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Why did we fail to predict GDP during the last cycle? A breakdown of forecast errors for Austria

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Editorial

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Why did we fail to predict GDP during the last cycle?
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Martin Schneider and Christian Ragacs

Abstract:

This paper proposes an informal taxonomy to break down forecast errors of institutional forecasts. This breakdown is demonstrated for the forecasts of the Oesterreichische Nationalbank (OeNB) for Austrian GDP. The main result is that the largest part of the forecast errors can be explained by erroneous projections of the international environment. Data revisions also substantially contribute to the forecasting error for the forecast of the current year. Domestic exogenous variables play a minor role only. The inclusion of judgement improves the forecasting performance.

Keywords: Forecast error taxonomy; Breakdown; Austria; Judgement; Technical forecast

1. Introduction

"The U.S. economy is assumed to head for a soft landing, with real GDP growth of 3.5% in both 2001 and 2002" (OeNB, 2000, p. 15). This quote from the forecast of the Oesterreichische Nationalbank from December 2000 shows the optimistic assessment of expected future developments in the world's largest economy at that time that was shared by the majority of forecasters around the world. Unfortunately, a series of unexpected shocks hit the US economy thereafter, resulting in a slowdown of growth to 0.8% in 2001 and 1.6% in 2002. The US recession beginning in March 2001 was neither predicted by professional forecasters nor by leading indicators (Stock and Watson, 2003, Filardo, 2004). At the same time, the euro began to appreciate both vis-à-vis the dollar as well as in real effective terms and oil prices began to increase. All these unforeseen developments led to huge errors in the forecasts of the majority of the professional forecasters around the globe.

Besides erroneous projections of the international environment, there are several other reasons why forecasting errors occur. Data revisions have an impact on the forecasting error. The models used to generate the forecasts are subject to mis-specification. The projected path of the residuals might contribute to the forecast error. The economy is hit by unexpected domestic shocks. In addition, forecasters are far from being perfect in their judgemental assessment of the prospects of the economy.

Given the various sources of forecasting errors, the question of their relative importance arises. This article attempts to answer that question for the OeNB's forecasts for Austrian real

[1] We like to thank Marianna Cervena, Gerhard Fenz, Marcus Scheiblecker, Klaus Vondra, an anonymous referee as well as the participants of the research seminar of the Economic Analysis and Research Section of the Oesterreichische Nationalbank for helpful discussions and comments on the paper. The views expressed in this paper are strictly those of the authors and do not necessarily reflect the views of the Oesterreichische Nationalbank.

GDP growth from 1998 to 2006, which are part of the “Broad Macroeconomic Projection Exercise” of the Eurosystem. The main results of the paper are as follows. The largest contribution to the forecast errors for all forecasting horizons (current year, next year, year after next year) stems from errors in projecting the international environment. In particular, demand for Austrian exports was overestimated during the downturn and underestimated during the recovery. Data revisions play an important role in explaining the forecasting error for the current year. Domestic exogenous variables play only a minor role. The remaining error partly offsets the other error components and hence helps to improve the forecasting performance. These results are in line with the fact that Austria – being a small open economy with an export share of 61.7% of GDP in 2007 – is highly dependent on international developments.

The paper is structured as follows: Section two gives a brief overview of the construction of macroeconomic forecasts in the OeNB. After presenting our informal forecast error taxonomy in section three, section four performs the breakdown for the OeNB´s forecast errors for Austrian GDP and discusses the role of judgement. Section five concludes.

2. Forecasting Austrian GDP at the OeNB

Embedded in the bi-annual “Broad Macroeconomic Projection Exercise” of the Eurosystem (published in June and December of each year), the OeNB produces a regular forecast of the Austrian economy, beginning in December 1998. In each forecasting round, forecasts for three years are provided (current year, next year, year after next year). The forecasts are published in the Quarterly Bulletin of the OeNB (Monetary Policy and the Economy, formerly Focus on Austria).

As agreed in the Eurosystem forecasting process, the OeNB’s macroeconomic forecasts are based on common technical assumptions such as short-term and long-term interest rates, exchange rates and the oil price. In addition, the Working Group on Forecasting (which consists of delegates of the ECB and of all national central banks of the Eurosystem) agrees on a common projection of the major regions of the world economy. Together with the projections of the other national central banks of the euro area, these projections form the basis for future growth of Austria's export markets and nominal-effective exchange rates. We refer to these assumptions as the *projection of the international environment*. After a joint discussion of these assumptions within the Working Group on Forecasting, they are treated as exogenous and the Austrian forecast is produced conditional on these assumptions.[2]

The Austrian forecast is based on both the “Austrian quarterly macroeconomic model” (AQM) of the OeNB (Schneider and Leibrecht, 2006) and additional expert judgement. The model is a medium size macroeconometric model. It is based on the neoclassical synthesis and is therefore in line with most models used by euro system central banks (Fagan and Morgan, 2005). The model parameters are estimated following a two-step Engle-Granger

[2] For more details on the Eurosystem macroeconomic projection exercises, see European Central Bank (2001a).

procedure. The forecasts produced by the model are adapted by residual adjustment to include additional information.

3. An informal forecast errors taxonomy

The literature on the decomposition of forecasting errors focuses on purely model-based forecasting and emphasises the role of structural breaks, mis-specification, mis-estimation and error accumulation. Clements and Hendry (1998, 1999) and Hendry (2000) have developed a formal taxonomy of forecasting errors for time series forecasts. Although such a taxonomy is of high importance, it does not provide very much guidance for the breakdown of the errors of institutional forecasts. It is astonishing that the evaluation of institutional forecasts is usually restricted to an assessment of the (absolute and/or relative) magnitude of the forecasting errors and their statistical properties such as unbiasedness, efficiency, directional accuracy and others (see e.g. Keereman 1999, Öller and Barot 2000, Blix et al. 2001, Timmermann 2006, Bowles et al. 2007, Ragacs and Schneider 2007, Vogel 2007). Although such evaluations provide valuable insights, they do not contain information on the sources of the forecast errors.

Diron (2006) performs a decomposition of forecasting errors into four elements (model specification, erroneous extrapolations of the monthly indicators, revisions to the monthly indicators and revisions to the GDP data series) and assesses their relative sizes. This is done in the context of a bridge equation framework for short-term forecasting of euro area GDP. To our knowledge, no similar breakdown exists for institutional forecasts that are produced on a regular base. Three specific features of those forecasts make such a breakdown a challenging task. First, institutional forecasts are produced conditional on a set of assumptions. So, one has to have access to a real-time data set that consists of all relevant data available at the time the forecasts were produced, including quarterly national accounts and conditioning assumptions. Second, a structural macroeconomic model is needed to quantify the impact of the erroneous conditioning assumptions on the forecast. Third, one has to have the relevant insider knowledge about the explicit judgement used in the projections in order to critically assess the results of the breakdown.

3.1 An overview of the breakdown the forecasting error

Let us begin with index notation. Superscript t $\left(t \in \{1998,...,2006\}\right)$ refers to the year a series was released (for historical data) resp. the year the forecast was produced. Superscript T refers to the current year, i.e. it stands for the final release of the data resp. of the exogenous variables. Subscript $(t+h)$ refers to the year to be forecasted, whereby h denotes the forecasting horizon in years $h \in \{0,1,2\}$.

The *forecast* for GDP for year $t+h$ produced in year t ($\hat{y}_{t+h}^{t}$) is given by

$$\hat{y}_{t+h}^{t} = F\left(x_{t+h}^{t}, \omega_{t+h}^{t}, y_{t}^{t}, u_{t+h}^{t}\right). \tag{1}$$

$F(.)$ describes the macroeconomic model used for producing the forecast (AQM, Schneider and Leibrecht, 2006). The forecast for year $t+h$ depends on four groups of variables: First, it depends on a projection of the *international environment* (x_{t+h}^{t}). The vector x_{t+h}^{t} consists of the growth of Austrian export markets, exchange rates (bilateral USD/EUR and nominal effective exchange rate for the export and import side), interest rates (three-month interest rate and 10 year government bond yield) and the oil price (USD per barrel Brent). Second, it depends on a projection of *domestic exogenous variables* (ω_{t+h}^{t}). In our case, the only relevant domestic exogenous variable is government consumption.[3] Third, it depends on the quarterly profile of the *historical GDP series* up to year *t* (y_t^t).[4] Finally, the forecast also depends on a vector of *model residuals* u_{t+h}^{t}. For a purely model-based forecast, these residuals should be kept at "neutral" levels. The most obvious way is to set them equal to zero over the forecasting horizon, but there are different other strategies to project the residuals, such as keeping them at the value of the last historical period, trend extrapolation, smooth return to zero, and others (Mestre and McAdam, 2008). The choice of the residual projection strategy depends on a bundle of factors. A thorough discussion of these factors is clearly out of the scope of this paper. Since additional information is included in the forecast "on top" of these neutral residuals by add-factoring, the residuals u_{t+h}^{t} do no necessarily reflect the amount of explicit judgement included in the forecast.

The *forecast error* (ε_{t+h}^{t}) of the forecast produced in year *t* for year *t+h* is given by

$$\varepsilon_{t+h} = \hat{y}_{t+h}^{t} - y_{t+h}^{T} \ , \tag{2}$$

where y_{t+h}^{T} refers to the final outcome (resp. the latest available release) of the GDP series. For every ε_{t+h},[5] we break down the forecast error into four components, namely an *error due to erroneous projections of the international environment* (ε_{t+h}^{I}), an *error due to erroneous projections of the domestic exogenous variables* (ε_{t+h}^{DX}), an *error resulting from revisions of historical data* (ε_{t+h}^{D}), and a *remaining error* (ε_{t+h}^{R})[6]

$$\varepsilon_{t+h} = \hat{y}_{t+h}^{t} - y_{t+h}^{T} = \underbrace{\underbrace{\varepsilon_{t+h}^{IX} + \varepsilon_{t+h}^{IE} + \varepsilon_{t+h}^{IR} + \varepsilon_{t+h}^{IO}}_{\varepsilon_{t+h}^{I}\,(International\ environment)} + \underbrace{\varepsilon_{t+h}^{DX}}_{(Domestic\ exog.variables)} + \underbrace{\varepsilon_{t+h}^{D}}_{(Data\ revisions)}}_{\varepsilon_{t+h}^{T}\,(Technical\ forecast)} + \underbrace{\varepsilon_{t+h}^{R}}_{(Remaining\ error)} . \tag{3}$$

ε_{t+h}^{I} is further decomposed into contributions stemming from growth of export markets (ε_{t+h}^{IX}), exchange rates (ε_{t+h}^{IE}), interest rates (ε_{t+h}^{IR}) and the oil price (ε_{t+h}^{IO}). Finally, we define $\varepsilon_{t+h}^{T} \equiv \varepsilon_{t+h}^{I} + \varepsilon_{t+h}^{DX} + \varepsilon_{t+h}^{D}$ as the error of the "*technical forecast*".

Figure one gives an overview of the determinants of the OeNB's forecast and the sources of forecast errors. In the remainder of this section, we describe the breakdown of the forecast errors in more detail.

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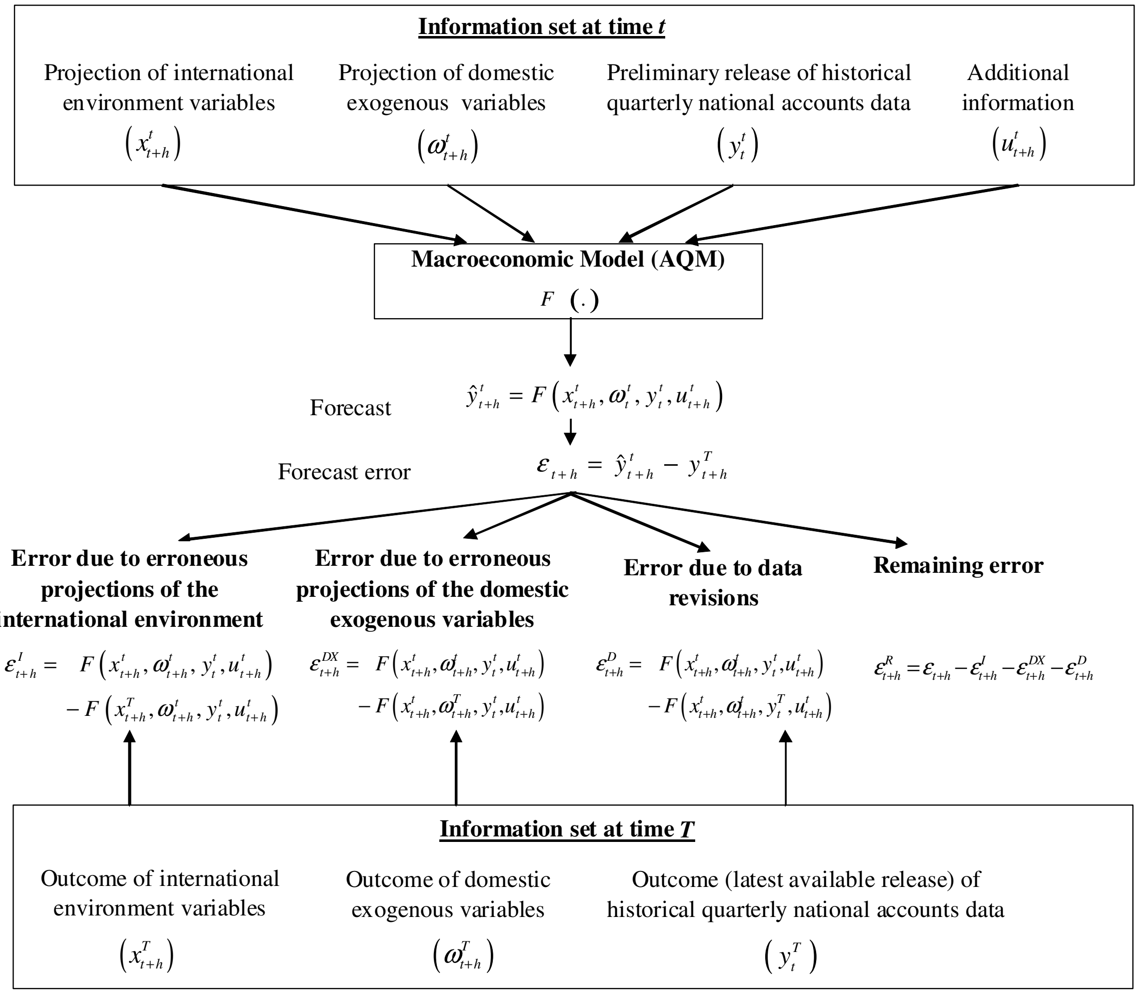
3 The other fiscal variables (taxes and transfers to resp. from households) are endogenous in the model. Additional information on these variables (e.g. on an announced tax-reform) is included in the forecast by residual adjustment.

4 To be precise, annual GDP growth in year *t* depends on the quarterly growth rates from the second quarter of the year *t-1* until the fourth quarter of year *t*. For more details, see section 3.4.

5 We have dropped the time superscript for the forecast errors, since they both depend on information available at time *t* (the information available at the production of the forecast) and information available at time *T* (outcome of GDP according the latest available release).

6 It is important to note that equation three holds for each point in time, but not for the overall error measure (RMSE), since the error components are not orthogonal.

Figure 1: Determinants of the OeNB's forecast and sources of forecast errors



Source: The author's own draft.

3.2 *Error due to erroneous projections of the international environment*

The forecasting error due to erroneous projections of the international environment (ε^I_{t+h}) is obtained as the difference of the forecast conditional on the projection of the international environment in year t (x^t_{t+h}) and the forecast conditional on the final outcome of these variables (x^T_{t+h})

$$\varepsilon^I_{t+h} = F\left(x^t_{t+h}, \omega^t_{t+h}, y^t_t, u^t_{t+h}\right) - F\left(x^T_{t+h}, \omega^t_{t+h}, y^t_t, u^t_{t+h}\right). \tag{4}$$

Both forecasts are produced using the same set of domestic exogenous variables (ω^t_{t+h}), the same historical data (y^t_t) and the same set of residuals (u^t_{t+h}). We have performed this exercise separately for the projections of export markets, exchange rates, interest rates and the oil price, yielding a decomposition of ε^I_{t+h} into ε^{IX}_{t+h}, ε^{IE}_{r+h}, ε^{IR}_{t+h} and ε^{IO}_{t+h} (see equation (3)).

3.3 *Error due to erroneous projections of domestic exogenous variables*

Similar to the above calculation, we obtain the error due to erroneous projections of domestic exogenous variables simply by comparing the forecast produced using the projected values of these variables (ω^t_{t+h}) with a forecast conditional on the final outcome of these variables (ω^T_{t+h})

$$\varepsilon^{DX}_{t+h} = F\left(x^t_{t+h}, \omega^t_{t+h}, y^t_t, u^t_{t+h}\right) - F\left(x^t_{t+h}, \omega^T_{t+h}, y^t_t, u^t_{t+h}\right). \quad (5)$$

3.4 Error due to data revisions

Many macroeconomic data series are subject to – often substantial – revisions.[7] Since GDP forecasts are typically produced utilizing quarterly national accounts data, this preliminary nature of the data creates essentially two problems for the forecaster. First, there is a direct mechanical impact of the revised historical quarters on the annual growth rate of the forecasted variable. Second, data revisions may also qualitatively change the forecast of GDP growth in the quarters ahead.

The quarterly profile of the available historical data has an impact on the forecast of annual GDP growth. The following approximation (log-linearization) formula might give some intuition of the role of quarterly growth rates (to the previous quarter) in year *t-1* and *t* on the annual growth rate in year *t* (y_t)

$$y_t \approx \underbrace{\tfrac{1}{4} y^{Q2}_{t-1} + \tfrac{2}{4} y^{Q3}_{t-1} + \tfrac{3}{4} y^{Q4}_{t-1}}_{Carry-over\ effect} + \tfrac{4}{4} y^{Q1}_t + \tfrac{3}{4} y^{Q2}_t + \tfrac{2}{4} y^{Q3}_t + \tfrac{1}{4} y^{Q4}_t.$$

The impact of the quarterly growth rates of the year *t-1* on the growth rate for year *t* is known as the "carry-over" effect.[8] As can easily be seen from the above equation, revisions of historical data affect the forecast for year *t* in a mechanical way. Taking the December 2001 forecast as an example, historical data until 2001Q2 was available. In this case, revisions of quarterly growth rates from 2000Q2 to 2001Q2 have an effect on the forecast for 2001. The revised quarterly growth rate for 2001Q2 impacts on the forecast for 2002. The forecast for the year 2003 is not affected by data revisions.

In order to determine the error due to data revisions (ε^D_{t+h}), we subtract a forecast using the latest available release of GDP data (y^T_t) from the forecast produced in time *t* using data available at that point in time

$$\varepsilon^{D}_{t+h} = F\left(x^t_{t+h}, \omega^t_{t+h}, y^t_t, u^t_{t+h}\right) - F\left(x^t_{t+h}, \omega^t_{t+h}, y^T_t, u^t_{t+h}\right). \quad (6)$$

Besides this "mechanical" impact, data revisions may also impact on a forecast via two additional channels. They have an effect on the forecast due to their impact on estimated model parameters. In addition, the assessment of the business cycle prevailing at the time the forecast was compiled might change, which may lead to changes in the forecast. However,

7 See e.g. Peracci and Lupi (2003) for the different sources of data revisions.

8 In its precise formulation, the carry-over is defined as the percentage deviation of the value of last quarter from the average value of the year (European Central Bank, 2001b).

since it not possible to analyse the impact of the revised historical data on this assessment ex post, we have refrained from quantifying this effect.[9]

3.5 Remaining error

Subtracting the impact of erroneous projections of the international environment, the impact of erroneous projections of domestic variables and the impact of data revisions from the overall forecasting error, we obtain a remaining error (ε^R_{t+h})

$$\varepsilon^R_{t+h} = \varepsilon_{t+h} - \varepsilon^I_{t+h} - \varepsilon^{DX}_{t+h} - \varepsilon^D_{t+h} . \tag{7}$$

This error is attributable to different sources. It can be due to an erroneous structure of the model (*model error*), errors in the *projection of trends and residuals*, and due to errors in *explicit judgement* stemming from external data sources (business climate surveys, monthly indicators, …). Explicit judgement can also be due to a correction for expected data revisions or additional information on the international environment (see section 4.3).[10]

4. A breakdown of forecast errors for Austrian GDP

4.1 Forecast errors for the years 1999 to 2006

We have calculated the breakdown of the forecast error for the OeNB's forecast from December 1998 to December 2006 using the Austrian Quarterly Model (AQM, Schneider and Leibrecht, 2006). Overall, we have 45 forecast errors (17 for the current year, 15 for the next year and 13 for the year after next year).

Figure two presents the forecast errors and the contributions of their components for the forecasts for the years 1998 to 2006. The reasons for the different forecasting errors are remarkably different: In the *boom years 1999 and 2000*, growth of the Austrian economy was systematically underestimated. This error is attributable to too cautious projections of the international environment (esp. world demand for Austrian exports was underestimated) and to effects of data revisions. Especially for the year 2000, these effects were compensated by a strong positive remaining error. In retrospect, these forecasts were produced including a considerable amount of positive judgement to compensate for the overly optimistic outlook for the international environment.

The huge positive forecasting errors for the years *2001 to 2003* are to a large extent attributable to the global downturn emanating from the US. The US economy was hit by a series of unexpected shocks (burst of the IT bubble, the US accounting scandals and the terrorist attacks from 9/11). The slowdown of the US economy and the transmission to

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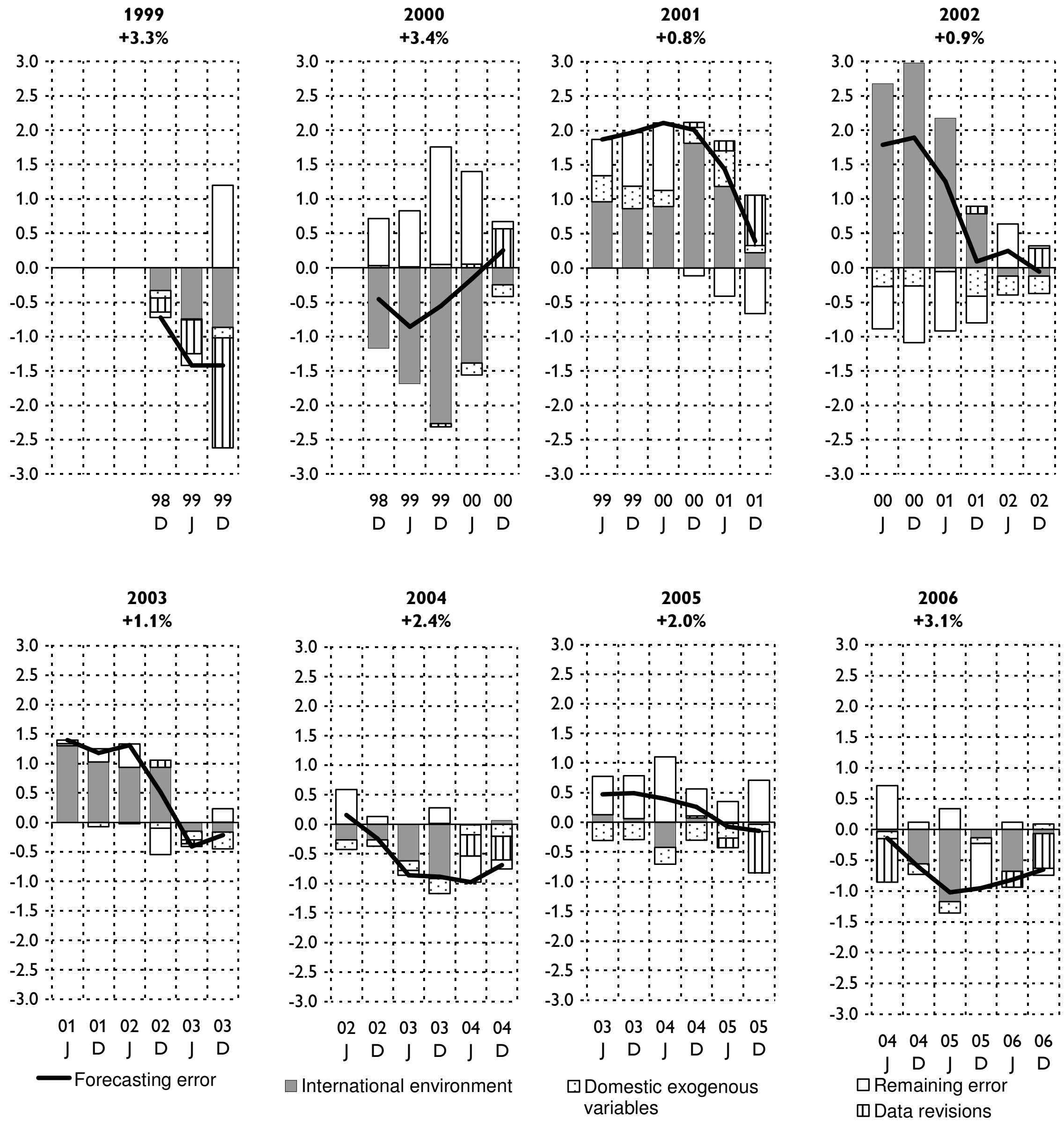
9 We have tried to mimic these effects by estimating simple time series models with preliminary and final GDP series. The difference of these two time series forecasts is interpreted as this additional effect of data revisions. This approach has delivered very strong effects, which we have assessed as implausible, especially for the forecast for the year after next year. Hence we have decided to not include these results.

10 It is important to note that errors from explicit judgement are not identical to the effects of model residuals (u^t_{t+h}) used in the forecast $\hat{y}^t_{t+h}$ (see figure one).

Europe were stronger than expected at that time. Furthermore, the unexpected weakness of the German economy also played an important role for Austrian exports. Consumer and business confidence declined significantly, and the German tax reform in January 2001 failed to generate the positive impulse that was expected in advance. In the forecast of December 2000, the OeNB expected Austrian export markets to grow by 8.1%, and 7.5% in the years 2001 and 2002, respectively. Actually, they grew by 1.9% (2001) and 1.5% (2002).

Figure 2: Breakdown of the forecasting errors for growth of Austrian real GDP from December 1998 to December 2006



Note: D: December forecast, J: June forecast. Final GDP growth rates are stated below year dates.
Source: The author's own calculations based on the OeNB forecasts and the first- and final release national accounts data for Austria (Eurostat).

One additional source of forecast error was that the optimism prevailing in the forecasts of the year 1999 and in June 2000 did not show up in the forecasts for 2000 only, but showed up also in the forecasts for the year 2001 as positive error contribution of the remaining error.

In *2004*, a stronger than expected pick-up of world trade growth triggered the upswing of the Austrian economy. The forecasts for the year *2005* exhibited only a marginal forecasting error. The strong GDP growth in *2006* was underpredicted, mainly due to the underestimation of world trade.

4.2 Aggregate results of the forecast error breakdown

Following our forecasting error breakdown (equation three), table one gives us the main results for the OeNB's forecasts for Austrian real GDP. They are as follows: First, on average over all forecasting horizons, the largest contribution to the overall forecasting errors of 1.00 (RMSE) originates from erroneous projections of the international environment (1.05). This is largely due to errors regarding the growth of export markets. Other international environment variables (including the oil price) and domestic exogenous variables play a minor role only. The error due to data revisions (0.36) is found to also contribute to the overall forecasting error.

Table 1: Overview of the forecast error breakdown for Austrian real GDP growth (from December 1998 to December 2006).

Forecasting horizon	Forecasting error (RMSE)	International environment					Projection of domestic exog. variables	Data revisions	Error of technical forecast	Remaining error
		Export markets	Exch. rates	Interest rates	Oil price	Total				
	ε_t	ε_t^{IX}	ε_t^{IE}	ε_t^{IR}	ε_t^{IO}	ε_t^{I}	ε_t^{DX}	ε_t^{D}	ε_t^{T}	ε_t^{R}
Absolute										
All horizons	1.00	0.99	0.32	0.18	0.20	1.05	0.21	0.36	1.21	0.63
Current year (t)	0.71	0.57	0.18	0.02	0.08	0.54	0.21	0.57	1.05	0.59
Next year (t+1)	1.06	1.13	0.40	0.18	0.22	1.19	0.20	0.10	1.26	0.72
Year after next (t+2)	1.23	1.21	0.36	0.28	0.26	1.35	0.23	-	1.33	0.55
Relative (Overall error per forecasting horizon= 1)										
All horizons	1.00	0.99	0.32	0.18	0.20	1.05	0.21	0.36	1.21	0.62
Current year (t)	1.00	0.80	0.24	0.03	0.12	0.75	0.30	0.80	1.47	0.82
Next year (t+1)	1.00	1.07	0.37	0.17	0.21	1.12	0.18	0.09	1.19	0.68
Year after next (t+2)	1.00	0.98	0.29	0.23	0.21	1.10	0.19	-	1.08	0.45

Note: Since the different errors partly compensate each other, the overall forecasting error is smaller than the sum of its components.

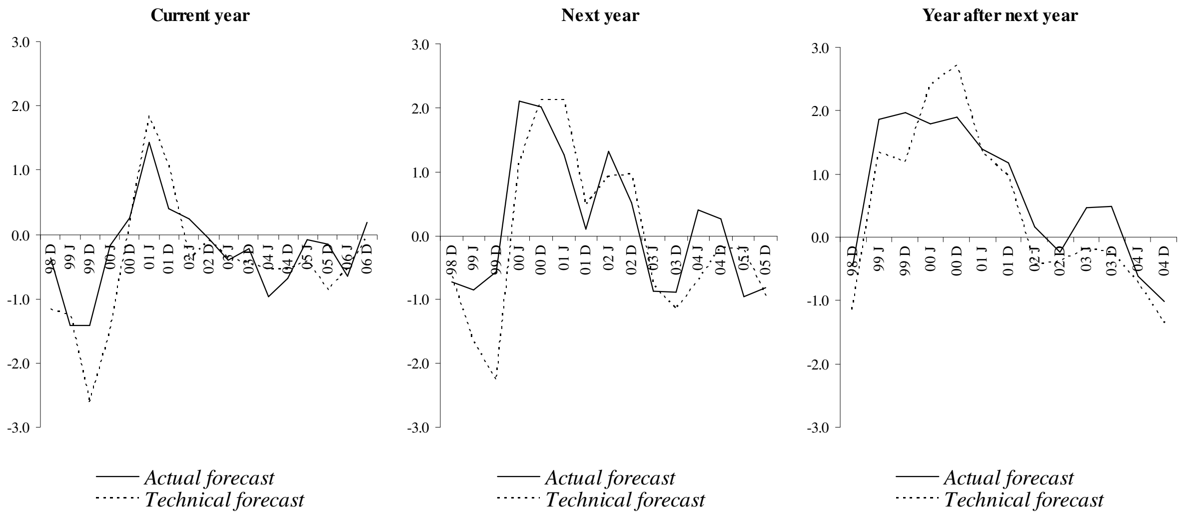
Source: The author's own calculations.

Looking at different horizons, we see remarkable differences in the relative importance of the different sources of error. For the current year, all error sources with exception of erroneous projections of domestic exogenous variables have more or less the same importance. For the next year and the year after the next year, the effects of the international environment dominate.

4.3 The role of the remaining forecast error

In order to better understand the role of the remaining forecast error, we compare the forecast error of the actual forecasts (ε_{t+h}) with the forecast error of the technical forecasts (ε_{t+h}^{T}). Table one shows that although the remaining error amounts to 62% of the overall forecasting error, it helps to decrease its size. On average, the error of the technical forecast is by 21% larger than the actual forecasting error. Figure three shows us the errors of the actual and the technical forecast for different forecast horizons. We perform a Diebold-Mariano test to test whether the differences of the forecast errors between the actual and the technical forecast are significant. The null hypothesis is that the actual forecast does not perform better than the technical forecast. The null can be rejected with error probabilities of 0.04, 0.09 and 0.02 for the current year, the next year and the year after the next year, respectively. This result underlines that the remaining error helps to improve the forecasting accuracy of the technical forecast.

Figure 3: Forecast errors of the actual and the technical forecast for different forecast horizons



Source: The author's own calculations.

We know that some of the forecasts have been produced by applying a considerable amount of explicit judgement to offset the effects of implausible projections of the international environment. Therefore we want to test the hypothesis, whether the remaining error (ε_{t+h}^{R}) is driven by the error due to erroneous projections for the international environment (ε_{t+h}^{I}). We have to make two assumptions. First, we have to assume that the model used for this exercise captures the effects of the international environment and the domestic exogenous variables on the forecast perfectly[11]. Second we have to assume that all trends and residuals have been projected correctly. Under these two assumptions, the remaining error should reflect the amount of explicit judgement included in the forecasts.

Table two shows that – on average over all horizons – the remaining error is mainly determined by the impact of the erroneous projections for the international environment. The coefficient of -0.32 (all horizons) is significant at the 1% level, indicating that the remaining error might be determined by the error due to erroneous projections of the international

[11] When the model under(over)estimates the effects of the international environment variables (ε_{t+h}^{I}), ε_{t+h}^{I} and the remaining error (ε_{t+h}^{R}) will exhibit a positive (negative) correlation. If the latter is the case, it is not possible to distinguish whether this negative correlation points to a confirmation of our hypothesis or whether it is just due to a bad model. A similar argument holds for the opposite case.

environment. The impacts of domestic exogenous variable and of data revisions are not significant. These results indicate – bearing the caveats in footnote 11 in mind – that the OeNB's forecasts were produced using additional information that partly gave different signals than the assumptions about the international environment.

Table 2: Determinants of the remaining forecasting error

Variable	**All horizons**	**Current year**	**Next year**	**Year after next year**
C	0.27	0.03	0.36	0.47
	[0.00]	[0.78]	[0.06]	[0.07]
Error due to erroneous projections for the international environment (ε^{I}_{t+h})	-0.32	-0.59	-0.43	-0.27
	[0.00]	[0.06]	[0.01]	[0.03]
Error due to erroneous projections for domestic exogenous variables (ε^{DX}_{t+h})	0.37	-0.35	1.37	0.84
	[0.33]	[0.61]	[0.15]	[0.07]
Error due to data revisions (ε^{D}_{t+h})	-0.20	-0.31	1.47	x
	[0.16]	[0.15]	[0.41]	
Adjusted R-squared	0.34	0.42	0.35	0.59
DW	x	2.35	1.89	1.92
Number of obs.	45	17	15	13

Notes: Results from an OLS regression. Dependent variable: Remaining forecasting error (ε^{R}_{t+h}). Values in brackets are p-values.

Source: The author's own calculations.

5. Summary and Conclusions

The breakdown of the forecast errors of the OeNB for Austrian GDP shows the relative importance of the different error sources. The largest share of the forecasting errors is attributable to erroneous projections of the international environment, whereby the technical nature of the interest and exchange rate assumptions causes much less problems than the erroneous assessment of the development of the export markets. Data revisions are also an important source of errors for the forecast of the current year. Domestic exogenous variables play a minor role only. The role of the remaining error is small, but positive: departures from a technical forecast improve the forecasting performance. Generally, our results underline the relevance of a proper assessment of the international environment for forecasting growth in a small open economy.

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Appendix: Detailed results

Table A-1: Detailed results of the forecast error breakdown for Austrian real GDP growth (from December 1998 to December 2006).

Date of forecast	Forecasted year	Fore-casting error	Projection of international environment: Export markets	Exch. rates	Interest rates	Oil price	Total	Projection of domestic exog. variables	Data revisions	Error of technical forecast	Remaining error
		ε_t	ε_t^{IX}	ε_t^{IE}	ε_t^{IR}	ε_t^{IO}	ε_t^{I}	ε_t^{DX}	ε_t^{D}	ε_t^{T}	ε_t^{R}
		(1)	(2.1)	(2.2)	(2.3)	(2.4)	(2)	(3)	(4)	(5=2+3+4)	(6=1-5)
Dec. 98	1998	-0.4	-0.5	0.3	0.0	0.0	-0.2	-0.1	-0.8	-1.2	0.8
Dec. 98	1999	-0.7	-0.7	0.2	0.0	0.2	-0.3	-0.1	-0.2	-0.6	-0.1
Jun. 99	1999	-1.4	-0.9	-0.1	0.1	0.3	-0.7	0.0	-0.5	-1.3	-0.2
Dec. 99	1999	-1.4	-0.7	-0.1	0.0	0.0	-0.9	-0.1	-1.6	-2.6	1.2
Dec. 98	2000	-0.5	-1.5	-0.5	0.3	0.5	-1.2	0.0		-1.1	0.7
Jun. 99	2000	-0.9	-1.9	-0.7	0.5	0.5	-1.7	0.0		-1.7	0.8
Dec. 99	2000	-0.6	-2.0	-0.6	0.0	0.3	-2.3	0.1	-0.1	-2.3	1.7
Jun. 00	2000	-0.2	-1.1	-0.5	0.0	0.2	-1.4	-0.2	0.1	-1.5	1.3
Dec. 00	2000	0.3	-0.5	0.3	0.0	0.0	-0.2	-0.2	0.6	0.2	0.1
Jun. 99	2001	1.9	0.9	-0.1	0.5	-0.2	1.0	0.4		1.3	0.5
Dec. 99	2001	2.0	0.9	0.0	-0.1	0.0	0.9	0.3		1.2	0.8
Jun. 00	2001	2.1	1.0	0.0	-0.1	0.0	0.9	0.2		1.1	1.0
Dec. 00	2001	2.0	1.3	0.7	-0.1	-0.1	1.8	0.2	0.1	2.1	-0.1
Jun. 01	2001	1.4	1.4	-0.1	0.0	-0.1	1.2	0.5	0.1	1.8	-0.4
Dec. 01	2001	0.4	0.2	0.0	0.0	0.0	0.2	0.1	0.7	1.1	-0.7
Jun. 00	2002	1.8	2.5	0.3	-0.2	0.0	2.7	-0.3		2.4	-0.6
Dec. 00	2002	1.9	2.6	0.4	-0.2	0.2	3.0	-0.3		2.7	-0.8
Jun. 01	2002	1.3	2.1	0.0	0.0	0.1	2.2	-0.1		2.1	-0.9
Dec. 01	2002	0.1	0.4	0.1	0.1	0.2	0.8	-0.4	0.1	0.5	-0.4
Jun. 02	2002	0.2	-0.2	0.1	0.0	0.0	-0.1	-0.3	0.0	-0.4	0.6
Dec. 02	2002	-0.1	-0.2	0.1	0.0	0.0	-0.1	-0.3	0.3	-0.1	0.0
Jun. 01	2003	1.4	0.6	0.6	-0.2	0.3	1.3	0.0		1.3	0.1
Dec. 01	2003	1.2	0.1	0.6	0.1	0.1	1.0	-0.1		1.0	0.2
Jun. 02	2003	1.3	0.4	0.7	-0.3	0.2	0.9	0.0		0.9	0.4
Dec. 02	2003	0.5	0.4	0.7	-0.3	0.2	0.9	-0.1	0.1	1.0	-0.4
Jun. 03	2003	-0.4	-0.3	0.0	0.0	0.1	-0.1	-0.1	-0.1	-0.4	0.0
Dec. 03	2003	-0.2	-0.2	0.1	0.0	0.0	-0.2	-0.3	0.0	-0.4	0.2
Jun. 02	2004	0.2	-0.4	0.3	-0.4	0.3	-0.3	-0.2		-0.4	0.6
Dec. 02	2004	-0.2	-0.4	0.3	-0.4	0.3	-0.3	-0.1		-0.4	0.1
Jun. 03	2004	-0.9	-1.0	-0.1	0.1	0.3	-0.6	-0.2		-0.8	-0.1
Dec. 03	2004	-0.9	-1.2	-0.1	0.0	0.3	-0.9	-0.3	0.0	-1.2	0.3
Jun. 04	2004	-1.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.4	-0.5	-0.4
Dec. 04	2004	-0.7	0.1	0.0	0.0	0.0	0.1	-0.2	-0.4	-0.5	-0.2
Jun. 03	2005	0.5	0.0	-0.2	0.0	0.3	0.1	-0.3		-0.2	0.6
Dec. 03	2005	0.5	0.1	-0.3	-0.1	0.4	0.1	-0.3		-0.2	0.7
Jun. 04	2005	0.4	0.0	-0.3	-0.2	0.0	-0.4	-0.3		-0.7	1.1
Dec. 04	2005	0.3	0.3	-0.3	-0.1	0.2	0.1	-0.3	0.0	-0.2	0.5
Jun. 05	2005	-0.1	0.0	0.0	0.0	0.0	0.0	-0.2	-0.2	-0.4	0.4
Dec. 05	2005	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.7	-0.9	0.7
Jun. 04	2006	-0.6	0.0	-0.2	-0.3	0.0	-0.6	-0.2		-0.7	0.1
Dec. 04	2006	-1.0	-1.0	-0.2	-0.3	0.3	-1.2	-0.2		-1.4	0.3
Jun. 05	2006	-1.0	0.0	-0.1	-0.1	0.0	-0.1	-0.1		-0.2	-0.7
Dec. 05	2006	-0.8	-0.9	0.1	0.0	0.1	-0.7	0.0	-0.3	-0.9	0.1
Jun. 06	2006	-0.7	-0.1	0.1	0.0	-0.1	-0.1	0.1	-0.6	-0.5	-0.1
Dec. 06	2006	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2

Source: The author's own calculations.

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