of the time series back to 1976 is concerned. The series of these data from 1976 to 1997 were in the former industrial classification of Austrian statistics (Betriebssystematik 1968) and in a first step had to be converted into NACE classification. This was done using the full census of the Austrian economy for 1995 (Nicht-Landwirtschaftliche Bereichszählung) with data in both classifications for NACE 3 digit industries and special studies by Austrian Social Insurance Association (Hauptverband der Sozialversicherungsträger) on data in both classifications for the base year 1995.

Time series on *unemployment* by industries are available from Unemployment Insurance Offices and were used to calculate sectoral *labour force* and *unemployment rates*. These data range from 1987 to 2000 and had also to be converted from former industrial classification of Austrian statistics (Betriebssystematik 1968) to NACE.

2.1.2 Data on Imports, Exports and Investment

As opposed to the first block of data described above, the situation with data on foreign trade and investment is less favourable.

The most comprehensive database available for *imports and exports* is maintained by the WIFO itself, and is based on the External Trade Statistics (Außenhandelsstatistik 1988–1995). The 6-digit commodities of external trade had been converted to PRODCOM and the further to NACE to arrive at time series from 1989 to 1999 for values and volumes. Given this information, unit values of imports and exports were computed based on the 3-digit level in order to derive the corresponding price index of the nominal series[1]. Aggregating up to the classification maintained in MULTIMAC IV resulted in an approximation for the

[1] Note that the computation of the unit values is conducted on the 3-digit level and is therefore necessarily imprecise since we are assuming here that each 3-digit good has the same weight. During the computation-process a correction for outliers has been performed.

series of nominal and real imports and exports as well as the corresponding price indices for the manufacturing sectors.

For services currently no time series are available on a disaggregated level. Hence, we applied the overall growth rates of imports and exports of service goods (which is available from National Accounts) uniformly to every service sector based on the disaggregated values of the IO-table 1990 to arrive at least at a rough approximation of those series. Information on import prices was completely unavailable, so those had to be approximated by the corresponding domestic price index[2].

The situation for *investment* is slightly different than the one for foreign exchange data in that there are time series from 1988 to 1999 for a total of 12 sectors available. Those sectors correspond roughly to the one-digit industries of ÖNACE 1995, which essentially means that services on the one hand are well captured but that manufacturing one the other hand is treated as a single sector only. The time series are readily available for both nominal and real values, hence a corresponding price index (base 1995) is easily computable. The investment data have been used together with the estimated sectoral capital stock by WIFO for 1987 to construct capital stock data following the perpetual inventory method (s.: Czerny, et al. (1997)). For this purpose the following parameters had to be chosen: (i) the sectoral depreciation rate and (ii) the long-term ('equilibrium') growth rate of investment. That allows to calculate the active and the reserve capital stock starting from a given value in t = 0.

Besides the fact that data on both foreign trade and investment are not available for each sector of MULTIMAC IV, it must also be noted, that at the moment there are no possibilities to extend those time series backward (as was the case with data described in the first section above). Therefore MULTIMAC IV has to deal with very short series in these groups which is a considerable shortcoming of the model in its current version.

2.1.3 Public and Private Consumption

Data on *public consumption* on the industry-level are not available for the time being. Hence we proceeded along the lines described earlier in connection with foreign trade data for service sectors. That is, the sectoral values of the IO-table for 1990 (in 1995 prices) are updated using the aggregate growth rate of real public consumption as given by the National Accounts. This results in a series of real public consumption ranging from 1988 to 1999 for three distinct sectors (since there are only three sectors in the classification of MULTIMAC IV that provide

[2] Note, however, that - as will be described later - imports of service good swill remain exogenous in MM IV, and import
prices are only used to re-base the IO-table of 1990 to prices of 1995.

public goods) plus the statistical difference between the IO-table and National Accounts. Since public consumption is treated as exogenous in MULTIMAC IV, it enters the model solely when it comes to determine total real final consumption, and hence no nominal values or price indices are needed.

The most recent data on *private consumption* are taken from National Accounts which provides annual values from 1988 through 1999 on a 5-digit level (corresponding to 225 different types of consumption goods) of the respective classification. Again, those time series could be extended backward making use of older series from the ESA 1979. However, the classification code of National Accounts has changed with the introduction of the ESA 1995, complicating the comparison of the two classifications below the 2-digit level (which comprises 12 groups). The most disaggregate level achievable for applying the growth rates turned out to be 21 groups. Eventually it was decided to incorporate 20 groups within MULTIMAC IV which can be taken from table 2 below.

Table 2: Consumption Categories in MULTIMAC IV

1 Food, Drink and Tobacco
2 Clothing and Footwear
3 Gross Rent and Water
4 Transport
    4.1 Cars
    4.2 Petrol,
    4.3 Public Transport
    4.4 Other Transport
5 Communication
6 Other Services
    6.1 Medical Care
    6.2 Entertainment
    6.3 Education
    6.4 Restaurants, Hotels
7 Other Goods and Services
8 Heating
    8.1 Electricity
    8.2 Gas
    8.3 Liquid Fuels
    8.4 Coke
    8.5 Biomass
    8.6 District Heating
9 Furniture

Since both nominal and real data are available we can compute a price index and end up with time series from 1976 to 1999.

2.1.4 Other Data

Other data utilized in MULTIMAC IV comprise the following series:

- Total disposable income in real terms as given by National Accounts
- Population, subdivided in both male and female population
- Labour force, in total and in the disaggregation of the labour market – block of the model (see section 6 for a description of those sectors)
- Variables taken from DAEDALUS, the energy-model of WIFO, which are treated as exogenous in MULTIMAC IV
- Data on housing stock
- Data on the depreciation rates of capital stock the 12 sectors for which investment data are available

All these series are treated as exogenous in MULTIMAC IV (disposable income is ‘quasi-exogenous’ in that it depends on an exogenous fraction of total value added) and are therefore given for the entire historical time period as well as the forecasting period of the model (i.e. from 1976 to 2010).

2.1.5 Variables Derived via Definitional Equations

Given the stock of data from sections 1.1 to 1.4, it is possible to compute a large set of variables using definitional equations. Among those variables are total demand (domestic demand plus imports), wage rates, total final demand and many more.

Note that whenever time series of shorter length (such as data on foreign trade) are involved in the computation of the variables just mentioned also the compounds will be running over the short period only, which of course limits the capability to use these series in regression equations.

2.2 The Input-Output Table 1990

At the time of the preparation of the database of MULTIMAC IV the most recent Input-Output table published for Austria dated back to the year 1990 (Statistik Austria, 2000a). The IO-table for 1995 became available by Statistik Austria in July 2001, its incorporation in the model is left over for future versions of the model. The 1990–table in use in the current version of the model is in NACE classification and is therefore – at least as far as the sectoral classification is concerned – directly compatible to the time series data used in the model. It must be noted however, that this table is not fully consistent with the ESA 1995 (which is for the first time achieved in the IO-table 1995). The table itself is set up according to the Make-Use framework and distinguishes between imported and domestic goods in the intermediate consumption and in the final demand matrix.

In order to incorporate the IO-table in the model two steps had to be carried out. First, the table had to be based on prices of 1995, the base year of MULTIMAC IV. This was accomplished at the most disaggregated level possible given the various constraints on prices, which in most cases were available for 55 industries (as opposed to 73 industries in the IO-table).

The second step involved the aggregation of the IO-table on the 36 industries structure of our model. Statistical differences between the values of the resulting IO-table and data from National Accounts are absorbed by an additional sector 37. In this way the complete Input-Output framework is made consistent with the data from National Accounts.

2.3 Bridge Matrices Linking the IO-Table with National Accounts Data

In order to link the time series of National Accounts data with the IO-table two 'bridge matrices' for consumption and investment had to be set up.

To illustrate this more thoroughly, consider the modelling block of private consumption. As will be described in section 5.1, the demand from the 20 categories of private consumption is modelled using simultaneous models or single equations and the groups are then summed up to nine main categories. The task is then to determine which sectors of the economy satisfy this demand. To be able to do this, one has to 'translate' the demand of the nine consumption categories (a classification that follows the National Accounts) into demand for goods of the 36 sectors of the model. For the case of private consumption, this is achieved by setting up a matrix that links the nine consumption categories with the 36 sectors of the model such that multiplying the consumption vector with this matrix yields the demand for goods in the 36 industry-structure of MULTIMAC IV.

These matrices are usually computed by using information from the year 1990, since in that year private consumption is available in both the 36 industry structure as well as the 9 groups of National Accounts, that is in 1990 we have information on the column and row sums of the matrix we wish to create. Further information to fill in the cells of the bridge matrix from input – output statistics comprise trade and transport margins and effective value added tax rates by commodity. Due to a lack of data, the structure of this matrix has to be kept the same throughout the entire time period if MULTIMAC IV and treated as constant.

In finishing the description of that database a brief prospective of future efforts dealing with the extension of the database can be made. First and foremost the shortage of the time series of foreign trade turned out to cause problems in several modelling steps, since it restricted the length of some very important variables that are derived from definitional equations. This is especially true when it comes to update the Input-Output coefficients via an equation for total intermediate demand, as will be described in section 4 below. Secondly the incorporation of the new IO-table 1995 into MULTIMAC will be an issue in the near future.

3. Input Demand and Output Prices

Industrial organizations literature generally treats price setting behaviour of firms in an overall model of goods and factor markets. The seminal paper for this approach is Appelbaum (1982), a recent empirical application for various industrial sectors in Austria can be found in Aiginger, Brandner and Wüger (1995). Besides that, numerous studies that deal with factor demands derived from cost functions additionally include a price equation, which is estimated simultaneously with the factor demand equations in one system.

Important examples for this line of research mainly using the flexible cost functions 'Translog' and 'Generalized Leontief' are Berndt and Hesse (1986), Morrison (1989, 1990), Meade (1998) and Conrad and Seitz (1994). The price setting equations combined with the factor demand equations differ in these studies. Some start from the assumption of perfect competition, so that prices equal marginal costs as is the case in Berndt and Hesse (1986), Morrison, (1989, 1990) and Meade (1998). An example for a 'mark up pricing' equation combined with factor demand corresponding to the market form of monopolistic competition can be found in Conrad – Seitz (1994).

Especially for the Generalized Leontief – cost function, which was first proposed by Diewert (1971), different concepts to allow for both technical progress variables and fixed factors have been developed. Morrison (1989, 1990) suggested an extension by technical progress and fixed factors with variable factors and the fixed factor capital, which has been proposed for the US INFORUM model by Meade (1998). Empirical results from estimations of Generalized Leontief – cost functions for several Austrian industries including technical progress as well as capital as a fixed factor can be found in Kratena (2000).

In MULTIMAC IV a simple form with only an extension for technical progress is chosen where the variable factors are the inputs of intermediate demand of an industry, V, with price p_v and labour input L with wage rate w, and a deterministic trend t representing technical progress. The price p for gross output QA shall be determined by a constant mark up μ n variable costs as in Conrad and Seitz (1994), which corresponds to the model of monopolistic competition in the markets. At perfect competition the price would equal marginal costs (p=MC) like in Berndt and Hesse (1986) and Meade (1998). Starting point is the (short-term) cost function for variable costs G:

$$(1) \qquad \mathrm{G} = \mathrm{QA}\left[\sum_i \sum_j a_{ij} \left(p_i p_j\right)^{1/2} + \sum_i d_{it} p_i t^{1/2} + \sum_i g_{tt} p_i t\right],$$

with p_i, p_j as the input prices of the variable factors.

Applying Shephard's Lemma we can derive factor demands, since the partial derivatives of (1) with respect to factor prices (p_v , w) yield the input quantities (V, L) :

$$(2) \qquad \frac{V}{QA} = \alpha_{VV} + \alpha_{VL}\left(\frac{w}{p_V}\right)^{1/2} + \gamma_{Vt} t^{1/2} + \gamma_{tt} t \ ,$$

(3) $$\frac{L}{QA} = \alpha_{LL} + \alpha_{VL}\left(\frac{p_V}{w}\right)^{1/2} + \gamma_{Lt}t^{1/2} + \gamma_{tt}t\ .$$

During estimation of (2) and (3) we assume symmetry concerning α_{VL} (i.e., $\alpha_{VL} = \alpha_{LV}$) and restrict one of the parameter for technical progress (γ_{tt}) to be the same in both factor demand equations. Due to data limitations the demand for total intermediates (i.e. from domestic and imported sources) is treated here as one input demand equation, which is an important shortcoming of MULTIMAC IV. The assumption of perfect competition in the markets would imply that prices equal marginal costs ($p = \partial G/\partial QA$). Instead a fixed mark up μ on marginal costs is introduced representing the model of monopolistic competition. As an alternative one could work with a variable mark up $\mu_{.}$ set on marginal costs implicitly including the ‚conjectural variations' of the oligopolistic model (see e.g. Aiginger, Brandner and Wüger (1995)). This variable mark up then would depend on the competitive price (which is usually approximated by the import price p_m) and the input prices p_v and w. Marginal costs $\partial G/\partial X$ for our case are given as:

(4) $$\partial G/\partial QA = \alpha_{VV}p_v + \alpha_{LL}w + 2\alpha_{VL}(p_v w)^{1/2} + \delta_{vt}p_v t^{1/2} + \delta_{Lt}wt^{1/2} + \gamma_{tt}(p_v + w)t$$

Hence, when applying a fixed mark up we get the following output price equation:

(5) $$p = [1 + \mu]\ [\alpha_{VV}p_v + \alpha_{LL}w + 2\alpha_{VL}(p_v w)^{1/2} + \delta_{vt}p_v t^{1/2} + \delta_{Lt}wt^{1/2} + \gamma_{tt}(p_v + w)t\ ].$$

This completes the system of equations – composed of (2), (3), and (5) – that will be applied in estimation. From the Generalized Leontief – cost functions one can derive cross- and own price elasticities. As microeconomic theory states that the compensated price elasticities must sum up to zero, we get for our 2 factor model: $\varepsilon(LL) = -\ \varepsilon(LV)$ and $\varepsilon(VV) = -\ \varepsilon(VL)$. Elasticities can be directly derived from the input – output equations (2) and (3), where the inputs of V and L are functions of input prices w and p_v. This gives for cross- and own - price elasticities:

(6) $$\varepsilon(LL) = -\ (\alpha_{VL}/2)\ (Y/L)\ (p_v/w)^{1/2}$$

$$\varepsilon(VV) = -\ (\alpha_{VL}/2)\ (Y/V)\ (w/p_v)^{1/2}$$

$$\varepsilon(VL) = (\alpha_{VL}/2)\ (Y/V)\ (w/p_v)^{1/2}$$

$$\varepsilon(LV)= \quad (\alpha_{VL}/2)\,(Y/L)\,(p_v/w)^{1/2}$$

Using the seemingly unrelated regression (SUR) estimation procedure, systems of equations as specified in (2), (3), and (5) have been etimatedor all industries of MULTIMAC IV except the energy sectors 2 through 6 (see section 1, table 1 for a description of the model's industrial classification). For 6 industries, however, we were not able to derive significant negative own price elasticities out of the system estimates and therefore unrestricted and freely specified functions similar to (2), (3), and (5) were applied to those sectors. Table 3 shows the resulting own price elasticities for both factor demands, where elasticities derived from freely specified models are marked with an asterisk (cross price elasticities are simply minus the own price elasticities, as both have to sum up to zero). Note, however, that the cross price was not included in the estimation of the freely specified industries and that hence the summation restriction of own and cross price elasticities does not hold for those sectors.

All of the elasticities in table 3 are evaluated at the sample means, whenever dynamic models were estimated (which can only be the case for the freely specified sectors) the long-run elasticities are reported in table 3. The results show important differences concerning the impact of factor prices on factor demand across industries. The sample mean of the time varying elasticities turns out to be in general rather low and significantly below unity. The exceptions are Mining of Coal and Lignite, Software&Data Processing and Other Market Services where factor demand is very elastic.

This model block of MULTIMAC IV determines labour demand and total intermediate demand for given input prices of both factors and for a given output level. Employment therefore changes uniformly with output, if no changes in input prices occur. Feedback mechanisms are built in by changes in the intermediate demand price through output price changes and by wage rate adjustments due to changes in the labour market.

Table 3: Own Price Elasticities of Factor Demand (Intermediates (V) and Labour (L)

	Model Industry	Intermediates	Labour
1	Agriculture and Forestry	–0.7303*	0*
2	Mining of Coal and Lignite	–1.0104*	exogenous
3	Extraction of Crude Petroleum and Natural Gas	0*	exogenous
5	Manufacture of Refined Petroleum Products	0*	exogenous
6	Electricity, Gas, Steam and Hot Water Supply	–0.1336*	exogenous
7	Collection, Purification and Distribution of Water	–0.2031*	exogenous
8	Ferrous & Non Ferrous Metals	–0.4909	–0.1928
9	Non–metallic Mineral Products	–0.3483	–0.1829
10	Chemicals	–0.1288	–0.0426
11	Metal Products	–0.3973	–0.2464
12	Agricultural & Industrial Machines	–0.515	–0.2824
13	Office Machines	–0.346	–0.0879
14	Electrical Goods	–0.3299	–0.1937
15	Transport Equipment	–0.6767	–0.2315
16	Food and Tobacco	–0.2244*	0*
17	Textiles, Clothing & Footwear	–0.7118	–0.3262
18	Timber & Wood	–0.1217	–0.0438
19	Paper	–0.131	–0.0381
20	Printing Products	–0.616	–0.3844
21	Rubber & Plastic Products	–0.0051	–0.0023
22	Recycling	–0.2538*	0*
23	Other Manufactures	–0.4832	–0.2836
24	Construction	–0.2229	–0.1503
25	Distribution	–0.3426	–0.3367
26	Hotels and Restaurants	–0.2934*	0*
27	Land Transport	–0.0462	–0.0743
28	Water and Air Transport	–0.6810*	0*
29	Supporting and Auxiliary Transport	–0.5872*	0*
30	Communications	–0.0014	–0.0054
31	Bank. Finance & Insurance	–0.2401	–0.3593
32	Real Estate	–0.667	–0.1214
33	Software & Data Processing	–1.0346	–0.9698
34	R&D, Business Services	–0.1595	–0.1204
35	Other Market Services	–1.2129	–1.4132
36	Non–market Services	–0.0623	–0.1274

Source: Authors' calculations.

4. Import Prices and Input Prices

The price of intermediate demand an industry faces in MULTIMAC IV is determined by the output prices of the other industries in the home country and abroad as described in the traditional input – output price model. In the input – output price model for given technical coefficient matrices for domestic and imported inputs the vector of domestic prices (**p**) is determined by domestic output prices themselves (**p**) and the vector of import prices ($\mathbf{p_m}$):

$$(7) \qquad p = p\,A(d) + p_m\,A(m) + w\,L/QA + c$$

where **c** is a vector of residual income and **w L/QA** is labour cost per unit of output as before in vector notation. Here the technical coefficients matrix is split up into a domestic (**A(d)**) and an imported (**A(m)**) matrix.

From input – output tables we know, that total intermediate demand of industry i, V_i , equals the sum of inputs produced by other domestic industries ($V_{ji}(d)$) and imported inputs ($V_{ji}(m)$):

Industry (i,j)

$$\begin{array}{cccc}
 & 1 & \ldots\ldots\ldots\ldots & n \\
1 & & & \\
. & & & \\
. & & V_{ji} & \\
. & & & \\
n & & & \\
\Sigma & V_1 & \ldots\ldots\ldots\ldots & V_n
\end{array}$$

The input coefficient along the column of an industry (V_i/QA_i), which was modelled in the last section with the help of the Generalized Leontief – function, is given as the total of the two column sums for *i* of technical coefficient matrices (derived from input – output tables) for domestic and imported goods (**A(d)** , **A(m)**).

From the traditional input – output – price model we can now write the intermediate input coefficient at current prices ($\mathbf{p_v V/QA}$) as a matrix multiplication of a row vector of domestic prices **p** and a row vector of import prices $\mathbf{p_m}$ with **A(d)** and **A(m)** to get the row vector $\mathbf{p_v V/QA}$:

$$(8) \qquad (\mathbf{p_v V/QA}) = (\mathbf{p_m\,A(m) + p\,A(d)})$$

In analogy to that we can introduce the input – output level of disaggregation in the factor demand equations described in the last section by treating the column sum

V/QA as a bundle of n inputs. Assuming a constant structure for the n inputs within **V/QA** given by matrices **Z** with elements Vji/Vi each for domestic (d) and imported (m) inputs, $\mathbf{p}_v$ becomes:

(9) $\mathbf{p}_v = (\mathbf{p}_m \mathbf{Z(m)} + \mathbf{p}\ \mathbf{Z(d)})$

This relationship now introduces the feedback of output price changes on output prices. Equation (9) solves exactly for the input – output years, in other years the price index of National Accounts for $\mathbf{p}_v$ may deviate from the value calculated with (9) using fixed matrices of the base year for **Z(m)** and **Z(d)**. With fixed matrices **Z** derived from the IO-table 1990 and time series (1976 – 1994) of the vectors **p** and $\mathbf{p}_m$ we constructed a 'hypothetical' vector of intermediate demand $\mathbf{p}_v^H$ according to (9). The actual price index of National Accounts ($\mathbf{p}_v$) and the price – index $\mathbf{p}_v^H$ intersect at t = 1990, and have different mean growth rates. This different growth rates simply reflect the actual change in matrices **Z** due to technical change. Both series $\mathbf{p}_v$ and $\mathbf{p}_v^H$ are at least difference stationary and the question is, if a stable (long-run) relationship between the first differences of both series exist. To implement that, the following simple regressions for first differences have been estimated with u_t as the residual with the usual statistical properties:

(10) Δpv,t = a0 + a1ΔpHv,t + ut

where Δ is the first difference operator. Including these equations in MULTIMAC IV gives an endogenous price of intermediate demand with exogenous import prices $\mathbf{p}_m$ and exogenous intermediate demand structures given by fixed matrices **Z**.

5.Total Demand and Input – Output Tables

The total goods demand vector **Q** is made up of the imports vector **M** and the vector of domestic output **QA**[3]**.** The input – output definition of the commodity balance is:

(11) **Q = QA + M = QH + F,**

where **QH** is the intermediate demand vector and **F** is the final demand vector. Introducing the technical coefficients matrix **A** (the sum of domestic and imported elements), **QH** can be substituted by the product of **A** and **QA**:

[3] MULTIMAC IV makes no distinction between industries and commodities (although Austrian input – output statistics does), but includes a row for transfers to take into account non-characteristic production by industries.

(12) $Q = A * QA + F.$

MULTIMAC IV treats energy transactions in a separate way, so that all matrices and vectors can be split into an energy (e) and a non-energy (ne) part. The commodity balance (12) for non-energy therefore becomes:

(13) $\mathbf{Q_{ne}} = \mathbf{A_{ne}} * \mathbf{QA} + \mathbf{F_{ne}}.$

The technical coefficients matrix $\mathbf{A_{ne}}$ comprises the non-energy input in non-energy sectors as well as the non-energy input in energy sectors; **QA** is the total output vector (energy and non-energy).

The original matrix of technical coefficients in the current version of MULTIMAC IV stems from the 1990 input – output table of Austria and the issue of technical change in matrix **A** has to be considered. This includes at a first stage changes along the column as described in section 2. When the total input coefficient **V/QA** is determined, the sum of non-energy inputs (along the column) is given by:

(14) $$\sum a_{ne} = V / QA - \sum a_e ,$$

where technical change in the sum of energy inputs $\sum a_e$ is described in the energy model DAEDALUS and is exogenously fit into MULTIMAC.

For explaining changes in technical coefficients along the row different methods are used in macroeconomic input-output models. One method dating back to Conway (1990) and Israilevich et al. (1996) consists of constructing a series of 'hypothetical' output $\mathbf{QA^H}$ using constant technical coefficients matrix of a base year ($\mathbf{A_0}$) and then estimating the relationship between hypothetical and true output. In our notation and omitting for the moment the fact, that energy sectors are treated exogenously, $\mathbf{QA^H}$ would then be computed via the following identity:

(15) QAtH = A0 * QAt + F0 - M0.

As the notation in (15) indicates, this method usually assumes also constant structures of final demand and imports such that $\mathbf{A_0}$, $\mathbf{F_0}$, and $\mathbf{M_0}$ would become updated simultaneously and hence no inference could be made on any of these three matrices (vectors) alone. However, this assumption is not necessary in MULTIMAC IV, as final demand structures, imports, and GDP are modelled in econometric sub-models where only the structure of the bridge matrices is held constant. That is, there are equations in MULTIMAC that yield predictions of $\mathbf{F_{ne}}$, $\mathbf{M_{ne}}$, and $\mathbf{QA_{ne}}$ (denoted as $\mathbf{F_{ne}}$*, $\mathbf{M_{ne}}$*, and $\mathbf{QA_{ne}}$* respectively):

(16a) Fne* = g(Fne)

(16b) Mne* = h(Mne)

(16c) QAne* = k(QAne).

where all these systems of stochastic equations have error terms that are assumed to be iid normal. Given (16a), (16b), and (16c) we can always compute a prediction for $\mathbf{QH}_{\mathbf{ne}}$ ($\mathbf{QH}_{\mathbf{ne}}$*) from the following identity:

(17) QHne* = QAne* – Fne* + Mne*.

This allows us to depart from the usual approach as applied by Conway (1990) and Israilevich et al. (1996) and to use the following basic identity, thereby concentrating on **A** alone in order to derive a system of equations that update the IO-coefficients:

(19) QHne = Ane * QA,

We begin by using actual data from the historical period 1989 – 1999 to calculate a series of hypothetical intermediate demand for the non-energy sectors ($\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}}$) from (19) above, assuming constant coefficients in $\mathbf{A}_{\mathbf{ne}}$. Introducing time subscripts, we can write:

(20) QHne,tH = Ane,90 * QAt.

Note that $\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}}$ as computed by (20) will by definition be equal to $\mathbf{QH}_{\mathbf{ne,t}}$ in the year 1990, but that both series are very likely to differ from each other in all other years. This is because the variations in $\mathbf{QA}_{\mathbf{t}}$ alone will not be able to explain all of the variation in $\mathbf{QH}_{\mathbf{t}}$, due to changes in the coefficients of matrix $\mathbf{A}_{\mathbf{ne,90}}$ at time t. The relationship of hypothetical and true intermediate demand can be stated as follows:

(21) Rt * QHne,tH = QHt,

where $\mathbf{R}_{\mathbf{t}}$ is a diagonal matrix. Our aim is to alter (hence update) $\mathbf{A}_{\mathbf{ne,90}}$ in such a way, that the entire variation in (20) is explained. Premultiplying both sides of (21) with $\mathbf{R}_{\mathbf{t}}^{-1}$, inserting the result for $\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}}$ into (20) and rearranging yields

(22) Rt * Ane,90 * QAt = QHne,t.

That is, matrix $\mathbf{A}_{\mathbf{ne,90}}$ is updated at time t with a fixed factor along the rows derived from matrix $\mathbf{R}_{\mathbf{t}}$. Note that this 'correction matrix' $\mathbf{R}_{\mathbf{t}}$ corresponds to the correction matrix used in the well known RAS – approach of updating IO-coefficients (Stone and Brown, 1962). Interpreting this economically, we can say that because $\mathbf{R}_{\mathbf{t}}$ pre-multiplies $\mathbf{A}_{\mathbf{ne,90}}$, the unexplained variation from (20) is attributed to the *technology of producing the output* (row-wise multiplication with a constant).

In order to make this updating process operable in MULTIMAC, i.e. to estimate the elements of the main diagonal of $\mathbf{R}_{\mathbf{t}}$, we introduce a block of econometric equations, that estimate a linear or log-linear relationship between $\mathbf{QH}_{\mathbf{ne,t}}$ and $\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}}$:

(23) QHne,t = F(QHne,tH).

The long-term nature of this relationship can be characterised by increasing, decreasing or constant 'intensities' of intermediate demand for a certain commodity across all industries. So the two series might be co-integrated (constant intensity) or not and in the latter case might have common short-term movements. For all three possible cases of changing 'intensity' of intermediate demand the relationship $\mathbf{QH}_{\mathbf{ne,t}}/\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}}$ might be modelled, alternatively the difference in the slope of the two time series might be analysed by regressing $\Delta log(\mathbf{QH}_{\mathbf{ne,t}})$ on $\Delta log(\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}})$:

$$\text{(24)}\qquad \begin{aligned} &\Delta log\,(\mathbf{QH}_{\mathbf{ne,t}}) \;=\; \alpha_1 + \alpha_2\,\Delta log\,(\mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}}) \text{ or}\\ &\mathbf{QH}_{\mathbf{ne,t}} \,/\, \mathbf{QH}_{\mathbf{ne,t}}^{\mathbf{H}} \;=\alpha_1 + \alpha_2\,(\mathbf{QH}_{\mathbf{ne,t-1}} \,/\, \mathbf{QH}_{\mathbf{ne,t-1}}^{\mathbf{H}}), \end{aligned}$$

where the α_i denote the parameters to be estimated. It should be noted finally, that the estimation of (24) has to be performed carefully keeping an eye on long-run properties of the relationship, which is also due to the fact, that **QH** is only available in the short time period of 1988 to 1999 (due to scarcity in the data on foreign trade, see section 1). Hence, one of the major goals in future modelling steps will be the incorporation of new data on foreign trade in order to base the estimation of the very influential system of equations (24) on more solid grounds.

This method of updating the coefficients of matrix $\mathbf{A}_{\mathbf{90}}$ works accordingly in the forecasting – period of MULTIMAC IV, using the estimates of $\mathbf{F}_{\mathbf{ne}}$, $\mathbf{M}_{\mathbf{ne}}$, and **QA** as given by (16a) – (16c) (note here, that in order to get the full vector of **QA**, we must also implement the exogenous forecasts for the energy-sectors as obtained in DAEDALUS) to compute a forecast of $\mathbf{QH}_{\mathbf{ne}}$, which in turn yields the desired adjustment factor via (24).

6. Final Demand and Imports

The final demand vector **F** is the sum of a vector of private consumption, **C**, a vector of gross capital formation, **I**, as well as a vector of exports, **EX,** and a vector of public consumption, **G**:

(25) $\mathbf{F} = \mathbf{C} + \mathbf{I} + \mathbf{G} + \mathbf{EX}$

Exports and public consumption are treated as exogenous in MULTIMAC IV, whereas private consumption, gross capital formation and imports are modelled econometrically.

6.1 Private Consumption

In MULTIMAC IV we also treat private real consumption (**CR)** on a very disaggregated level. The model comprises 9 main groups, with three of them further subdivided summing up to 20 distinct groups in total. The main groups and subgroups can be taken from table 2 in section 1 above. In order to model these groups we follow a nested procedure which allocates total expenditure on the nine main groups first and then estimates the subgroups in a second step given the total expenditure of the corresponding main group[4]. Both single equation specifications and system estimation are used in the empirical application. The reason for this is threefold: first and foremost, our data do not allow the estimation of all nine main groups within a simultaneous demand system due to a lack of degrees of freedom. Secondly, some groups (especially *Gross Rent and Water*) need specific explanatory variables in order to be modelled satisfactorily. Finally we wanted to make use of additional exogenous (energy) variables that can be forecasted using the energy model DAEDALUS, the energy-model of WIFO.

The main groups modelled via single equations comprise *Gross Rent and Water* (3), *Transport* (4), *Heating* (8), and *Furniture* (9).

The energy sectors *Transport* and *Heating* take an exceptional position – as already indicated above – since we make use of endogenous variables from DAEDALUS in their estimation. Among those variables are consumption of electricity, coke, gas, fuel oil, biomass, and long distance heating as well as total vehicle stock, and consumption of petrol and diesel fuel. The models for the subgroups of real consumption of transport goods (CR4) therefore take the following form:

$$\Delta LOG(CR41) = \Delta F(D(FA\text{-}FA(-1)), DUM)$$

$$\text{LOG(CR42/FA)} = \text{F(PC42/PC43, CR42(-1)/FA(-1), AVBN, AVDS)}$$

$$\text{LOG(CR43/FA)} = \text{F(PC43/PC42, CR43(-1)/FA(-1), DUM)}$$

$$\text{LOG(CR44)} = \text{F(FA, PC44, DUM)}$$

where ΔLOG denotes that the dependent variable is transformed to logarithms and estimated in first differences. F is a log-linear function and ΔF is a function in difference-log-linear form. FA denotes stock of cars, AVBN and AVDS denote average consumption per kilometre for both petrol and diesel and DUM stands for various dummy variables that account for outliers in the data. A definitional equation is added summing up over the subgroups to give total consumption of transport goods (CR4).

For *Heating* (group 8) we model the expenditure on the main category and 5 of its 6 subgroups and derive the consumption on the remaining subgroup (CR81) as a residual to ensure additivity. All of the equations are estimated in log-difference form and explain the respective consumption expenditure by the amount of energy consumption of the respective good by households as modelled in DAEDALUS. That is for example, real expenditure on consumption of gas (CR82) is explained by total gas demand from the energy model.

Gross Rent and Water appeared to be modelled best without the use of both price and income variables which is most likely due to some statistical artefacts (i.e., imputed rents) contained in the time series. We therefore use the stock of housing (DW) and dummies to explain the annual change in consumption of that group:

$$\Delta\text{LOG(CR3)} = \text{F(DW, DUM)}.$$

According to the estimated parameters, the annual change in consumption expenditure on CR3 will increase by 0,2% if the housing stock increases by 1%.

Consumption of *Furniture* (CR9) is estimated in a standard log-linear model that comprises both real income (YD/PC) and the lagged endogenous variables:

$$\text{LOG(CR9)} = \text{F(YD/PC, CR9(-1), DUM)}.$$

The short run income elasticity for CR9 is estimated to be 0,51, and goes up to 1,46 in the long-run, clearly indicating that furniture is what is usually termed a luxury good.

Having obtained estimates for those four categories, the remaining fraction of total expenditure (after deduction of expenditure on the first 4 groups) is distributed

[4] Note that we have to assume the underlying utility function to be weakly separable when we want to apply this nested procedure.

among the remaining categories via a system of demand equations, more precisely, an Almost Ideal Demand System (AIDS). That is, in order to satisfy additivity over the entire consumption categories we compute total expenditure for the AIDS (denoted as CNAIDS) as a residual, such that the following identity holds:

(26) CNAIDS = CN – CN3 – CN4 – CN8 – CN9.

Here CN is total nominal consumption and CN3, CN4, CN8, and CN9 is nominal consumption of consumption groups 3, 4 8, and 9 respectively, which are obtained from real consumption (as estimated above) multiplied by the corresponding price index. Note that we are modelling nominal consumption within the system of equations, since the demand equations in the AIDS are stated in budget share form.

The AIDS, which was first proposed by Deaton and Muellbauer (1980), has been used extensively in the literature in a wide range of consumption studies ever since it's first presentation. Deaton and Muellbauer depart from a PIGLOG cost function which they specify empirically by the use of a Translog and a Cobb-Douglas type function. Solving the dual optimisation problem by applying Shepard's Lemma, they derive the well known budget share equations:

(27) $$w_i = \alpha_0 + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{CNAIDS}{P}\right),$$

where w_i denotes the budget share of good i, p_j is the price of good j, CNAIDS is total expenditure on all goods within the system and the Greek letters are the parameters to be estimated. P is a price index for the whole group, specified according to the following translog – function:

(28) $$\ln P = a_0 + \sum_{k=1}^{n} a_k \ln p_k + \frac{1}{2}\sum_{k=1}^{n}\sum_{j=1}^{m} \gamma_{kj}^{*} \ln p_k \ln p_j \quad .$$

Note that in our case n (the amount of goods modelled within the AIDS) equals five. The relationship between γ_{ij} and γ^*_{ij} can be stated as

(29) $\gamma ij = ½(\gamma^*ij + \gamma^*ji)$.

To avoid non-linearities during the estimation process, we follow the usual approach of approximating P by the price – index of Stone, P^S, which is given by

(30) $$\ln P^S = \sum_k w_k \ln p_k ,$$

and we therefore estimate a so-called linear approximate AIDS model, often termed as LA-AIDS. Inserting (30) into (27) above yields our final model:

(31) $$w_i = \alpha_0 + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{CNAIDS}{P^S}\right)$$

The symmetry condition of the demand equations is satisfied by restricting the parameters of (31) to assure $\gamma_{ij} = \gamma_{ji}$.

In order to interpret the results from estimating the system of equations (31), we want to derive both expenditure and price elasticities. Following Green and Alston (1990) and drawing on Monte-Carlo simulations by Alston et al. (1994) for the derivative of the Stone price index with respect to p_j, we can assume the uncompensated price elasticities for the LA-AIDS to be reasonably well approximated by

(32) $$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i} w_j .$$

The correct formula for expenditure elasticities in the LA-AIDS is given by equation 7 in Green and Alston (1991, p.874) which is a simultaneous system of equations. Very often, however, simply the elasticities from the AIDS model (with no approximation of the price index P) are computed for the LA-AIDS in the literature:

(33) $$\eta_{ix}^{AIDS} = 1 + \frac{\beta_i}{w_i} .$$

Comparing the true elasticities and the approximation from (33) we found very small differences, so for the sake of simplicity we will compute the expenditure elasticities according to (33) and hence assume

(34) $$\eta_{ix}^{AIDS} = 1 + \frac{\beta_i}{w_i} \approx \eta_{ix}^{LA-AIDS} .$$

The subgroups of Other Services were estimated in log-linear form and Restaurants and Hotels were treated as residual in order to ensure adding up within group 6. Table 4 below depicts income and own-price elasticities for main groups and sub-groups as well as the estimated values of the β_i's. The expenditure elasticities of the subgroups are also stated to reflect changes in total expenditure (as opposed to expenditure on the corresponding main group only).

Table 4: Expenditure and Own Price Elasticities of Consumption Categories Modelled in the AIDS

		Own price	Total expenditure
1	Food, Drink and Tobacco	–0.32	0.47
2	Clothing and Footwear	–2.41	0.56
5	Communication	–1.27	2.09
6	Other Services	–1.05	1.41
	6.1 Medical Care	0	1.38
	6.2 Entertainment	0	2.12
	6.3 Education	–0.46	1.58
	6.4 Restaurants and Hotels	Residual	0.84
7	Other Goods and Services	–0.76	1.40

Source: Authors' calculations.

In order to link the 9 main consumption categories with the 37 industry structure of private consumption in the IO table (**CIO**) we use a bridge matrix **BM(ij)** (see section 1.3) , such that

(35) CIO = BM(ij) * CR .

In this bridge matrix *i* represents the 9 consumption categories and *j* the 37 industries of MULTIMAC IV.

The total sum of **CR** is given by an aggregate consumption equation with disposable household income as explaining variable:

(36) $\Delta CRt = (\Delta(YDt/PCt), ECM)$

where ECM denotes an error correction mechanism.

In the current version of MULTIMAC IV we have to utilize a time-dependent coefficient to link disposable income to the sum of nominal value added, since data for income distribution are currently not available in National Accounts.

6.2 Gross Capital Formation

The vector of gross investment, **I**, given in the structure of the supplying sectors of the IO table, is divided up using fixed coefficients once the total sum of investment, Σ_i **J_i**, in the structure of investing sectors, is determined:

(37) $I = B(ji) * \Sigma i\ Ji$

with j and i being industries. Investment data in Austria are currently not supporting the disaggregated 37 industries structure of MULTIMAC IV. Instead, we have data on 10 sectors available, with manufacturing being treated as a single sector. To obtain the current capital stock for sector i ($K_{i,t}$) a starting value of an initial capital stock given from former Austrian National Account data is combined with assumptions on depreciation rates (δ) within the sectors, so that capital stock evolves as:

(38) $Ki,t - Ki,t\text{-}1 = Ji,t - \delta\ Ki,t\text{-}1.$

Hence, gross investment $J_{i,t}$ is given as the sum of the change in the capital stock and depreciation.

Making use of *stock adjustment* – models the time path of the actual capital stock is explained as an adjustment process to some ‘desired’ or ‘optimal’ capital stock. These models have been applied to investment in housing (see Egebo, et al. (1990), Czerny, et al. (1997)) and are based on the work of Stone and Rowe (1957), assuming the following adjustment process of the current capital stock K to its desired level K* (Czerny, et al., (1997), Appendix A):

(39) $$\frac{K_{i,t}}{K_{i,t-1}} = \left[\frac{K^*_{i,t}}{K_{i,t-1}}\right]^{\tau_1} \cdot \left[\frac{K^*_{i,t-1}}{K_{i,t-2}}\right]^{\tau_2}.$$

Taking logarithms in (39) we get the model in log-linear form:

(40) $\log(Ki,t) - \log(Ki,t\text{-}1) = \tau 1\ [\log K^*i,t - \log Ki,t\text{-}1] + \tau 2\ [\log Ki,t\text{-}1 - \log Ki,t\text{-}2\ ].$

with the necessary condition $\tau_1 < 0$.

The model is closed by explaining the desired capital stock K*. This desired capital stock could result from including a fixed factor capital in the Generalized Leontief – functions described in section 1 above, whenever *user costs* of capital are given.. The adjustment process then depends on the difference between user costs and the shadow price of capital given from the Generalized Leontief –

functions. However, due to data limitations we assume in MULTIMAC IV that K* depends on the current level of output only. That is,

(41) $\log(K^*i,t) = F[\log QAi,t]$

Inserting K* into (40) above yields the stock adjustment equation, which is estimated for each of those 10 sectors, where investment data are available:

(42) $\log(Ki,t) - \log(Ki,t-1) = \alpha K + \gamma K \log(QAi,t) - \tau 1 \log(Ki,t-1) + \tau 2 (\log(Ki,t-1) - \log(Ki,t-2))$

Table 5: Parameter Estimates of Capital Stock Adjustment Equations

Dependent variable: $\log(K_t) - \log(K_{t-1})$			
	Log (QA)	**$\log(K_{t-1})$**	**$\log(K_{t-1}) - \log(K_{t-2})$**
Agriculture and Forestry	0.0227	–	–
Coal Mining & Crude Oil	0.0012	–0.0777	–
Energy	0.0289	–0.0529	–
Manufacturing	0.0817	–0.1614	0.2784
Construction	–	–	0.8941
Distribution	0.0644	–0.0709	–
Hotels and Restaurants	0.0334	–0.4613	–
Transport & Communication	0.0486	–0.1820	0.5605
Other Market Services	0.0201	–0.0717	–

Source: Authors' calculations.

For the output variable different lag structures or averages as in Czerny, et al. (1997) have been used. For the industries 'Banking, Finance & Insurance', 'Real Estate', and 'Non-Market Services' no useful specification was found and it was also for other reasons of model use decided to treat investment in these industries as exogenous. The estimation results in table 5 show, that the full model of specification (42) with the first and the second adjustment term only turned out to be applicable in two of the 10 aggregated industries. The second adjustment term was significant in some other industries, but the magnitude of the two terms together led to instability in the long-run behaviour of the capital stock in that cases, so that the second term was excluded. That did not deteriorate the equation fit in these cases.

6.3 Imports

Time series data on imports (starting from 1988) are readily available in Austria only for the primary and secondary sector. From National Accounts we get an aggregated series for nominal imports of services, whose annual growth rates are projected on the 1990 values of imports from the IO-table, to give at least an approximation for nominal imports of services at a more disaggregated level. For service imports we have to assume import prices equal to domestic prices, which clearly makes a sensible treatment and appropriate modelling impossible. In MULTIMAC IV we adopt a slightly modified AIDS to determine the imported and domestic fractions of total demand for goods of the primary and secondary sector. That is, total demand is split up into two components yielding two equations which are estimated simultaneously. A typical example of such a demand system is the import demand model of Anderton, Pesaran and Wren-Lewis (1992). As Kratena and Wüger (1999) have shown, the problems of regularity of the AIDS model, i.e. the boundedness of the shares within the [0,1] interval, become especially relevant in the two goods case, where a rising share with positive response to total expenditure is combined with a decreasing share with negative response to total expenditure. Therefore the AIDS model for import demand is likely to require some modifications, especially in dynamic applications such as MULTIMAC IV. For example one could follow the lines of Cooper and McLaren (1992) and derive a Modified AIDS model (MAIDS) or the Flexible Modified AIDS model proposed by Kratena, Wüger (1999). However, due to the non-linearity of both the MAIDS and flexible MAIDS and convergence problems in system estimation, we apply in the current version of MULTIMAC IV the model of Anderton, Pesaran and Wren-Lewis (1992), in which the shares are given as:

$$(43) \qquad \frac{mn_i}{qn_i} = \alpha_m + \gamma_{md} \log p_i + \gamma_{mm} \log p_{m,i} + \beta_m \log\left(\frac{QN_i}{PQ_i}\right) + \mu x \text{, and}$$

$$(44) \qquad \frac{qan_i}{qn_i} = \alpha_d + \gamma_{dm} \log p_i + \gamma_{dd} \log p_{d,i} + \beta_d \log\left(\frac{QN_i}{PQ_i}\right) + \mu x \text{.}$$

In (43) the fraction of imports of good i in total demand of that good is explained by both the domestic (p_i) and imported price ($p_{m,i}$), the proportion of total demand on i (QA_i) and an composite price index PQ_i, as well as a variable x which shall capture the gap between the individual level of the demand function (on which the cost and utility functions of the AIDS are based) and the actual empirical level of market demand functions, which are observed by the data (see Cooper and McLaren, 1992, Kratena and Wüger (1999). In the case of private consumption information about the income distribution could be incorporated in the system through this variable. Here, we chose a measure of the openness of the economy as a proxy for a larger variety of goods from different sources that are available all over the world. This 'openness variable' is approximated by the share of total exports in total output (EX/VAN).

Table 6: Output- and Own Price Elasticities for Imports

	Goods	Output elasticity	Own price elasticity
8	Ferrous & Non Ferrous Metals	1.38	–1.17
9	Non-metallic Mineral Products	1.32	–1.10
10	Chemicals	1.68	–1.24
11	Metal Products	1.43	–1.08
12	Agricultural & Industrial Machines	0.94	–0.99
13	Office Machines	0.83	–0.91
14	Electrical Goods	1.55	–1.16
15	Transport Equipment	1.11	–1.04
16	Food and Tobacco	3.02	–1.25
17	Textiles. Clothing & Footwear	1.79	–1.49
18	Timber & Wood	0.66	–0.97
19	Paper	1.03	–1.01
20	Printing Products	0.76	–0.95
21	Rubber & Plastic Products	1.49	–1.14
23	Other Manufactures	1.64	–1.21

Source: Authors' calculations.

As in section 5.1 we avoid non-linearities in the estimation procedure by approximating PQ_i by the Stone price index PQ_i^S and restrict the parameters in order to satisfy symmetry (i.e. $\gamma_{md} = \gamma_{dm}$). Since we are interested in modelling imports in this section, only elasticities from (43) will be tabulated below. As far as the derivation of those elasticities is concerned, the same formulas as in section 5.1 above are applied here.

The own price elasticities are all near the 'normal case' of –1, whereas for 'output' or better demand elasticity larger differences between the commodities exist. These differences are important for model simulation behaviour, because they show that demand increases in different sectors stimulate domestic output and imports in rather different ways across the industries

7. Labour Markets and Wage Formation

The seminal work for disaggregated labour markets is Layard, Nickell, Jackman (1991). Large part of the labour market literature stresses the importance of disaggregation by skill groups or professions, as the stylised facts show that major changes in labour market variables (wages, unemployment) have occurred among groups of these classifications, whereas in the industry classifications less dynamics can be found (see Nickell, 1997).

In any case one starting point of a disaggregated labour market model are the labour demand functions for each industry, which are given by factor input equations. In the simple two sector case one could assume the labour input coefficient being a function of the wage rate (derived via Shephard's Lemma from a cost function):

(45) $$\frac{L_1}{QA_1} = \alpha_1 \left(\frac{1}{w_1} \right) \quad ; \quad \frac{L_2}{QA_2} = \alpha_2 \left(\frac{1}{w_2} \right)$$

with $\alpha_1 > 0$ and $\alpha_2 > 0$ and $L_1 + L_2 = L$.

Employment demand of this type is given in MULTIMAC IV at a disaggregated level by the input demand equations from section 2:

(46) $$L = \left[\alpha_{LL} + \alpha_{VL} \left(\frac{p_V}{w} \right)^{\frac{1}{2}} + \gamma_{Lt} t^{\frac{1}{2}} + \gamma_{tt} t \right] QA$$

Total output QA could be assumed to be distributed to the sectors via demand shift parameters d_1 and d_2, which for the moment are assumed to be given:

(47) $$\frac{QA_1}{QA} = d_1 \quad ; \quad \frac{QA_2}{QA} = d_2$$

This model differs from the Layard, Nickell, Jackman model (1991) by explicitly defining sectoral labour demand for each sectoral output level and transferring the demand shift parameter to the goods market. In MULTIMAC IV the goods demand of type (46) is determined by the functions for final demand, intermediate demand and imports described in the last sections.

Defining a (full employment) productivity variable $X = Q/N$ the labour demand function of the theoretical model can be written as:

(48) $$w_1 = \alpha_1 \left[\frac{L_1}{N_1} \frac{N_1}{N} \right]^{-1} d_1 X \quad ; \quad w_2 = \alpha_2 \left[\frac{L_2}{N_2} \frac{N_2}{N} \right]^{-1} d_2 X$$

The equilibrium wage rate could be found in a competitive labour market model by labour supply reactions to changes in the consumer net wage, by an efficiency wage mechanism or by union wage bargaining. Assuming a bargaining mechanism the wage rate is the outcome of redistribution of the value of a job and a function of the unemployment rate and productivity:

(49) $$w_1 = \varphi_1 \left[\frac{N_1}{L_1} \right] + \phi_1 X \quad ; \quad w_2 = \varphi_2 \left[\frac{N_2}{L_2} \right] + \phi_2 X$$

with $\varphi_1 < 0$ and $\varphi_2 < 0$. The parameters φ and ϕ measure the ‚wage pressure' factors, which by themselves depend on union bargaining power.

Combining (48) and (49) we find equilibrium unemployment (u_i) and wage rates (w_i) for each sector at given demand shift parameters d_1, d_2 and given labour force shares N_1/N, N_2/N.

(50) $$u_1 = 1 - \frac{L_1}{N_1} = \frac{\varphi_1}{\phi_1} - \frac{\alpha_1 d_1}{\phi_1} \left(\frac{N_1}{N} \right)^{-1} + 1 \quad ;$$
$$u_2 = 1 - \frac{L_2}{N_2} = \frac{\varphi_2}{\phi_2} - \frac{\alpha_2 d_2}{\phi_2} \left(\frac{N_2}{N} \right)^{-1} + 1$$

(51) $$w_1 = \varphi_1 \left(\frac{\phi_1}{d_1 \alpha_1 \left(\frac{N_1}{N} \right)^{-1} - \varphi_1} \right) + \phi_1 X \quad ;$$
$$w_2 = \varphi_2 \left(\frac{\phi_2}{d_2 \alpha_2 \left(\frac{N_2}{N} \right)^{-1} - \varphi_2} \right) + \phi_2 X$$

Most studies do not explicitly deal with labour mobility between the sectors. For the case where the sectors represent skilled and unskilled labour markets, mobility is restricted and incurs cost of training and moving to the skilled segment. The Layard, Nickell, Jackman (1991) study introduces costly movement between the labour market segments in a Harris-Todaro model of migration between the sectors. In such a setting (see Harris and Todaro, 1970) migration in the labour force is driven by differences in expected income, where the employment rate is used as a proxy for the probability to find a job in the other sector, so that the expected income differential is: $w_1(1 - u_1) - w_2(1 - u_2)$.

More recent studies on migration start from an equilibrium *stock* of migrants, which under certain conditions have been moving from one labour market to another. The idea is based on a study by Hatton (1995) and implies – as a recent study on East-West migration in an enlarged European Union points out (Boeri and Brücker, 2000) – that the total number of the migration potential of a society is limited. For each expected income differential a certain percentage of the total labour force is willing to migrate. The labour force in each segment can then be seen as comprising one constant part given by pure labour supply effects and one part of migrant stock from other labour market segments, which reacts to expected income differentials.

The total participation of the labour force in total population in working age could be a function of total economic activity as measured by total output and/or employment and the overall real wage rate (as in E3ME, Barker et al. 1999):

(52) $(LF/POP) = \mathrm{F}\,(QA, w/PC, L)$

with *LF* as the MULTIMAC variable for the labour force. As in E3ME male and female labour force participation are treated separately.

The distribution of this total labour force among sectors is then guided by the constant describing the supply of certain skill levels, so that a change in the skill level of new entrants in the labour markets might shift the constant parts in the sectoral labour force equations. This shift is modelled by introducing an elasticity of sectoral labour forces to total labour force in a PIGLOG specification as in AIDS and simultaneously taking the wage differential elasticity into account:

(53) $\mathrm{LFi/LF} = \mathrm{a1} + \mathrm{a2}\log(\mathrm{LF}) + \mathrm{a2}\log(\mathrm{wi/w})$

where *w* is the total wage rate.

The theoretical sectoral labour market model outlined here is commonly used at the level of regions, skill groups or occupations. In the case of a model in industries classification as MULTIMAC IV a link between skill groups or occupations could be introduced through the skills or occupations dimension at the industry employment side. Employment demand then becomes a two step procedure, where first the total labour input is determined and then in a second step is split up in different skill groups as in the general equilibrium approach in McGregor et al. (1998). The relevant labour market classification then becomes skill groups and labour markets are linked to goods markets by the general equilibrium mechanisms. The disaggregated labour market in MULTIMAC IV tries a synthesis between working at the industry level with labour mobility across the industries and the use of skills and occupations data for describing segmented labour markets. This is done by aggregating the 37 industries of MULTIMAC into 3 industries with different average skill levels (high skilled, medium skilled, low skilled). The data base for this aggregation procedure is the industries * occupations employment matrix for 2000. The occupation groups are aggregated to a 8 stage level of ISCO, where they correspond broadly with skill levels and these 8 groups are then further integrated into 3 final skills/occupations groups.

The MULTIMAC IV industries are aggregated in the following way:

1. *High skill industries*:

3 Oil & Gas Extraction, 5 Manufactured Fuels, 6 Electricity & Heat, 7 Water Supply, 8 Ferrous & Non Ferrous Metals, 10 Chemicals, 11 Metal Products, 12 Agricultural & Industrial Machines, 13 Office Machines, 14 Electrical Goods, 15 Transport Equipment, 23 Other Manufactures, 28 Water and Air Transport, 30 Communications, 31 Bank, Finance & Insurance, 33 Software & Data Processing, 34 R&D, Business Services, 36 Non-market Services

2. *Medium skill industries*:

16 Food & Tobacco, 17 Textiles, Clothing & Footwear, 18 Timber & Wood, 19 Paper, 21 Rubber & Plastic Products, 24 Construction, 25 Distribution, 27 Inland Transport, 29 Other Transport Services, 35 Other Market Services

3. *Low skill industries*:

1 Agriculture, Forestry, Fishing; 9 Non-metallic Mineral Products, 20 Printing Products, 22 Recycling, 26 Hotels and Restaurants, 32 Real Estate

The treatment of labour force by industry allows us to work with unemployment rates by industries, ur_i, which are : $ur_i = (LF_i - L_i) / LF_i$

Union wage bargaining equations complement the model, which are again specified similar to E3ME (Barker, et al. 1999), but without external industry effects taking into account the interaction with the economy as a whole. Wage formation depends on consumer price changes, ΔPC, on productivity changes, $\Delta(QA_i/L_i)$, and on the level as well as on changes in the sectoral unemployment rate. The latter variables measure the influence of labour market performance in the target function of unions.

The wage equations for *wr* as the sectoral wage rate in MULTIMAC IV are specified with:

(54) $\Delta\log(wr_i) = a_1 + a_2\,\Delta\log(PC) + a_3\,\Delta\log(QA_i/L_i) + a_4\,\Delta\log(ur_i) + a_5\,\log(ur_i)$

Table 7 shows results for the sectoral labour force equations and table 8 for the wage rate equations at the same aggregation level. Only the main parameter values are reported, the full specification including all lag structures is not shown here. The 'total labour force elasticity' of the sectoral labour forces is in the PIGLOG specification given as the income elasticity in AIDS by $1 + a_2/(LF_i/L)$ (with a_2 as in (53)), so that we get 'total labour force elasticities' below 1 for high and medium skilled workers and above 1 for low skilled workers. The relative wage parameters have the expected sign in the sectoral labour force equations, so that high and medium skilled sectors attract labour force dependent on the wage differential between their sectoral wage and the low skilled wage.

In the wage equations we found only consumer prices and unemployment rates as relevant variables and sectoral productivity growth proofed to have no impact.
The wage rates for the 36 industries are further explained in terms of the wage rate of the skill category industry to which they belong with:

(55) $\Delta\log(wr_j) = a_1 + a_2\,\Delta\log(wr_i) + a_3\,\Delta\log(QA_j/L_j)$

with j as 36 industries and i as the 3 skill category industries.

These estimation results as well as the estimation results for the participation rate equation are not shown here, but are available from the authors upon request.

Table 7: Parameter Estimates of Sectoral Labour Force Equations

	Labour force: LF(i)/LFTOT		
	High skill (hs)	Medium skill (ms)	Low skill (ls)
Wage rates			
wr_hs/wr_ls	0.3248 (0.1900)	–	
wr_ms/wr_ls	–	0.0747 (0.0361)	
log (LFTOT)	–0.3306 (0.1879)	–0.1065 (0.0436)	0.0762 (0.0071)
	(Standard error in parenthesis)		

Source: Authors' calculations.

Table 8: Parameter Estimates of Sectoral Wage Equations

	Wage rate:Δ log(wr)		
	High skill (hs)	Medium skill (ms)	Low skill (ls)
Unemployment rates			
log(ur_hs)	–0.0447 (0.0126)	–	–
log(ur_ms)	–	–0.0284 (0.0231)	–
log(ur_ls)	–	–	–
Δ log(PC)	0.6207 (0.1755)	0.8547 (0.2916)	0.9879 (0.2057)
		(Standard error in parenthesis)	

Source: Authors' calculations.

Appendix A: Time Series Variables in MULTIMAC IV

Appendix A summarizes the time series variables of MULTIMAC IV along the structure maintained in the data describing section and gives the abbreviations used in the model.

Table A1: Data in the 37 Industry Structure

Description of the data	***Abbreviation***
Value added, nominal	van
Value added, real	va
GDP, nominal	qan
GDP, real	qa
Price of GDP	p
Intermediate demand by industry, nominal	sqhn
Intermediate demand by industry, real	sqh
Price for intermediate demand by industry	pqh
Wages and salaries	w
Dependent employment	l
Investment, nominal	jn
Investment, real	J
Price for investment	pj
Capital stock	k
Capital stock I	ki
Capital stock II	kii
Depreciation rate	s
Public consumption	g
Imports, nominal	mn
Imports, real	m
Price for imports	pm
Exports, real	ex

Table A2: Variables Computed via Identities

Description of data	*Abbreviation*
Total demand, nominal	qn
Total demand, real	qn
Price for total demand	pq
Intermediate demand by commodity, real	qh
Price of intermediate demand by commodity	cqh
Final demand by commodity	f

Table A3: Data in the Labour Market and on Population

Description of data	*Abbreviation*
Dependent employment by skill groups	Lhs, lms, lls
Labour force by industry	lf
Labour force by skill groups	Lfhs, lfms, lfls
Labour force by gender	lffem, lfmask
Wage rate by industry	wr
Unemployment rate by skill groups	u
Population by gender	popfem, popmask

Table A4: Data in the Categories of Private Consumption

Description of data	*Abbreviation*
Private consumption, nominal	cn
Private consumption, real	cr
Price of private consumption	pc

Table A5: Variables in 37 Industry Classification, Computed by Multiplication with Bridge Matrices

Description of data	*Abbreviation*
Private consumption	c
Investment	i

Table A6: Other Variables

Description of the data	*Abbreviation*
Hypothetical output	qhhyp
Disposable income, nominal	yd
Housing stock	dw

TableA7: Energy Variables from DAEDALUS

Description of the data	*Abbreviation*
Petrol consumption	Bn_pkw
Fuel oil consumption	brent
Diesel consumption	ds_pkw
Stock of automobiles	fa
Biomass consumption	enbmhh
Liquid fuels consumption	endohh
Electricity consumption	enelhh
Gas consumption	engahh
Coke consumption	enkohh
District heating consumption	ensthh
Total energy consumption	entohh
Price of liquid fuels	pdo_dl
Price of petrol	pbn
Price of diesel	pds
Price of gas	pg_dl
Price of electricity	pel_dl
Price of coke	pko_dl

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MULTIREG –A Multiregional Integrated Econometric Input–Output Model for Austria*

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1. Introduction

Since Austria is a rather small country and its economy thus very open, attempts to move from the national to a regional level of macroeconomic modeling are not only hampered by severe data restrictions but also by the fact that Austrian regions are characterized by an extremely high degree of openness. This limits the usefulness of single region models since economic impacts from changes in economic policy or public investment projects mostly emerge not within the region where these policies or projects are implemented but in other Austrian regions. In addition, single region models are often top-down-type models where changes in regional economic activity (employment, output, consumption etc.) are derived from changes in the corresponding national variables. In modeling larger regions, e.g. the metropolitan region of Vienna, which accounts for almost 20% of the Austrian population, simultaneity, thus, becomes more and more problematic. Therefore, after having completed two single region models for the federal

* MULTIREG was developed by a the team of researchers including, in alphabetical order and by institutions, Raimund Kurzmann, Gerhard Streicher, Gerold Zakarias (all Joannem Research), Oliver Fritz, Kurt Kratena and Peter Mayerhofer (all WIFO).
We would also like to express our deep gratitude towards numerous members of Statistik Austria for their invaluable support of our work. Above all, Erich Greul and Rudolf Mazanek provided indispensable regional information and Erwin Kolleritsch was always willing to guide us through the shallows of input-output table compilation.
Financial support of this work by the Jubiläumsfonds of the Oesterreichische Nationalbank (Projects No. 9759 and 9798) is gratefully acknowledged.

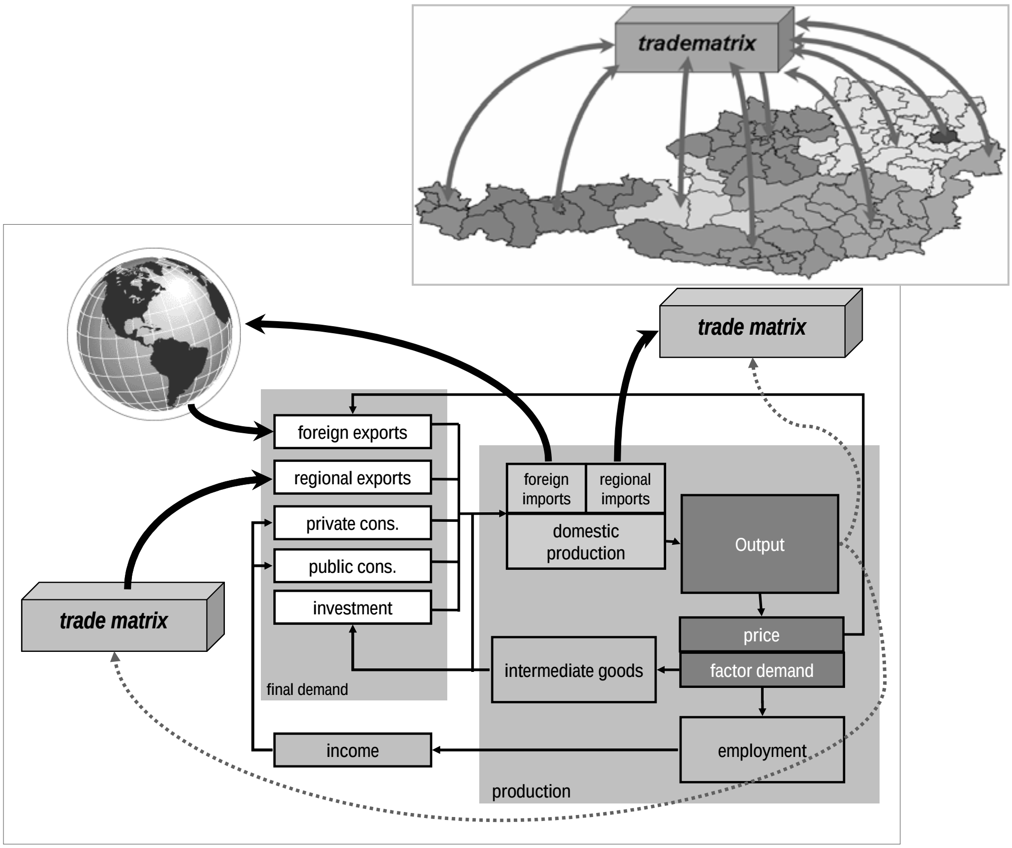
provinces of Styria and Upper Austria (Fritz et al., 2001; Zakarias et al., 2002), an attempt to bring all nine Austrian federal provinces into one multiregional model was undertaken.

MULTIREG integrates two model types, econometric models and input-output models, at the multiregional scale; a first and preliminary version has just been completed and is now undergoing extensive testing. The aim of building an integrated model is to benefit from the advantages of either model type and remedy their respective shortcomings. Integrating econometric and input-output models draws its motivation both from theoretical as well as practical aspects (Rey, 2000): for instance, instead of applying the linear production technology assumption of the standard input-output model, more flexible production functions may be estimated and included in integrated models. Similarly, instead of assuming final demand to be exogenous as is often the case in a pure input-output framework a more theoretically sound treatment of private consumption, investment etc. can be achieved when an econometric modeling approach is applied. A high degree of industrial disaggregation (MULTIREG comprises 32 industries, see also the Appendix), on the other hand, is often put forward as one of the main advantages of input-output models; this becomes especially important when the model is to be applied for impact analysis.

While the single-region models for Styria and Upper Austria were built very much in the tradition of Conway's integrated regional econometric input-output model (Conway, 1990), the modeling approach taken in MULTIREG is closer to the one implemented in MULTIMAC (Kratena, 1994; Kratena and Zakarias, 2001), which in turn was developed along the lines of the INFORUM model family (Almon, 1991) and the European multiregional model E3ME (Barker et al., 1999). This implies that compared to its predecessors MULTIREG not only replaces the single-region framework with a multiregional setting but relies to a much greater extent on functional forms consistent with microeconomic theory instead of pure statistically-driven variable relationships.

MULTIREG's model structure is illustrated in chart 1. A simple description of the model's solution algorithm may start out with total final demand, which is composed of private and public consumption, investment, and regional and foreign exports. This demand can be met either by importing commodities from other regions or abroad or by commodities produced by regional firms. While foreign imports (and exports) are still exogenously determined in the first version of the model but will later be modeled separately, regional imports (and exports) are established in the interregional trade block. Regional production is simulated in the output block, where output prices and factor demand are derived based on cost functions. Factor demand consists of intermediate inputs (which feed back to total regional demand) and labor. By generating income, labour influences final demand. Another feedback channel will operate via output prices, since changing relative prices lead to changes in the demand for foreign exports (and foreign imports). Finally, changing regional production patterns also lead to changes in regional trade patterns.

Chart 1: The Structure of MULTIREG



The paper first discusses conceptual and estimation issues in the construction of the multiregional input-output table for Austria, which is embedded in MULTIREG. The table is based on a multiregional make-use system which was derived from the national make-use system of the year 2000 using an extensive regional data base. Since all regional matrices sum up to the corresponding national matrices the multiregional system is fully consistent with the national system. One of the key conceptual issues to be resolved concerned the distinction in the table between place of production and place of consumption; furthermore, in order to be able to relate consumption to income in the econometric parts of the model, commuters' place of income had to be distinguished from place of work. The paper will also elaborate on the estimation of the interregional trade matrix. Interregional trade flows were first estimated using survey data on regional export activities. These estimations were then used as starting values in a RAS procedure set up to balance the multiregional make-use system.

Following the discussion of the multiregional input-output table construction theoretical and empirical features of the econometric model blocks are presented. Afterwards the paper turns to a more extensive treatment of the way the per se static coefficients of the multiregional input-output tables are transformed into time-variable coefficients; among those are the technical coefficients of intermediate demand as well as the coefficients of the interregional trade matrix. For the latter a gravity model was estimated based on interregional transport data and then used to generate a time series of transport flows between Austrian districts over time. These interregional transport flows were subsequently transformed into interregional trade flow matrices. We finish with a summary and conclusions.

2. The Multiregional Input–Output Block

While most integrated regional econometric input-output models use quadratic input-output tables in MULTIREG the econometric blocks are linked with a complete multiregional make-use table system. As a consequence the model includes industries as well as commodities. In this section the basic identities and definitions of the input-output block are presented before details on the compilation of the multiregional table system are provided.

For the complete vector of commodity output values $\mathbf{g_i}$ in each region i the following fundamental identity must hold (commodity balance):

$$\mathbf{g_i} = \mathbf{g_i^d} + \mathbf{m_i^f} + \mathbf{m_i^r} = \mathbf{g_i^{int}} + \mathbf{f_i} \qquad (2.1)$$

where $\mathbf{g_i^{int}}$ is the intermediate demand vector and $\mathbf{f_i}$ is the (total) final demand vector (for both regionally produced as well as imported commodities), $\mathbf{m_i^f}$ are foreign imports, $\mathbf{m_i^r}$ denotes interregional imports and $\mathbf{g_i^d}$ is the vector of output values of regionally produced commodities in region i. In MULTIREG the use-matrix provides the basis for the coefficients matrix $\mathbf{A_i}$ (which is hence a commodity-by-industry matrix) in which one element a_{kl}^i is defined as:

$$a_{kl}^i = \frac{u_{kl}^i}{q_l^i}, \qquad (2.2)$$

where u^i_{kl} denotes the value of commodity k used in industry *l* located in region *i* and q^i_l denotes total output of industry *l* in region *i*. Substituting the product of $\mathbf{A_i}$ and $\mathbf{q_i}$ for $\mathbf{g_i^{int}}$ in (2.1) above gives

$$\mathbf{g_i} = \mathbf{A_i} \cdot \mathbf{q_i} + \mathbf{f_i} \, . \tag{2.3}$$

The final demand vector $\mathbf{f_i}$ is the sum of a vector of private and public consumption, $\mathbf{cp_i}$ and $\mathbf{cg_i}$, a vector of gross capital formation, $\mathbf{i_i}$, as well as a vector of foreign exports $\mathbf{ex_i^f}$ and of interregional exports $\mathbf{ex_i^r}$,

$$\mathbf{f}_\mathrm{i} = \mathbf{cp}_\mathrm{i} + \mathbf{cg}_\mathrm{i} + \mathbf{i}_\mathrm{i} + \mathbf{ex}_\mathrm{i}^\mathrm{f} + \mathbf{ex}_\mathrm{i}^\mathrm{r} \tag{2.4}$$

Total output of industries located in region *i*, $\mathbf{q_i}$, follows from multiplying the commodity demand vector with the regional market shares matrix $\mathbf{D_i}$,

$$\mathbf{D_i} = \mathbf{V_i} \cdot \hat{\mathbf{g}}_\mathbf{i}^{\mathrm{d}\,-1} \, , \tag{2.5}$$

and

$$\mathbf{q_{i_i}} = \mathbf{D_i} \cdot \mathbf{g_i^d} \, , \tag{2.6}$$

where $\mathbf{V_i}$ is the make-matrix of dimension industries-by-commodities and $\hat{\mathbf{g}}_\mathrm{i}^\mathrm{d} = diag(\mathbf{g}_\mathrm{i}^\mathrm{d})$.

The input-output tables for the nine Austrian federal provinces included in MULTIREG were derived from the national input-output tables compiled for the year 2000 by Statistik Austria. The latter are based on a make-use system comprising 58 sectors (2-digit NACE industries plus imputed financial intermediation services – FISIM) and 57 commodities (corresponding to 2-digit CPA codes). Retaining this level of aggregation, each national table was split up into nine regional sub-tables.

Table compilation proceeded in five steps:

- Estimation of a regional make matrix
- Estimation of regional intermediate and final use matrices independent of the origin of the commodities used
- Preliminary estimation of interregional trade flows by commodities

- Final estimation of interregional trade flows conditional upon balancing the multiregional make-use system with respect to each commodity
- Derivation of regional intermediate and final use matrices for regionally produced commodities

The resulting regional tables may be characterized as hybrid: Table compilation relied on extensive amounts of primary and secondary regional data from official sources and on data from a survey on interregional trade flows. Nevertheless for some sections of the tables, in particular those that depict service industries and commodities, regional data was scarce or did not exist at all. In those cases the structure of the corresponding sections of the national tables had to be retained and the regional information was limited to column sums of the tables (i.e. output levels).

Below the methods applied in the compilation of the matrices of the regional make-use system are described in more detail.

2.1 Regional Make Matrices

Commodity output values by industries included in the regional make matrices were calculated by multiplying total output values by industries and regions with the respective commodity shares. Estimates of regional total output values by industries were based on corresponding value added figures obtained from Statistik Austria's regional accounts. Two problems needed to be resolved: first, regional accounts are published only for 15 1-digit NACE industries (Agriculture, Forestry and Hunting / Fishing are combined, exterritorial units excluded). Statistik Austria provided a custom report for nine groups of the 23 2-digit NACE industries of the manufacturing sector. Further disaggregation into 2-digit industries was accomplished by utilizing indicators from other sources (e.g. employment by industries from the 2001 Austrian census). Secondly, the official regional value added figures were themselves derived from regional total output values, which, however, remained unpublished. Therefore, in order to arrive at consistent regional total output values, Statistik Austria's estimation procedure had to be applied reversely. This was accomplished using information on output to value added ratios by industries and on the development of regional annual revenues by industries.

Finally, the resulting regional total output values for the 57 2-digit NACE industries (FISIM excluded) had to be decomposed into commodity output values. For the different industries of the secondary sector (mining & manufacturing), regional survey information on commodity output levels was available from Statistik Austria. For the remaining industries no such information was at hands; consequently, national commodity output shares by industries as included in the national make matrix had to be applied across all regions. To ensure compliance of the resulting regional make matrices with regional total output levels by industries on the one hand and aggregate, i.e. national commodity output levels by industries as contained in the national make-matrix on the other hand, we used a variant of the familiar RAS method as described in Piispala (2000).

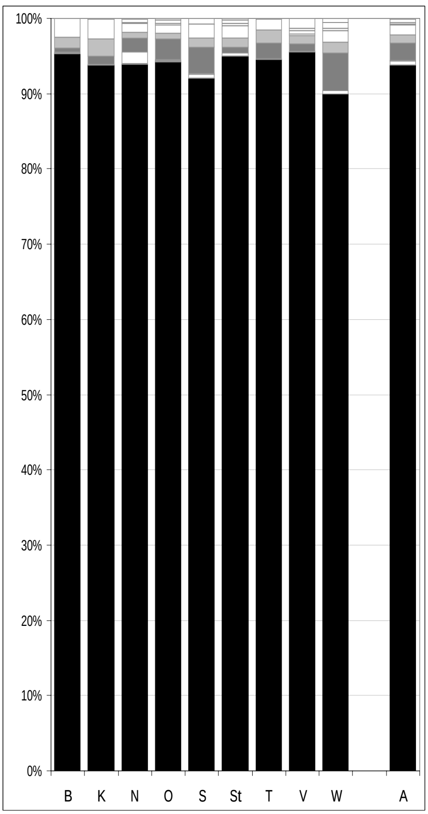
As expected, with respect to the commodity mix regional industrial output is more diverse than national output. However, entries on the main diagonal of the make matrix are strongly dominant at the regional level as well. As an example, chart 2 shows regional and national commodity composition of output for two industries, *Manufacture of Food Products and Beverages* (NACE 15) and *Manufacture of Motor Vehicles, Trailers and Semi-Trailers* (NACE 34). As can be seen, the commodity structure of output is regionally much more diverse for *Motor Vehicles* than in the case of *Food and Beverages*. This is also reflected in the regional commodity structure of intermediate use (see chart 3): the input pattern is much more diverse for *Motor Vehicles* than it is for *Food and Beverages*. In addition, the *Vehicle* industry is much more concentrated: more than 75% of total output is produced in only two regions, Styria and Upper Austria.

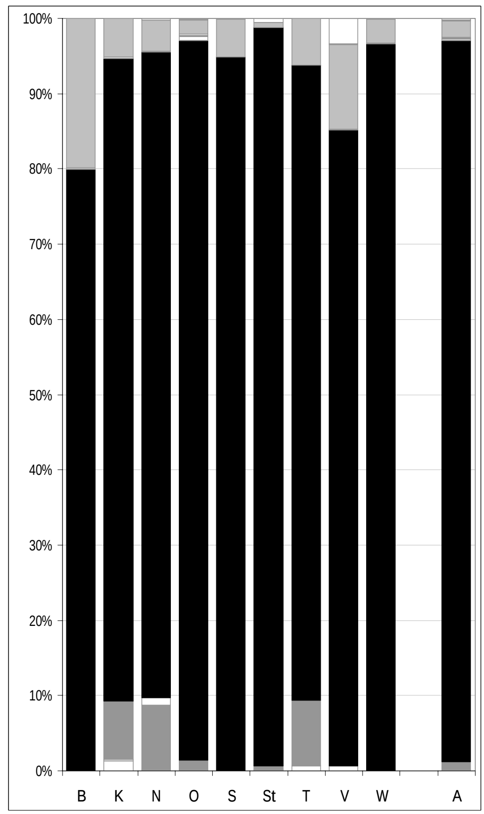
2.2 Regional Intermediate Use Matrices

For the regional intermediate use matrices a very similar approach was taken: here, regional commodity input values by industries resulted from multiplying total intermediate use values by industries and regions with the respective commodity shares. Total intermediate use values were calculated by deducting value added from total output values. Concerning the commodity shares in total intermediate use generic regional information was yet again available only for mining and manufacturing, here both with respect to industries and commodities. Since data on the use of services as well as the use of materials by the service sector is missing, national commodity input shares by industries from the national intermediate use table were used for all service inputs as well as for material inputs in the industries of the service sector. As above in the case of the regional make tables, Piispala’s RAS method was applied to ensure consistency with the national intermediate use matrix both with respect to total intermediate use values by industries and total intermediate commodity use.

Hence, for make and intermediate use tables only the mining and manufacturing sections can be truly characterized as survey based, while the sections containing service industries and service commodities (in particular on the intermediate use side) much more reflect the national input-output structure. Both make and intermediate use matrices were finally discussed with experts from Statistik Austria and appropriate adjustments were made where recommended.

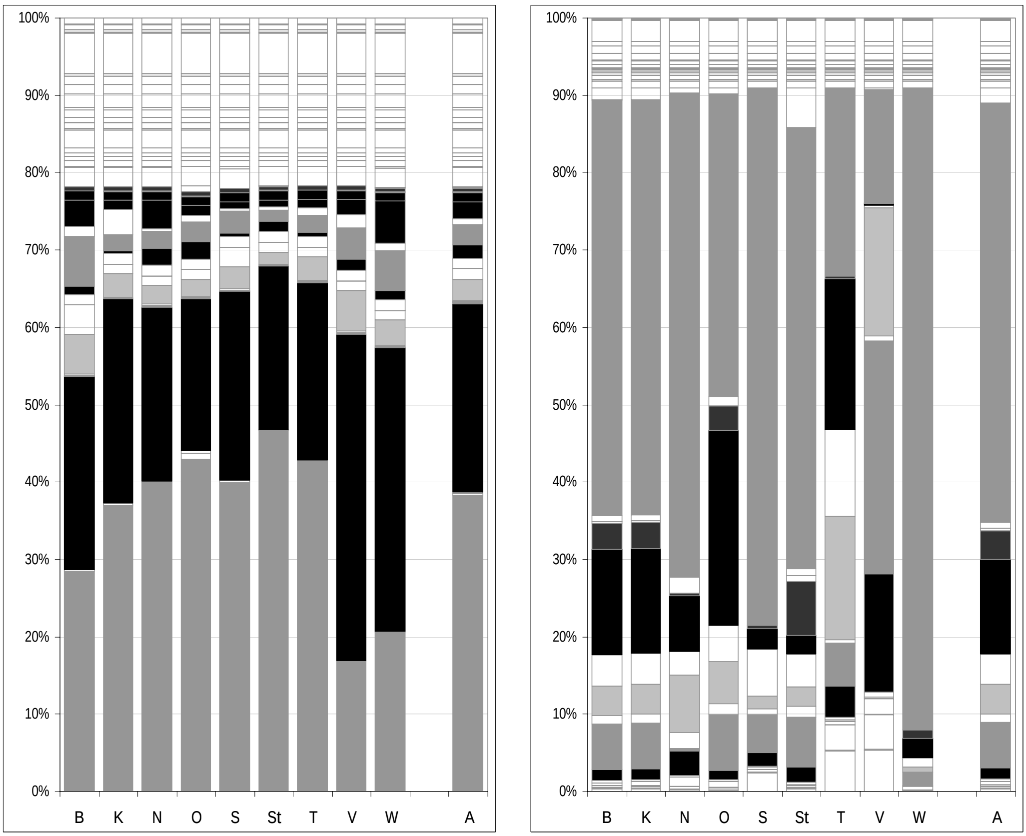
Chart 2: Regional Commodity Shares of Production for Industries NACE 15 and NACE 34 [1]





[1] For a definition of the regional codes see the appendix. Commodities are not designated as it is only the (similiarity in) the structure of regional production which is of interest in the present context.

Chart 3: Structure of Regional Intermediate Use for Industries NACE 15 and NACE 34 [2]



Source: Statistik Austria; authors' calculations.

2.3 Regional Final Use Matrices

Regional final use is separated into private consumption, government consumption, investment and foreign exports.

Regionalization of *private consumption* started by transforming data on household consumption expenditures by regions from expenditure categories into

[2] For a definition of the regional codes on the abscissa of the diagram see the appendix. . Commodities are not designated as it is only the (difference in) the structure of regional production which is of interest in the present context.

commodities via a bridge matrix. Regional household consumption, however, was measured at the place of residence, while private consumption in the input-output tables was to be based on a place-of-consumption concept. Thus further adjustment for both domestic tourism and shopping was required.

Data on overnight stays by domestic tourists which includes information not only on the location of the accommodation but also on the place of residence of the tourist is available. This allowed calculating net overnight stays for each region, i.e. the number of overnight stays of regional residents outside the region minus the number of overnight stays of non-regional residents within the region. In the case of positive (negative) net overnight stays consumption expenditures measured at the place of residence were increased (decreased) in order to take regional tourism expenditures into account. For this adjustment it was assumed that the expenditures per overnight stay of foreign tourists, both with respect to their level and commodity structure, were equal to those of domestic tourists as well as across regions; multiplying the number of net overnight stays of a region with tourism expenditures per overnight stay provided the amount that was deducted from (in the case of negative net overnight stays) or added to (in the case of positive net overnight stays) the regional consumption expenditures measured at the place of residence.

Further need for adjustment resulted from households shopping outside their region of residence. This mainly concerned the region of Vienna and its surrounding region of Lower Austria, where considerable cross-border shopping takes place in both directions. Results from surveys undertaken in four Austrian regions, including Vienna and Lower Austria, over the last few years shed some light on cross-border shopping and even quantify regional shopping in- and outflows.[3] Even though these surveys are based on very small samples, the data together with a fair amount of assumptions and guesswork was used to further adjust regional consumption expenditures.

With respect to expenditures by foreign tourists, estimations on the regional allocation of these expenditures do not distinguish between consumption categories; such data exists only at the national level. Consequently, the consumption structure of foreign tourists had to be assumed equal across regions.

National *public consumption* expenditures were regionalized with respect to each commodity in part directly by using regional public consumption data provided by Statistik Austria, in part indirectly by applying different regional indicators which were consistent with a place of consumption concept. Specifically, shares of regional population in total Austrian population were used as indicators for commodities that could be classified as public goods like national defense and part of national government services. Education services were

[3] See Österreichische Gesellschaft für Marketing, 1997, Institut für Handelsforschung, 1998, Stadtplanung Wien 1999.

regionalized by the number of students at different levels of education, counted at the location of the educational institution. Public expenditures on health services and pharmaceuticals were first allocated to different (partly regional) health insurance carriers based on the number of insurants and then further regionalized if necessary. Since employees and their dependants are assigned to health insurance carriers based on the location of their employer and furthermore often stay in hospitals outside their home region adjustments for commuting (based on census data) and out-of-province hospitalization (based on data on regional hospital occupancy and the assumption of equal cost per occupied hospital bed across all regions) had to be made in order to comply with the place of consumption concept.

Regional investment was derived from the corresponding column of the Austrian input-output table by assuming, for each industry and each component of investment[4], equal ratios of investment to production across regions. Resulting regional differences in investment commodity expenditures thus merely reflect the different industrial composition of each regional economy.

Regional foreign exports were computed by utilizing information on the location of the exporter contained in the national external trade statistics database. The main drawback of this data is its unit of observation: it is the company level, whereas a meaningful regional input-output table compilation requires the establishment level since especially larger companies not only tend to have several establishments located in different regions but also one single business unit responsible for managing exports and imports for the whole company. Considerable effort and additional data (e.g. sales tax statistics) were used to correct for this problem. The regional foreign exports derived in this way serve only as first estimates and are revised when interregional trade is added to balance the multiregional input-output table system (cf. below).

For the estimation of *regional foreign imports* national external trade statistics are less useful: additional to the company-establishment problem imports are often not declared by the company the imported good is intended for but by the company responsible for its transport. Therefore, in the case of imports for intermediate use, national import ratios were used: for each industry and commodity the ratio of imported to total use was calculated from the Austrian intermediate use table. These ratios were then assumed constant across regions. Imported commodities for the different categories of final consumption were calculated analogously. Again, these results only served as starting values for a balancing mechanism (cf. below).

2.4 Interregional Trade

Since data on interregional trade are usually not collected by statistical offices and short cut methods often proved unreliable, a dedicated survey was conducted

[4] Investment in dwellings; other buildings and structures; machinery, transport equipment; cultivated assets and intangible fixed assets.

among Austrian business establishments, mainly in the manufacturing sector, construction as well as the following service industries: land transport (NACE 60), telecommunications (NACE 64), computer and related activities (NACE 72) and other business activities (NACE 74). Mail questionnaires asked firms about the shares of sales with respect to their regional destinations. A stratified sample of the approximately 90,000 Austrian establishments was used in the survey with the number of employees as stratification criterion: while only a small percentage of small establishments (less than 10 employees) was contacted, with respect to large firms (in most industries this involved establishments with more than 250 employees) a full survey was aimed at. In total about 6,600 establishments received questionnaires.

After conducting a mail follow-up and another follow-up by phone a response rate of 27.7% was achieved. Aggregating over each individual industry the responding establishments account for 19.7% of total employment with industrial response rates ranging between 7 and 65%. Sales to final customers (this included households and other firms except wholesalers, but including retailers) were distinguished from sales to wholesalers, whose location need not be identical to the final customer's location. It turned out that on average some 24% of total sales of responding firms went through a wholesaler. To be able to derive the final regional destination of sales through wholesalers, a separate survey was targeted at the wholesale industry. In this, some 8,000 wholesalers (out of about 20,000) were questioned about the regional distribution of their purchases and sales; however, due to budget restrictions, no follow-ups could be conducted so the response rate did not exceed 10%. In terms of employment the responding firms cover 6.7% of total employment in this industry in Austria.

The results of both surveys were extrapolated using employment weights for different firm size classes in each industry. The final results were then used as starting values in a RAS procedure applied to balancing the whole system of regional input-output tables.

The balancing procedure utilizes the following identity (see also equation 2.1 above): for each region and each commodity the value of total use of a commodity by firms and households within this region plus the value of regional and foreign exports must equal the total value of a commodity available in the region, i.e. the value of production by regional firms and the value of imports from other regions or from abroad. In other terms, whatever is consumed within the region or is exported must be produced somewhere, either in the region itself or in other regions or abroad. Equivalently, for each region and each commodity it must hold that the total value of production is equal to the total value of use of a regionally produced commodity within the region (by firms and households) plus the value of exports of regional production to other regions and abroad. In other terms, whatever is produced within the region must be consumed somewhere.

Chart 4: Balancing of Interregional Trade

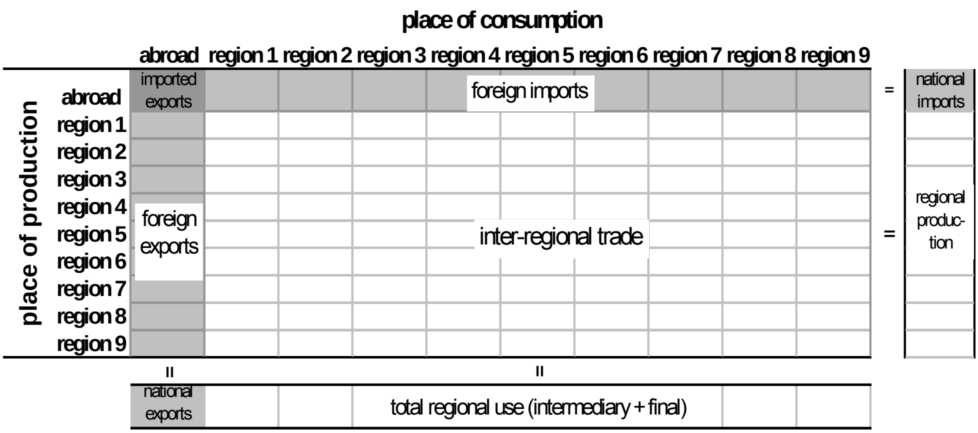


Chart 4 depicts a trade matrix on which these restrictions are imposed and which is set up for each commodity: the column sums contain total use in each region and the sum of foreign exports, the row sums show total regional production and the sum of foreign imports. These column and row sums are known from the regional make and use tables. Moreover, from our preliminary regionalization of national imports and exports we can fill the cells of the first column and the first row. The first column, however, does not contain regional total foreign exports: rather, it contains regional foreign exports net of regional imported exports (i.e. foreign exports of commodities which were previously imported into the region from abroad). The first cell in this column, then, contains total national imported exports, which are known from the Austrian input-output table. As for the interregional trade part, preliminary figures are available from the trade survey.

Assuming row and column sums as fixed, the trade flows can be taken as starting values such that a bi-proportional adaptation method (such as the well-known RAS-method, which was used in the present context) can be applied; the resulting tables represent a balanced multiregional input-output table system.

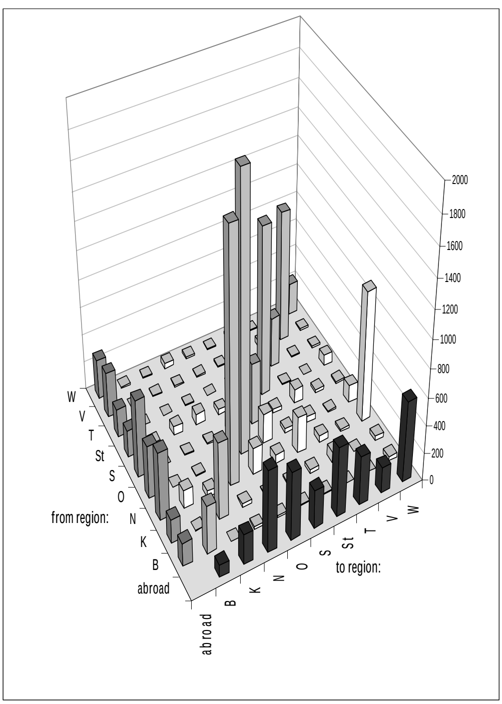
The major advantage of this method is that it allows for "cross-hauling": a commodity can at the same time be bought and sold by each region (instead of assuming that only "surplus production" is exported and only that part of demand is imported which cannot be satisfied out of regional production, respectively). The major drawback is that it disregards the possibility of "trans-shipping": this is the case when a commodity is imported into region 1 from region 2 and sold – unchanged – to region 3. From an input-output point of view this results mainly in a regional miss-allocation of trade (and transport) margins.

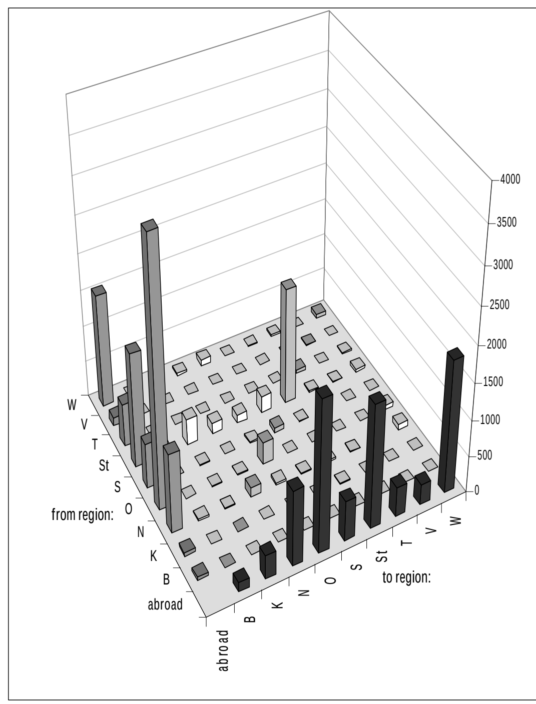
For most commodities the interregional trade flows after completing the balancing procedure do not greatly differ from the flows previously estimated.

Most cases where post-balancing trade flows do deviate significantly from pre-balancing flows concern industries where one or several larger companies did not participate in the survey.

Chart 5 shows interregional and international trade patterns for two commodities: food products (CAP 15, left diagram) are mainly regionally produced, although a significant part is internationally traded. Trade in vehicles (CPA 34, right diagram), on the other hand, is mostly external: although in terms of net exports, Austria is "self sufficient", the gross trade flows reveal that almost all vehicles which are consumed in Austria are imported while practically the whole domestic production of that commodity is exported.

Chart 5: Interregional and International Trade in Food and Vehicles (in Million EUR)





2.5 Regional Use Matrices for Regionally Produced Commodities

The final step of table compilation consisted of computing for each region matrices depicting the intermediate and final use of only those commodities that are produced within the region itself. Given these matrices and the region's make matrix a quadratic regional input-output table can be derived.

One important word of caution is to be issued with respect to these tables: When balancing the multiregional table system, regionally produced commodities were distinguished from commodities produced in other Austrian regions and those imported from abroad only with respect to total use. This implies that uniform import shares across all consuming industries and final consumption categories were assumed. Relaxing this assumption by collecting additional information on commodity use, possibly at a more disaggregated commodity level, is left to future efforts.

3. The Blocks of Econometric Equations

The econometric blocks of equations and their theoretical underpinnings are reported only very briefly in what follows. For a more elaborate description the reader is referred to Kratena and Zakarias (2001).

3.1 Factor Demand and Output Prices

This chapter depicts the determination of factor demand and output prices. The production factors modeled within MULTIREG comprise two variable factors, labor and a compound of intermediate goods, as well as a quasi-fixed, input capital. Following the approach usually adopted in the industrial organization literature, the price setting behavior of firms is treated within an overall model of goods and factor markets. The seminal paper for this approach is Appelbaum (1982), important examples which served as a basis for the approach adopted in MULTIREG include Berndt and Hesse (1986), Morrison (1989, 1990), Flaig and Steiner (1990), Conrad and Seitz (1994) and Meade (1998).

A Generalized Leontief cost function for each sector in each region was estimated and implemented in MULTIREG. Omitting indices denoting regions and commodities, this cost function GL (which is due to Diewert, 1971, and therefore sometimes also called the Diewert cost function) including a trend to capture technological progress (see Morrison, 1989) can generally be stated as:

$$
\begin{aligned}
\mathrm{GL}(q,\mathbf{p^{int}},\mathbf{x},t) = {} & q\left[\sum_{i=1}^{k}\sum_{j=1}^{k}\beta_{ij}\left(p_i^{\text{int}}p_j^{\text{int}}\right)^{1/2} + t^{1/2}\sum_{\text{i=1}}^{\text{k}}\beta_{it}p_i^{\text{int}} + t\sum_{\text{i=1}}^{\text{k}}\beta_{tt}p_i^{\text{int}}\right] + \\
& + q^{1/2}\left[\sum_{\text{i=1}}^{\text{k}}\sum_{l=1}^{m}\beta_{il}p_i^{\text{int}}x_l^{1/2} + 2\sum_{\text{i=1}}^{\text{k}}\beta_{tl}p_i^{\text{int}}t^{1/2}x_l^{1/2}\right] + \sum_{\text{i=1}}^{\text{k}}p_i^{\text{int}}\sum_{l=1}^{m}\sum_{k=1}^{m}\beta_{lk}\left(x_l x_k\right)^{1/2}
\end{aligned}
\tag{3.1}
$$

where q is (regional) output, p_i^{int} and p_j^{int} are input prices of the *k* variable inputs summarized in the price vector $\mathbf{p_i^{int}}$, x_l denotes the m fixed factors, t the trend component and the β are the parameters to be estimated. The cost function (3.1) is homogenous of degree one, exhibits constant returns to scale and will be concave in factor prices, if

$$\beta_{ij} = \beta_{ji},\ \forall i \neq j\,,$$

that is, the cross substitution elasticities β_{ij} and β_{ji} will be equal if the symmetry condition is satisfied; this restriction was imposed in the estimation process.

In the present application two variable inputs labor w with price wr and intermediate demand s with price ps as well as a quasi fixed factor, capital k, are used. By Shepard's Lemma the factor demand equations for intermediate inputs and labor can be obtained by taking the first derivatives of the cost function with respect to factor prices ps and wr. Imposing the symmetry condition and dividing the right hand side of the equation by total output q yields the shares of the variable input factors as a share of total output:

$$\frac{\partial \mathrm{GL}}{\partial ps}\cdot\frac{1}{q} = \frac{s}{q} = \beta_{ss} + \beta_{sw}\left(\frac{wr}{ps}\right)^{1/2} + \beta_{st}t^{1/2} + \beta_{tt}t + \beta_{sk}\left(\frac{k}{q}\right)^{1/2} + 2\beta_{tk}\left(\frac{k}{q}\right)^{1/2}t^{1/2} + \beta_{kk}\left(\frac{k}{q}\right) \tag{3.2}$$

$$\frac{\partial \mathrm{GL}}{\partial wr}\cdot\frac{1}{q} = \frac{w}{q} = \beta_{ww} + \beta_{sw}\left(\frac{ps}{wr}\right)^{1/2} + \beta_{wt}t^{1/2} + \beta_{tt}t + \beta_{wk}\left(\frac{k}{q}\right)^{1/2} + 2\beta_{tk}\left(\frac{k}{q}\right)^{1/2}t^{1/2} + \beta_{kk}\left(\frac{k}{q}\right) \tag{3.3}$$

In order to determine the price vector of regional output ($\mathbf{pd}$) endogenously the system is further expanded by a price equation. To allow for monopolistic competition, output prices must equal marginal costs multiplied by fixed mark-up μ which is determined during estimation:

$$pq = (1+\mu)\frac{\partial \mathrm{GL}}{\partial \mathrm{q}} = (1+\mu)\left[\begin{array}{l}\beta_{ss}ps + \beta_{sw}(ps \cdot wr)^{1/2} + \beta_{ws}(ps \cdot wr)^{1/2} + \beta_{ww}wr + \beta_{st}ps \cdot t^{1/2} + \\ + \beta_{wt}wr \cdot t^{1/2} + \beta_{tt}t(ps+wr) + \frac{1}{2}\left(\frac{\mathrm{k}}{\mathrm{q}}\right)^{1/2}\left(\beta_{sk}ps + \beta_{wk}wr + 2t^{1/2}\beta_{tk}(ps+wr)\right)\end{array}\right] \quad (3.4)$$

The final system of equations estimated within MULTIREG to determine factor demands and output prices for each sector in each region hence consists of equations (3.2), (3.3) as well as (3.4).

3.2 Components of Final Demand

3.2.1 Investment Demand

A common way to model investment demand, which is applied here as well, utilizes the deviation of the actual capital stock from its optimal value, which can be derived from the cost function estimated above. In a first step the shadow price of capital can be obtained by taking the derivative of the cost function with respect to capital k multiplied by (–1):

$$pk^* = -\frac{\partial GL}{\partial k} = -\frac{1}{2}\left(\frac{q}{k}\right)^{1/2}\left[\beta_{sk}ps + \beta_{wk}wr + 2t^{1/2}\beta_{tk}(ps+wr)\right] - \beta_{kk}(ps+wr) \quad (3.5)$$

In equilibrium, the shadow price of capital will equal the price of capital pk (which can be determined only approximately via the composition of capital stock in each sector). Introducing this equality, equation (3.5) is reformulated and the market price of capital substitutes the shadow price. This yields the equilibrium or optimal value of capital, k^*, at each point in time:

$$k^* = q\left[-\frac{\beta_{sk}ps + \beta_{wk}wr + 2t^{1/2}\beta_{tk}(ps+wr)}{2(pk + \beta_{kk}(ps+wr))}\right]^2 \quad (3.6)$$

Given the optimal amount of capital at each point in time, investment demand is made dependent on a stock adjustment process of the current capital stock k to its desired level k^* (Czerny et al., 1997, Appendix A), which – after taking logarithms – is implemented as:

$$\Delta\log\left(k_{i,t}\right)=\tau_1\left[\log\left(k_{i,t}^*\right)-\log\left(k_{i,t-1}\right)\right]+\tau_2\Delta\log\left(k_{i,t-1}\right). \tag{3.7}$$

A necessary condition for (3.7) to converge to an equilibrium is for τ_1 to be positive, while the second parameter is subject to no constraint; if τ_2 lies between 0 and 1, adjustment to initial shocks will be slow (the smaller the value, the slower the adjustment) while for estimated values larger than one initial shocks might lead to an overshooting of the desired capital stock k^*. Negative values of τ_2 on the other hand will lead to cyclical fluctuations in the adjustment process.

The model can finally be closed by explaining the desired capital stock k^*. A natural way of doing this would be to utilize capital as explained by the Generalized Leontief cost functions described above, whenever user costs of capital are given. The adjustment process then would depend on the difference between user costs and the shadow price of capital estimated in the cost functions. In Czerny et al. (1997) k^* is furthermore depending on disposable income, interest rates, active population, rents as well as inflation. The absence of user costs of capital in the database, however, prohibits the application of this approach in MULTIREG and hence it has to be assumed that k^* equals some (positive) function of the current level of output only. That is:

$$\log\left(k_{i,t}^*\right)=\mathrm{F}\left[\log\left(q_{i,t}\right)\right]. \tag{3.8}$$

Inserting the optimal capital stock into (3.7) above yields the stock adjustment equation, which is the final equation estimated to determine investment demand in each sector:

$$\Delta\log\left(k_{i,t}\right)=\alpha_k+\beta_k\log\left(q_{i,t}\right)-\tau_1\log\left(k_{i,t-1}\right)+\tau_2\Delta\log\left(k_{i,t-1}\right). \tag{3.9}$$

The parameter β_k comprises the (necessarily positive) value of τ_1 and some positive value for the relationship between regional output and the optimal capital stock k^*. Hence, β_k must be positive, while the estimated parameter value on $\log(k_{i,t-1})$ has to be negative (the negative of a necessarily positive parameter).

Finally, adding the depreciation of capital stock in the current period to (3.9) by applying the same rates assumed throughout the set up of the time series for capital stock by industries yields investment:

$$I_i=\Delta\log\left(k_{i,t}\right)+\delta_i\cdot k_{i,t-1}. \tag{3.10}$$

3.2.2 Private Consumption

Private consumption was estimated applying the linear approximation of the well known Almost Ideal Demand System (AIDS; see Deaton and Muellbauer, 1980). For private consumption data at the regional level are not readily available. Their compilation would involve considerable effort which is left to future revisions of the model. Instead, the demand system estimated at the national level was applied to each region. The choice of consumption groups puts emphasis on transport categories and hence the following categories were modeled:

Table 1: Classification of Consumption Categories

1	Food, Drink and Tobacco
2	Clothing and Footwear
3	Medical Care
4	Purchases of Vehicles
5	Operation of Personal Transport Equipment
6	Transport Services
7	Communications and Entertainment
8	Restaurants, Hotels
9	Other Goods and Services

In selecting these groups emphasis was also placed on an approximately equal-sized distribution of the groups. Furthermore, groups consisting mainly of non-durable goods other than demand for vehicles did not enter the demand system; moreover, due to imputed components in the series for rents and housing expenditure, this group – along with durable consumption goods – is treated outside the demand system in single equations.
The budget shares equations for the AIDS can be written as:

$$\mathrm{w_i} = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{\mathrm{x}}{P_1}\right). \tag{3.11}$$

In (3.11) w_i denotes the budget share of commodity i, x are the total nominal outlays on the commodities treated within the AIDS-model and P_1 is an aggregated price index, which is set up according to Stone (1954):

$$\log P_1 = \sum_k \mathrm{w}_\mathrm{k} \log p_k \quad . \tag{3.12}$$

When the system of budget share equations (3.11) above shall satisfy the standard properties of demand functions, three sets of restrictions have to be implied on the estimated parameters. First, for (3.11) to satisfy the Adding-Up condition it must hold true that:

$$\sum_{i=1}^{n} \alpha_i = 1; \; \sum_{i=1}^{n} \gamma_{ij} = 0; \; \sum_{i=1}^{n} \beta_i = 0 \quad . \tag{3.13}$$

It can easily be checked that if restrictions (3.13) are inserted into the budget shares equation (3.11), the sum of budget shares w_i over i will equal one, which is what Adding-Up requires. In terms of interpreting the budget shares equation note that this also means that the shares remain constant if prices and real total expenditure remain unchanged. The Adding-Up property will automatically be satisfied in empirical analysis whenever the data used in estimation add up perfectly. Homogeneity in prices and total expenditure is assured if:

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \quad . \tag{3.14}$$

Finally, symmetry of the Slutsky – equation is attained by:

$$\gamma_{ij} = \gamma_{ji} \; . \tag{3.15}$$

Both the homogeneity as well as the symmetry restriction was imposed during the estimation process in MULTIREG.

Disposable income was obtained via an error-correction type equation using total value added in the respective region as regressor. Total outlays on the commodities treated within the AIDS were obtained via a two stage budgeting process, first determining the outlays on the durable consumption goods.

The necessary transition of consumption demand categories estimated in the AIDS-model into demand for commodities in the input-output part of the model was accomplished via a bridge matrix which was available for the 1995-input-output table and whose coefficients were extrapolated to the year 2000.

3.2.3 Foreign Exports and Government Consumption

Both foreign exports as well as public consumption are treated as exogenous in the prevailing version of MULTIREG. Future revisions of the model will include the determination of foreign demand by a simple model of world production.

3.2.4 Foreign Imports

The foreign import shares in nominal terms for each commodity k, $mn_i^{f,k} / qn_i^k$ **,** are modeled by an equation derived from an linear approximate AIDS-model (Deaton and Muellbauer, 1980) to split up between domestic and imported commodities:

$$\frac{mn_i^{f,k}}{qn_i^k} = \alpha_m + \gamma_{md} \log pq_i^k + \gamma_{mm} \log pm^k + \beta_m \log\left(\frac{qn_i^k}{P_i}\right), \tag{3.16}$$

where P_i denotes the Stone-price-index formed with the output and import price of commodity k; mn, qn are the nominal values of imports and output, with pm and pq the respective prices.

3.2.5 Regional Exports and Imports

Regional exports and imports are linked by the trade shares matrix $\mathbf{T_{ij}^k}$ for *i* and *j* as the regional indices and for k commodities:

$$ex_i^{r,k} = \sum_{j=1}^{n} \left(\mathbf{T_{ij}^k} * m_j^{r,k} \right) \tag{3.17}$$

As this trade share matrix includes the elements $i = j$, i.e. the deliveries to the own region, the sum of regional imports of commodity k, $m_i^{r,k}$, is given by the commodity balance:

$$m_i^{r,k} = q_i^k - q_i^{d,k} - m_i^{f,k}. \tag{3.18}$$

The trade shares matrix is directly linked to the road transport flow matrix $\mathbf{TR}^l$ (in volumes) where the commodity index l represents an aggregation of the commodity index k according to different classifications in economic and transport statistics.

The development of each element of this matrix at time *t*, $tr_{ij,t}^l$, is a result of the application of a gravity model at the subregional level. For those commodities for which road transport plays an important role and for which commodity classification l corresponds to classification *k* the estimated development path is applied to the elements of the trade shares matrix $t^{l}_{ij,t}$. This procedure, which is described in more detail in section 0 below, yields an adapted trade shares matrix, which is then re-inserted into the model to derive a new solution for output and all other endogenous variables, especially road transport flows. The loop between output, road transport flows, and trade shares is applied in an iterative mechanism until convergence of the model solution is achieved. This method guarantees a fully consistent modeling of road transport flows, regional production and interregional trade.

Other stochastic equations in MULTIREG, not shown here, comprise wage equations as well as error correction-type equations determining disposable income and total consumption. Furthermore, several price feedbacks are modeled: one is from the domestic output price estimated in (3.4) above to the compound price index of intermediate demand for each industry, another concerns the commodity prices (and hence the inflation rate which is also part of the wage equations) which also respond to changes in the domestic output prices.

4. Updating the Technical Input–Output Coefficients

The issue of updating input-output coefficients has had a long tradition in economics, since there are a number of reasons why those coefficients do not remain constant over time (some of those comprise technological change, variations in the product mix, price changes, input substitutions or shifts in trade patterns). Especially when an input-output model is applied to long-term projections, the per se static nature of its input-output coefficients must therefore be overcome. The updating mechanism of each matrix $\mathbf{A_i}$ incorporated in MULTIREG further expands the approach proposed by Kratena and Zakarias (2004). The updating process "along the rows" (see e.g. Conway, 1990; Israilevich et al., 1996) is thereby supplemented by an adjustment "along the columns". Kratena and Zakarias (2004) demonstrate empirically that their more comprehensive updating procedure results in a better estimation of the true coefficients of the underlying matrix. However, as their method involves only a one time adjustment of columns followed by a one time adjustment of rows, they also find that a full RAS performs even better. As a consequence, in MULTIREG a full bi-proportional adjustment was implemented.

Such an adjustment requires that the row and column sums of matrix $\mathbf{A_i}$, i.e. the constraints necessary to make the RAS approach applicable, are determined endogenously within the model.

To begin with, the endogenous determination of the rows sums of matrix $\mathbf{A_i}$ involves the traditional estimation of the deviations of total intermediate demand from its so-called "hypothetical" value. The latter series is obtained by multiplying total demand in each year by matrix $\mathbf{A_i}$ for the base year.

More formally, the starting point to determine the constraint for the row sum of matrix $\mathbf{A_i}$ is the following relationship already stated above:

$$\mathbf{q_i} = \mathbf{A_i} \cdot \mathbf{q_i^d} + \mathbf{f_i} . \tag{4.1}$$

Subtracting the vector of final demand from total goods demand in region *i* yields intermediate demand:

$$\mathbf{q_i^{int}} :$$

$$\mathbf{q_i} - \mathbf{f_i} = \mathbf{q_i^{int}} = \mathbf{A_i} \cdot \mathbf{q_i^d} . \tag{4.2}$$

Introducing time subscripts to the equation on the left hand side above yields:

$$\mathbf{q}_{\mathbf{i},t} - \mathbf{f}_{\mathbf{i},t} = \mathbf{q}_{\mathbf{i},t}^{\mathbf{int}} , \tag{4.3}$$

that is, the time series of intermediate demand. However, if one takes the right hand side of equation (4.2) above and adds time subscripts, the result is a so called “hypothetical” series of intermediate demand, $\tilde{\mathbf{q}}_{\mathbf{i},t}^{\mathbf{int}}$:

$$\tilde{\mathbf{q}}_{\mathbf{i},t}^{\mathbf{int}} = \mathbf{A_i} \cdot \mathbf{q_i^d} . \tag{4.4}$$

The difference between the two series is, of course, that matrix $\mathbf{A_i}$ is held constant over time as it is available only for the base year. The deviations of actual intermediate demand from its hypothetical counterpart can be attributed to the changes in coefficients within matrix $\mathbf{A_i}$. Now, the relationship between $\tilde{\mathbf{q}}_{\mathbf{i}}^{\mathbf{int}}$ and $\mathbf{q_i^{int}}$ over time can be stated as:

$$\hat{\mathbf{r}}_{\mathbf{t}} \tilde{\mathbf{q}}_{\mathbf{i},t}^{\mathbf{int}} = \mathbf{q}_{\mathbf{i},t}^{\mathbf{int}} . \tag{4.5}$$

where $\mathbf{r_t}$ is an estimable vector. Inserting (4.5) into (4.4) and rearranging terms yields the following relationship:

$$\hat{\mathbf{r}}_{\mathbf{t}} \cdot \mathbf{A_i} \cdot \mathbf{q}_{\mathbf{i},t}^{\mathbf{int}} = \mathbf{q}_{\mathbf{i},t}^{\mathbf{int}} . \tag{4.6}$$

Hence, each row of matrix $\mathbf{A_i}$ is updated each year with the respective constant factor from vector $\mathbf{r_t}$. Equation (4.6) is at the same time the relationship that allows for the endogenous determination of intermediate demand within the model, once the elements of $\mathbf{r_t}$ are known. Kratena and Zakarias (2004) suggest estimating an error correction model on (4.5) which is also applied here. As the final demand components are also known – either modeled endogenously (investment, private consumption) or given exogenously (foreign exports and government consumption) – the share of intermediate goods demand in total demand can be computed. As a result, this yields the row sum of matrix $\mathbf{A_i}$ and hence the first restriction needed to make the RAS approach operable.

The derivation of the second restriction necessary to implement a RAS on matrix $\mathbf{A_i}$ is straightforward. Recalling that the factor demand equation (3.2) above derived the share s/q (in the notation introduced above, omitting indices for the region as well as the commodity) it becomes immediately obvious that this share is also equal to the column sum of matrix $\mathbf{A_i}$. Once both restrictions required for the implementation of a RAS are given the adjustment procedure can be implemented, even though this implementation comes at a high programming cost.

5. Updating the Coefficients of the Trade Matrix

Chapter 2 above described the derivation of the trade matrix for the year 2000. This chapter deals with aspect of the dynamization of this static trade matrix.

Conceptually, two components of trade dynamics are distinguished. The first one is the regional structure of production: if production of some commodities expands in a region, regional exports from this region to others should expand as well (probably disproportionately so). But even assuming constant regional production levels, trade between regions is likely to increase due to deepening regional specialisation. These two factors are dealt with separately: the trade impact of regional production levels is modeled by a cross-sectional gravity model, the impact of deepening regional specialisation by a time-series analysis of total transport volumes.

5.1 A Gravity Model

The gravity model is based on transport survey data from which transport is inferred at a sub regional level. Data are disaggregated into 14 commodity groups which are composites of the NSTR-24 classification of commodities (see Table 2). The geographical unit is the district and only transport flows among Austrian districts are considered in the analysis. All in all, transport flows of 14 commodities between 99 districts[5] can be distinguished in the base year. The formal structure of the transport model is rather ad hoc. This is due to the framework for which it had been developed in the first place, viz. a project which aimed at forecasting inter-district transport volumes.

Table 2: Commodity Classification of the Gravity Model

Multireg group	NSTR 24	definition	Multireg group	NSTR 24	definition
A	1,2,3,7	agricultural products	H	13,21	metal products
B	4	timber	I	14,22	construction materials
C	5,23	textile and leather	J	15	crude and processed minerals
D	6	food and animal feed	K	16,17,18	fertilizer, chemical products
E	8	solid mineral fuel	L	19	pulp and paper
F	9,10	crude and refined petroleum	M	20	vehicles, machines, machine parts
G	11,12	iron and metal ores; scrap metal	N	24	special transport goods

The model follows a two-step approach: in the first stage the total volume of shipments which would enter or leave a district given the size of the district's economy was estimated, while in the second stage, total in- and outbound transport was allocated to sending and receiving districts by a gravity model. In this way plausible shipments between districts could be computed that match up with local production possibilities[6]. A RAS was used to ensure that the total inbound transport volume equalled total outbound transport volume. The step 1 model was quite simple: total in- and outbound transport was modeled on various indicators of economic activity (similar to the indicators of "economic mass" used in the gravity model; see below) and/or population.

The second step follows a modified gravity approach: flows between districts are (positively) influenced by "economic mass" and (negatively) by the distance between them. In our case, distance is represented by average travel time between each pair of districts. The indicator of "economic mass" depends on the commodity being modeled: it is approximated by a district's output value of industries which either produce or consume the respective good in significant quantities. For instance, transport of building materials is assumed to be influenced by the size of a district's cement-producing industry on the one hand and the size of its construction industry on the other. Each commodity, therefore, is modeled by a gravity model which is specific with respect to the indicator of "economic mass". The measure of distance, though, is identical for all commodities.

[5] Austria is divided into nine federal provinces and 121 districts. The 23 districts making up Vienna, though, are lumped together, leaving 99 different (groups of) districts.

[6] The "pure gravity approach", i.e. omitting step 1, resulted in what might be termed the "small neighbour problem": for small districts which are located close to large ones the model sometimes produced implausibly high transport volumes.

The main modification as compared with usual applications of the gravity model concerns its functional form: whereas in most cases the model is estimated in logarithms here levels are used. The reason for this is that at the district level quite a few industries which might influence transport volumes are present only in a minority of districts. This is a problem as some transport commodities are regressed on the output levels of as much as five or six different industries. Using a logarithmic function, districts where only one of those industries has zero production would drop out of the estimation, thus appreciably reducing the sample size. Moreover, the heteroscedasticity-correcting quality inherent in the logarithmic approach has some drawbacks in the present case. The basic form of the equations, thus, is

$$TR_{ij}^{c} = \alpha_l + \sum_n \beta_n \left(q_i^n / dist_{ij}\right) + \sum_m \beta_m \left(q_j^m / dist_{ji}\right), \qquad (5.1)$$

with TR_{ij}^{c} being the transport volume of commodity c from district i to district j, and $dist_{ij}$ being the average travelling time between the respective districts. q_i^n are output levels of the n industries thought to influence transport volumes on the part of the source district; typically the industries used here are those that produce the commodity for which the model is set up. Analogously, q_{ji}^{m} are m industry output levels which determine the transport flows in the target district; here mostly industries are included which use the respective commodity.

A second modification was implemented as well: for all NSTR commodities, not all of the 99x99 transport relations among districts exhibit positive values (for less important commodities, e.g. group E – solid mineral fuel – positive transport values for less than 3% of all 9801 district relations are observed). This is not really surprising given the very detailed level of geographical disaggregation (after all, on average, a district accounts for as little as about 30 000 employees). The gravity model implemented in levels, though, allots a value to each and every district relation. To solve this dilemma, a two-stage gravity model was estimated: in the first stage, a binary (probit) model is used to determine whether some relation should be attributed any transport flow at all; only if the model results do suggest that such flows exist, a concrete value for the transport volume is estimated by the proper gravity model. Technically, the regressors used in the probit model are essentially the same as those used in the respective gravity equation (thus mimicking a "threshold model").

For their implementation in MULTIREG the transport flows estimated for the 99 districts were aggregated to the level of the nine regions modeled in MULTIREG. At the regional level the transport flows were translated into trade flows via a 9x9 bridge matrix. The link between the different classifications of the gravity model on the one hand and the trade model on the other hand was solved econometrically: for each of the 55 NACE commodities, a linear combination of the 14 NSTR transport matrices was estimated to ensure maximum correlation.

The reason for modeling trade and transport flows at different levels of regional aggregation is due to data availability issues: as transport data were available for one year only, a pure cross-section approach had to be applied. An aggregation to the level of the nine regions at this pre-modeling stage, however, had to be ruled out, as it would render the distance variable meaningless (the nine regions feature highly diverse areas: the largest region, Lower Austria, covers about a quarter of Austria and thus more than the four smallest regions combined). For this reason, gravity modeling proceeded at the district level. Consequently in simulations with MULTIREG results are broken down from the regional to the district level (distinguishing between different types of districts in the process: rural, urban, peripheral) to be fed into the gravity model; results from the gravity model are then re-aggregated to the regional level and fed back into the other blocks of MULTIREG.

5.2 Simulations with the Transport Model

One problem of the gravity model concerned its restriction to cross section data; any time series information was lacking. This drawback was overcome by introducing a block of transport equations that links regional economic output to an overall amount of transport volume shipped as inland traffic. Apart from changing output levels, these equations also consider time-varying transport intensities in each industry.

The simulation of interregional trade thus proceeds as follows: in the first step total transport volume $\mathbf{TR}_{\mathbf{tot}}$ is calculated based on the transport equations. Then, for given output levels for all districts, this total transport volume is broken down to the 99 districts, separately for inbound and outbound transport volumes ($\mathbf{TR}_{\mathbf{j}}$ and $\mathbf{TR}_{i}$, respectively). In the third step, for each cell of $\mathbf{TR}_{i\mathbf{j}}$, the probit-model determines whether this particular relation from district *i* to district *j* carries any transport at all. If so, the proper gravity model is used in step four to estimate the transport volume between districts *i* and *j*. A RAS is employed to ensure the compliance of the gravity model's results with the previously determined in- and outbound transport volumes.

Once the model is solved at the district level, a 9x9 regional transport matrix is compiled by simply by aggregating over all districts within a region (see chart 6). The last step involves using the bridge matrix linking transport and trade at the regional level to finally arrive at the new trade matrix.

Chart 6: The Transport Matrix

TR_{tot} / to district: / from district:	1	2	3	4	5	6	7	8	9	.	.	98	99	total outbound transport
1	$TR_{1\,1}$	$TR_{1\,2}$	$TR_{1\,3}$	$TR_{1\,4}$	$TR_{1\,5}$	$TR_{1\,6}$	$TR_{1\,7}$	$TR_{1\,8}$	$TR_{1\,9}$					$\Sigma = TR_{1.}$
2	$TR_{2\,1}$	$TR_{2\,2}$	$TR_{2\,3}$	$TR_{2\,4}$	$TR_{2\,5}$									$\Sigma = TR_{2.}$
3	$TR_{3\,1}$	$TR_{3\,2}$	$TR_{3\,3}$	$TR_{3\,4}$										$\Sigma = TR_{3.}$
4	$TR_{4\,1}$	$TR_{4\,2}$	$TR_{4\,3}$											$\Sigma = TR_{4.}$
5	$TR_{5\,1}$	$TR_{5\,2}$												$\Sigma = TR_{5.}$
6	$TR_{6\,1}$													$\Sigma = TR_{6.}$
7	$TR_{7\,1}$													$\Sigma = TR_{7.}$
8	$TR_{8\,1}$													$\Sigma = TR_{8.}$
9	$TR_{9\,1}$													$\Sigma = TR_{9.}$
.														
.														
98													$TR_{98\,99}$	$\Sigma = TR_{98.}$
99												$TR_{99\,98}$	$TR_{99\,99}$	$\Sigma = TR_{99.}$
total inbound transport	$\Sigma = TR_{.1}$	$\Sigma = TR_{.2}$	$\Sigma = TR_{.3}$	$\Sigma = TR_{.4}$	$\Sigma = TR_{.5}$	$\Sigma = TR_{.6}$	$\Sigma = TR_{.7}$	$\Sigma = TR_{.8}$	$\Sigma = TR_{.9}$			$\Sigma = TR_{.98}$	$\Sigma = TR_{.99}$	$\Sigma = TR_{tot}$

6. Summary and Conclusions

While regional models integrating econometric and input-output approaches are fairly widespread, only a few of them truly operate on a spatially disaggregate level.[7] Modeling the nine Austrian federal provinces, MULTIREG links a multiregional make-use system with region-specific econometric equations and thus qualifies to be a member of the exclusive club of spatially disaggregate integrated models.

Three strong points of MULTIREG are to be stressed: In developing the model, an extensive regional database was set up and used both for the compilation of input-output block of the model as well as for estimating its econometric equations. Furthermore, most of these econometric equations are derived from microeconomic theory; hence MULTIREG departs from the much more empirically oriented econometric approach of its single-region predecessors.

Rather innovative ways of modeling are followed with respect to time-adjusting both the technical coefficients of intermediate input use as well as the interregional

[7] For a discussion of multiregional linkages in integrated models see Rey (2000). He identifies only three models, by Dewhurst and West (1990), Kort and Cartwright (1981) and Rey and Dev (1997), that are spatially disaggregate.

trade flows. The static nature input-output coefficients has been at the core of input-output model criticism; at the interregional level constant trade flows were strongly brought forward against such models. Therefore, even though there are numerous shortcomings the MULTIREG approach may suffer from, allowing for time-dependent changes in input-output coefficients and trade flows tackles important modeling problems.

Any discussion of MULTIREG's merits and flaws, however, is strongly hampered by the fact that a first version of the model has just been completed but is still being extensively tested by its developers. Therefore, no model simulations are available at this time. Further evaluation of the model will have to await these simulations as well as the models performance "in practice", i.e. when applied to answer regional economic policy questions.

Appendix

Chart A1: Map of Austria and the Nine Federal Provinces Included in MULTIREG

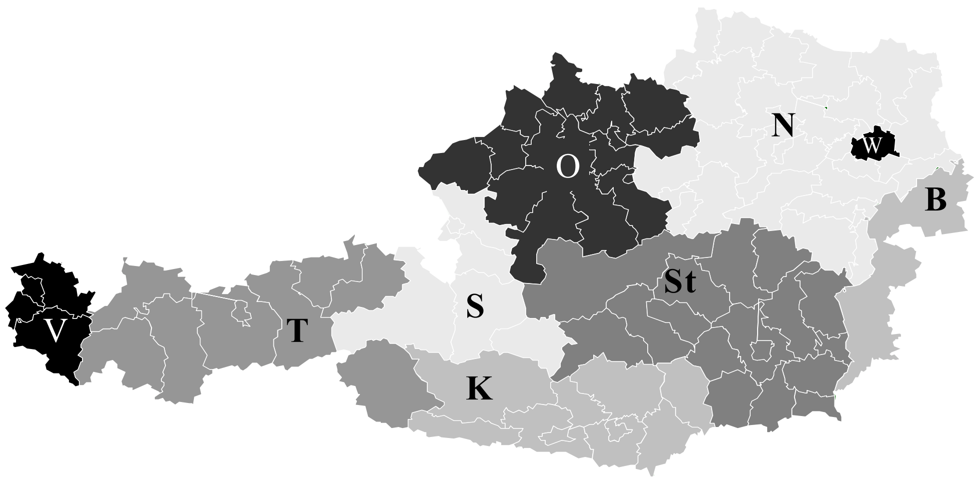


Table A1: Summary Statistics on the Nine Regions Included in MULTIREG

Code	Region		population 2000	GRP 2000 [Mio €]	GRP/pop [1000 €]
B	Burgenland		277,962	4,467	16.1
K	Kärnten	*Carinthia*	563,207	11,549	20.5
N	Niederösterreich	*Lower Austria*	1,542,393	30,901	20.0
O	Oberösterreich	*Upper Austria*	1,379,524	31,605	22.9
S	Salzburg		517,096	13,785	26.7
St	Steiermark	*Styria*	1,202,275	24,418	20.3
T	Tirol	*Tyrol*	669,710	16,189	24.2
V	Vorarlberg		349,421	8,658	24.8
W	Wien	*Vienna*	1,608,656	52,840	32.8
A	Österreich	*Austria*	8,110,244	194,413	24.0

Source: Statistik Austria.

Table A2: Industries Included in MULTIREG

NACE	MultiREG Sector	Definition
1	1	Agriculture, hunting and related service activities
2	1	Forestry, logging and related service activities
5	1	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
10	2	Mining of coal and lignite; extraction of peat
11	2	Extration of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying
12	2	Mining of uranium and thorium ores
13	2	Mining of metal ores
14	2	Other mining and quarrying
15	3	Food products and beverages
16	3	Manufacture of tobacco products
17	4	Manufacture of textiles
18	4	Manufacture of wearing apparel; dressing and dyeing of fur
19	4	Tanning and dressing of leather; manufacture of luggage, handbages, saddlery, harness and footwear
20	5	Manufacture of wood and of products of wood and cork, except furniture; Manufacture of articles of straw and plainting material
21	6	Manufacture of pulp, paper and paper products
22	7	Publishing, printing and reproduction of recorded media
23	8	Manufacture of coke, refined petroleum products and nuclear fuel
24	8	Manufacture of chemical and chemical products
25	9	Manufacture of rubber and plastic products
26	10	Manufacture of other non-metallic mineral products
27	11	Manufacture of basic metals
28	11	Manufacture of fabricated metal products, except machinery and equipment
29	12	Manufacture of machinery and equipment n. e. c.
30	13	Manufacture of office machinery and computers
31	13	Manufacture of electrical machinery and apparatus n. e. c.
32	13	Manufacture of radio, television and communication equipment and apparatus
33	13	Manufacture of medical, precision and optical instruments, watches and clocks
34	14	Manufacture of motor vehicles, trailers and semi-trailers
35	14	Manufacture of other transport equipment
36	15	Manufacture of furniture; manufacturing n. e. c.
37	15	Recycling
40	16	Electricity, gas, steam and hot water supply
41	16	Collection, purification and distribution of water
45	17	Construction
50	18	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51	18	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	18	Retail trade, except of motor vehicles and motor cycles; repair of personal and household goods
55	19	Hotels and Restaurants
60	20	Land transport; transport via pipelines
61	21	Water transport
62	21	Air transport
63	22	Supporting and auxiliary transport activities; activities of travel agencies
64	23	Post and telecommunications
65	24	Financial intermediation, except insurance and pension funding
66	24	Insurance and pension funding, except compulsory social security
67	24	Acivities auxiliary to financial intermediation
70	25	Real estate activities
71	25	Renting of machinery and equipment without operator and of personal and household goods
72	26	Computer and related activities
73	27	Research and development
74	27	Other business activities
75	28	Public administration and defence; compulsory social security
80	29	Education
85	30	Health and social work
90	31	Sewage and refuse disposal, sanitation and similar activities
91	31	Activities of membership organizations n. e. c.
92	32	Recreational, cultural and sporting activities
93	32	Other service activities
95	32	Private households with employed persons

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1^{st} Comment on "MULTIMAC IV and MULTIREG"

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1. Advantages and Drawbacks of Input-Output Modelling

Various empirical analyses demonstrate the compatibility and versatility of input-output models.
Advantages of I/O models:

From a mathematical point of view I/O models are methodically quite simple. One of the most powerful uses of I/O techniques is the estimation of direct and indirect effects on macroeconomic aggregates like final demand, consumption, etc. The examination of direct and indirect demand magnifies the relationship between the sectoral structure of the economy (on a quite disaggregated basis) and infrastructure demand. Therefore, I/O is used to analyse alternative development scenarios.

But there are some *limitations* of these techniques to be mentioned. First of all, there is the assumption that each sector's output is homogenous (i.e., each sector produces exactly one product). Furthermore, basic I/O models assume linear production technology, i.e. factor inputs of each sector are proportional to the sector's production. This has two aspects: on the one hand there is no substitution possibility within the factor inputs (=> independence of relative factor prices) and on the other hand the assumption of constant returns to scale.

Secondly, feedback from foreign countries and overseas linkages are not taken into account. Increased import demand introduces additional production and demand abroad, via intermediate imports a part of the additional value added takes effect abroad). The only possible way out is the application of multi-country models.

A third drawback is the current publication timetable in Austria. I/O tables are published with a quite long time-lag (the I/O table 2000 was published in spring 2004). Structural changes and productivity shifts occurring between two publication dates are not taken into account.

The technical coefficients are per se static. But in practise, and as shown within both papers, the integration of I/O techniques within a model based on behavioural equations offers a dynamic approach to evaluate various economic and sectoral questions on a quantitative basis.

2. Comment on "MULTIMAC IV – a Disaggregated Macroeconomic Model of the Austrian Economy"

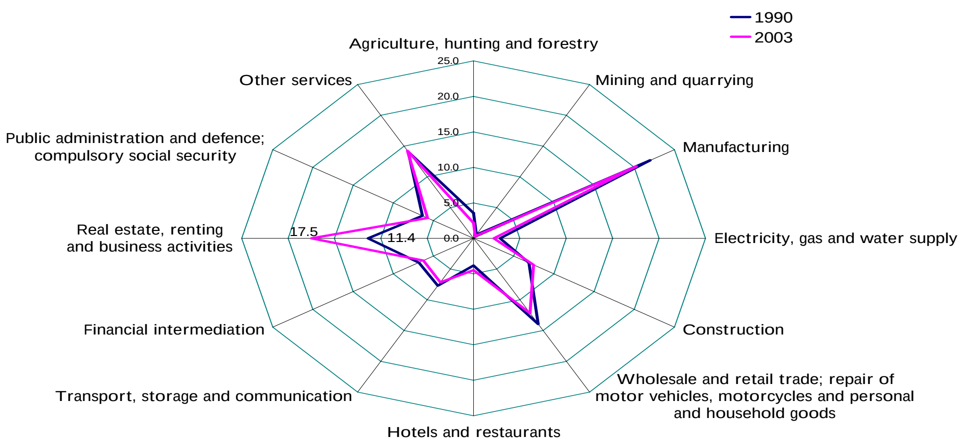
MULTIMAC is presented as a powerful tool to calculate and evaluate many policy-relevant questions and topics. It allows for estimation of various economic and environmental impacts of a proposed macroeconomic measure. Within his presentation, Kurt Kratena gives 2 examples: the analysis of road pricing effects and the implications of increased IT investment.

The model of the paper is in contrast to its predecessors following ESA 95 and includes ESA95 data starting 1988. As this is from an econometric point of view a quite short time period with a reduced number of data points available, the authors tried to expand the time series to the starting point 1976 (therefore they had to use ESA79 and Betriebssystematik 68 data). This procedure gives good results for the variables GDP, value added, salaries and employment. But it causes problems regarding the variables imports, exports and investment. Later on, this has an impact within the modelling procedure and limits the capability to use these series in regression equations. For final demand the short data series is a major restriction for the regression analyses within the model.

- *Proposal*: A restriction/drawback is the fact that investment data are not available on a more disaggregated level. Instead having them in a 37 sectors disaggregation, there are only 10 sectors implemented (the important sector manufacturing is just 1(!) sector.
- I propose to implement the investment matrices which will be produced within the I/O calculations and will be available in a 5 years rhythm.
- *Proposal*: private consumption: Within the sub sector Communication (a sector that has become more important in recent years) a further disaggregation would make sense.
- *Proposal*: Within the imports for services, import prices are set equal to consumer prices. I think setting import prices equal to the import deflator would make sense (the import prices include trade and profit margins, while the CPI displays the consumers' behaviour)
- *Problem/Question*: For linking national accounts with the I/O tables bridging tables are constructed. A drawback is the fact of keeping these bridging tables constant.
- *Problem/Question*: Inventories (and changes in inventories) are missing. They are not displayed within the model!

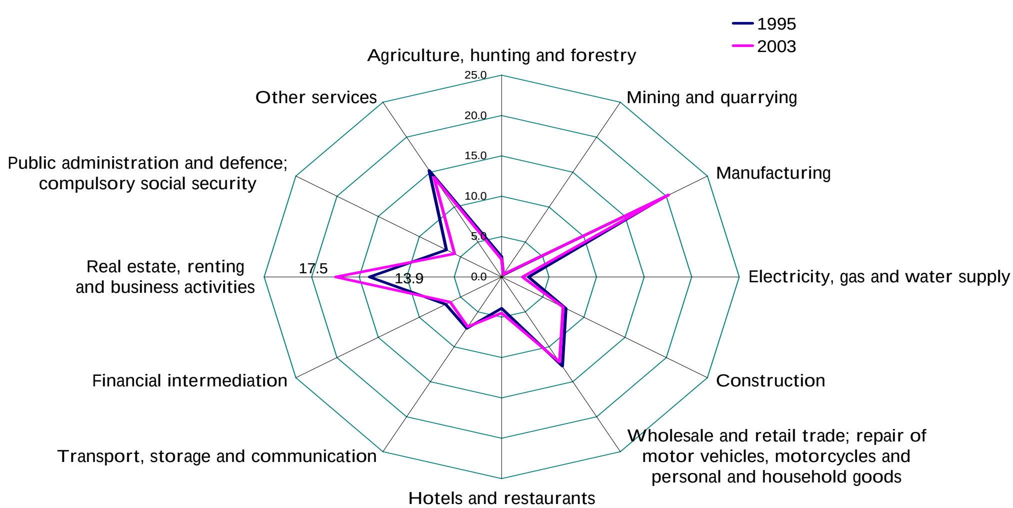
- *Problem/Question*: MULTIMAC IV is based on I/O tables 1990 and on tables based on prices 1995 respectively. But in Austria since 1990 and even since 1995, there were quite great productivity shifts within sectors. An update is strongly recommended.

Chart 1: Gross Value Added in Austria 1990–2003 (Share in % of total)



Source: Statistik Austria.

Chart 2: Gross Value Added in Austria 1995–2003 (Share in % of total)



3. The Challenges of Regional Impact Analysis

3.1 Advantages

- Evaluation of the performance of key sectors in the regional economy
- Ability to calculate a gross *regional* product
- Ability to evaluate possible direct and indirect economic effects on a regional basis

Therefore, regional I/O modelling is often used as basis for regional planning (specialisation, diversification, search for new markets, finding of economic clusters).

There exist three approaches to construct regional I/O models. The paper includes elements of all three methods:

- *top down approach* (national data are disaggregated into regional components: after 1995 a top-down disaggregation into a 2-digit level was conducted)
- *bottom up approach* (undertakes a survey of all firms of a region to obtain aggregated data for the regions input supply and outputs: for data series starting before 1995 this approach was used by incorporating secondary statistics)
- *hybrid methods* (a top down disaggregation of the national model and afterwards selective surveys of some key sectors)

3.2 Disadvantage: Missing Data for Regional I/O

- Often data series on a regional level are not available
- Calculation of regional technical coefficients
- Data on regional imports, regional exports, some price indices

4. Comment on “MULTIREG - A Multiregional Integrated Econometric Input-Output Model for Austria

- *Proposal:* In chart 1 (trade matrix) the reader does not get a clear information that the regions are the nine provinces of Austria. Later on, this is stated for the first time. It would be helpful to make this a bit clearer by adapting chart 1 in this way.

- *Proposal:* For the regionalisation of private consumption, the problem occurs that the regional consumption is measured at the *place of residence* while within the I/O tables the *place of consumption* concept is used. Adjustment for domestic tourism and shopping was done. Maybe, labour mobility information or *working place* adjustments should be implemented.
- *Proposal:* To construct the trade matrix the authors apply a gravity model based on transport survey data. A transport matrix of 99 districts is constructed. Flows between districts are positively influenced by the indicator "economic mass" and negatively influenced by the distance between them. Distance is represented by average travel time between two districts. The construction procedure (how to get from the transport matrix to the trade matrix should be explained at grater length (a chart would be helpful). I propose to consider transport costs as third indicator. Spatial and regional economic problems comprise three topics: natural-resource advantages, economies of concentration, and costs of on the one hand transport and on the other hand communication. Regional analyses identify three "foundation stones": imperfect factor mobility, imperfect divisibility, and imperfect mobility of goods and services. Especially location theory examines the role of transportation costs. Various studies focus particularly on interregional location of manufacturing industries, for which transportation costs are relatively more important than for most other sectors. The current version of the model implicitly simplifies the problem by letting transfer costs uniform per ton mile and using just travel time as indicator. But transfer costs are characteristically less than proportional to distance, and the average transfer cost per mile decreases as the length of haul increases. So, I would suggest an expansion of the model by including transport costs as third indicator for the construction of the transport matrix. Furthermore, concerning the supply side and the first "foundation stone": In which way interregional mobility of labour and capital, is taken into account with MULTIREG?
- *Problem/Question*: For constructing the trade matrix surveys were conducted. But from a statistical point of view the sample size is far too small (representativeness! – there is a response rate of 10%, the responding firms cover in terms of employment 6.7% of total employment in Austria!). Furthermore, although the trade matrix and the transport matrix are crucial for the model these surveys are only available for 1(!) year. There are papers dealing with minimum information required, especially with regard to exports and imports, how (hybrid) regional I/O tables can be constructed that provide

reasonable accuracy in comparison to a complete survey (e.g., Harris and Liu, 1998).

- *Problem/Question*: Within the RAS method explained within the paper the authors ensure that the total inbound transport of volume is equal to total outbound transport. But within the paper it is left completely unclear how inventories are treated within the model.
- *Problem/Question*: Regarding the statement: "Consequently in simulations with MULTIREG results are broken down from the regional to the district level (distinguishing between different types of districts in the process: rural, urban, peripheral) to be fed into the gravity model" How is this difference treated within the model? This is left completely unclear within the paper. Within the paper the 23 districts of Vienna are lumped together. It would be extremely important to explain this. Otherwise, the differences between two districts, like Vienna and a Tyrolean district are left unclear. These districts are from a geographical point of view and also from aspects of the supply and demand side completely different!!

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2nd Comment on "MULTIMAC IV and MULTIREG"

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1. Why Macroeconomic Input-Output Models?

Before discussing the two papers presented the question needs to be addressed why macroeconomic input-output (IO) models should be constructed and used.

The main argument is that they pay due attention to at least part of the sectoral differences existing in the economy. They need not to rely on the assumption of a single representative producer and on the hypothesis of one production function for all branches. By disaggregating the economy in some detail and by modelling the interdependencies between the various branches and groups of commodities, they extend the analytical potential of macroeconomic models considerably.

Part of the aggregation effects on macroeconomic variables is taken into account explicitly; there is no need to construct "auxiliary variables" to integrate such effects as in the case of explaining import demand in macromodels.

The sectoral disaggregation permits the analysis of structural developments and makes such models important tools to evaluate the structural implications of economic development. They are mighty instruments for scenario writing especially in the medium and long-term perspective. They are not necessarily equally ideal tools for short-term forecasting.

Shocks and political measures affecting only one group of commodities or one economic branch can be examined in a consistent manner in their effects on other goods or branches as well as on the whole economy. Kurt Kratena mentioned two nice examples which illustrate the special merits of IO based macromodels, the analysis of the effects of road pricing and the implications of an increase in investment in IT.

2. Criteria to be Met by Macroeconomic IO Models

Starting from industry and commodity detail macroeconomic IO models should have all the properties of a well elaborated macromodel. The core of the production side should be represented by the IO system. Gross production is then driven by final demand components, each of them itself represented by a structural equation system in the required commodity and industry detail.

The price model – starting from the cost structure - should capture the influence of changes in the costs of primary inputs and the interdependencies among commodity prices in the economy.

The demand model and the price model have to interact at the disaggregated level. Changes in prices should influence the volume and the composition of final demand and (more difficult to model) intermediate demands, on the other hand changes in volumes (including price dependent intermediate demands) ought to have implications on the prices.

Division of labour and the interrelationships between the various activities and commodities are not limited to the domestic market. If one wants to incorporate the "across the border interrelationships" in a similar way as the domestic ones it becomes necessary to make the national IO macromodel part of an international system of similar models. Such a link offers the capacity to evaluate effects from changes in other countries via the interrelationship of demand and price formation. Models focusing exclusively on the domestic economy tend to underestimate such implications as the larger part of repercussions works nowadays mainly through the international markets.

Although the "technical solution" is quite different, the basic problem is similar to the alternative of either estimating an isolated regional IO model or a multiregional model. The smaller the region (nation), the more important is to capture the "across the border effects" in a detailed way.

Any macroeconomic IO model has to pay attention to which extent the criteria are met on which IO analysis is based. Usually many modelling efforts are devoted to the questions whether the coefficients may be assumed stable or not. Less attention is paid to the need to have homogeneous aggregates. But lack of homogeneity in the valuation for example may do more harm to the empirical validity of the results than somewhat instable technical relations. Electricity (a really homogeneous product in the technical sense) appears in the Austrian IO table at prices which differ by the factor 1:9. The standard IO calculation assumes – if no revaluation is undertaken – that for the production of 1 unit of electricity in one industry 9 times more primary energy is requested than in the case of a delivery of 1 unit to a different branch.

Given this high relevance of homogeneity a lot of attention should be paid to find a level of aggregation which is adequate to the questions that should be addressed by the model.

Last but not least it deserves mentioning that it is by far more difficult to establish a consistent empirical foundation for an IO macromodel than for a model on the macro level.

3. Characteristics of MULTIMAC IV – A Disaggregated Econometric Model of the Austrian Economy

MULTIMAC IV is a macroeconomic IO model based on sets of behavioural equations which were estimated econometrically on the basis of Austrian data. In the good tradition of analysis carried out by the Austrian Institute for Economic Research (WIFO) it is designed in order to answer questions of relevance.

Since it was created with the intention to allow investigations, the results of which might be useful and helpful for policy makers in Austria, a lot of work was put into establishing a sound empirical basis. MULTIMAC IV is routed in the Austrian statistical system; the parameters are based on evidence derived from Austrian data, it can be seen a true Austrian model. Consequently, it does not belong to the family of Computable General Equilibrium Models, which are subject to the critique that "it is not just that the assumptions are descriptively unrealistic but that any correspondence to the real world is sacrified for the sake of analytical tractability" (BLAUG 1994, p. 131).

MULTIMAC IV consists of a demand model and a price model, although it is not quite clear how they are interlinked. As it is the case for most models of this type, some relationships are modelled in a rather simple way; on the other hand some of the modules (examples are private consumer expenditure and investment) are very well elaborated and rely on sophisticated methods.
In many respects MULTIMAC IV is a model of the type “working with what we have” (Stone, 1982). It makes use of most of the available data; the lack of statistical data quite often also appears as a limiting factor.

4. Characteristics of MULTIMAC IV – Problem Areas

MULTIMAC IV does not make an explicit distinction between commodities and industries, although the make matrices available in Austria clearly indicate that there is a considerable share of non-characteristic production.
Caused by the lack of data, not enough attention is paid to the dichotomy between domestic and national concepts. Private domestic consumption by categories for example is explained by disposable (national) income. Setting domestic and national income equal is not correct on the macro level either, but taking the numerical differences into account, perhaps tolerable. The problem is more pronounced on the level of specific commodity groups. The consumption of

services of hotels and restaurants in Austria for example is more affected by the disposable income of tourists coming to Austria than by the income of Austrians.

MULTIMAC IV is based on the IO table for 1990, although in the meanwhile tables for 1995 and 2000 have been released. The data base is thus not only out of date; a major disadvantage of the IO table for 1990 must also be seen in the fact that it was not fully compatible with national accounts. For the purpose of simplification a number of bridge matrices are kept constant although there is evidence that the structures change considerably over time.

The sectoral breakdown is not very balanced for a multipurpose model. The special emphasis put on energy related activities can however be explained by the fact that the model is meant to serve as the overall economic background for an energy specific model.

MULTIMAC IV is also a “stand alone model“. As simulations with a previous Austrian model (which existed until 1995) indicated the integration of even an elementary national model into an international family is IO models is of high importance for a small country like Austria.

5. The Multi-regional Input-Output Model for Austria – Characteristics and Problem Areas

Describing the characteristics of the multiregional IO model for Austria is a very difficult task, it is almost impossible. The paper of very preliminary nature which was distributed discusses a few aspects of building such a model, but gives no general description. Even such basic information as the number of regions, the number of activities and the number of groups of commodities is missing. The transparencies used for the oral presentation – which covered most of the essential background information - were not made available in advance. Therefore, the following discussion will concentrate on the few issues raised in the paper.

The model will be based on a multiregional IO table for Austria based on and consistent with the national IO table for 2000. Consequently, a clear distinction is made between activities and commodities. This property must be seen as a major advantage.

For deriving regional structures, in some cases, use was made of special tabulation of the micro data. On the other hand the calculations for other components of the regional tables had to rely on rather simple (and often very questionable) assumptions. For deriving investment on a regional level for example the hypothesis was made that the ratio of investment by category and by industry to production in the respective industry is the same in all regions. Although the final estimate includes some “weighting effect” it is not quite clear why no use was made of data on investment by industries and regions available from the “Leistungs- und Strukturehebung” for 2000.

According to the paper it is planned to make a clear distinction between the region of production (and thus income generation) and the region of consumption. To model the flows of factor income between regions will be a real challenge. However, if a meaningful solution can be found, it will add substantially to the analytical power of the model.

The attempt not to assume stable input coefficients and fixed trade relationships between regions but instead to model both of them explicitly, is also a very promising and ambitious one. A gravity type model is used to explain changes in interregional trade relationships.

The estimation of the underlying interregional trade matrix itself was based on a sample survey. This approach has some advantages. As the authors correctly point out it allows for “cross hauling”. But it is very doubtful whether a survey with a response rate of about 27 % can yield results of any empirical relevance. At the regional level and in a disaggregation by enterprises and commodity groups it is essential to have information for at least **all** the “big flows”. The basic assumptions on which sampling theory rests are not given under the prevailing circumstances.

6. Data Situation for Macroeconomic IO Modelling in Austria

From both of the papers one may conclude that the availability of statistical data is the limiting factor. Quoting Cicero, public servants use to say: “Quod non est in actis, non in mundo”. One could translate this statement into the language of an empirically oriented economist in the following way: “The knowledge about economic reality is limited by the availability and by the characteristics of the available statistical data.” In the case of macroeconomic models and macroeconomic IO models economic reality is primarily perceived through the lenses of IO tables and national accounts.

At the end of a workshop on macroeconomic modelling in Austria, it therefore seems worthwhile to devote a few minutes to the present and future data situation in Austria.

On the one hand there are a number of very positive aspects:

- According to the European System of National Accounts ESA 1995 the compilation of IO tables is fully integrated into the system.
- Supply tables at producer prices and use tables at purchasers’ prices have to be produced annually, symmetric tables and cross classifications of production accounts by industry and by sector every five years.

- Almost all the national accounts aggregates have to be provided at current and constant prices, this also applies to the annual transmission of supply and use tables.
- European legislation does not only define all the standards and concepts in very great detail, it also regulates which data in which classification has to be delivered to EUROSTAT at which date. The advantage of this situation for the user is, that he knows well in advance which data can be expected when.

Although more data and more coherent data will become available in the near future there are also some major disadvantages:

- In the European Union the compilation of statistical data is to a high degree standardised and regulated primarily with the operational role of statistical results in mind. This statement holds in particular for national accounts. Statistics is not longer primarily viewed as a scientific discipline in order to provide a well organized perception of reality, meeting the needs of empirical analysis. One example is the newly established standard to use the prices of the previous year for calculations at constant prices.
- National accounts and IO data has to be provided at the A (activity) 60 and P (product) 60 level of disaggregation, corresponding to the two digit level of NACE and CPA. The aggregates that are formed are neither homogeneous with respect to technology, nor homogeneous with respect to labour input. Branch 70 "Real estate activities" for example comprises very labour intensive service activities such as 70.31 "Real estate agencies" and activities such as 70.2 "Letting of own property" in which no or almost no labour input is required.
- Vertical integration – with all its undesired consequences for IO analysis – can also be found quite frequently. One example is activity 40 "Electricity", an industry in which both the production and the distribution of electricity are merged together. Other examples for this problem are activity 21 "Paper and paper production" and activity 20 "Production of wood and wood products".

Despite these shortcomings, the net implications for macroeconomic modelling will be very positive, if Statistics Austria can be persuaded to make the detailed material which is used internally in the process of compiling the data available to the qualified user. He or she will then find herself or himself in a position to compile a data set which is more adequate to his needs than the standard product.

Statistics Austria should also be asked to continue the calculations of national accounts at constant prices on the basis of a fixed year. This set of data, which was available for decades, is indispensable for many modelling purposes, especially in the field of constructing macroeconomic IO models. The costs are – compared to the total costs of providing national accounts – rather moderate.

Following the example of the Federal Statistical Office of Germany, Statistik Austria should be encouraged to offer special tabulations in accordance to the needs of model builders.

A much better empirical foundation of models in Austria could be achieved if the dialogue between Statistics Austria and modellers could be intensified. However, in order to make such a dialogue to a rewarding one, model builders will have to pay much more attention to the "material" they use in constructing their sophisticated models.

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The OeNB's *Working Paper* series is designed to disseminate and provide a platform for discussing findings of OeNB economists or outside contributors on topics which are of special interest to the OeNB. To ensure the high quality of their content, the contributions are subjected to an international refereeing process. The opinions are strictly those of the authors and in no way commit the OeNB.

Conference on European Economic Integration
(Conference Proceedings) *annual*

(formerly East-West Conference)

This series, published by a renowned international publishing house, reflects presentations made at the OeNB's annual central banking conference on Central, Eastern and Southeastern European issues and the ongoing EU enlargement process.

For further details see *ceec.oenb.at*

Newsletter of the Economic Analysis and Research Section *quarterly*

The English-language *Newsletter of the Economic Analysis and Research Section* is only published on the Internet and informs an international readership about selected findings, research topics and activities of the Economic Analysis and Research Section of the OeNB. This publication addresses colleagues from other central banks or international institutions, economic policy researchers, decision makers and anyone with an interest in macroeconomics. Furthermore, the *Newsletter* offers information on publications, studies or working papers as well as events (conferences, lectures and workshops).
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