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Stability and Security.

Workshops

Proceedings of OeNB Workshops

Price Setting and Inflation Persistence in Austria

December 15, 2005

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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.

Editors in chief
Peter Mooslechner, Ernest Gnan

Scientific coordinators
Claudia Kwapil
Fabio Rumler

Editing
Rita Schwarz

Technical production
Peter Buchegger (design)
Rita Schwarz (layout)
OeNB Printing Office (printing and production)

Inquiries
Oesterreichische Nationalbank, Secretariat of the Governing Board and Public Relations
Postal address: PO Box 61, AT 1011 Vienna
Phone: (+43-1) 404 20-6666
Fax: (+43-1) 404 20-6698
E-mail: oenb.info@oenb.at

Orders/address management
Oesterreichische Nationalbank, Documentation Management and Communications Services
Postal address: PO Box 61, AT 1011 Vienna
Phone: (+43-1) 404 20-2345
Fax: (+43-1) 404 20-2398
E-mail: oenb.publikationen@oenb.at

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Editorial

Claudia Kwapil
Fabio Rumler

Oesterreichische Nationalbank

On December 15, 2005, the Oesterreichische Nationalbank (OeNB) held a workshop on "Price Setting and Inflation Persistence in Austria". The aim of this workshop was to discuss the OeNB's recent research results in the field of price dynamics and inflation[1] with policymakers and the scientific community in Austria. The papers presented at the workshop analyzed the price-setting process and the determinants of inflation persistence in Austria from different perspectives and on the basis of various data sources. The first session addressed the degree and determinants of price rigidities at the micro level. Session 2 provided an analysis of inflation persistence in Austria at the aggregate and sector levels, while session 3 dealt with Austrian consumers' inflation perceptions. A policy panel discussion concluded the workshop.

In his introductory statement, *Ernest Gnan (OeNB)* presented a paper co-authored with Jesús Crespo Cuaresma (University of Vienna). He argued that empirical studies of price stickiness and inflation persistence can be useful for monetary policy design and implementation, as well as for designing structural policies which facilitate shock absorption by euro area economies, and for achieving better-informed inflation and growth forecasts. Summarizing findings from the IPN network, he argued, inter alia, that inflation persistence in the euro area fell to moderate levels in the course of the 1990s – similarly as in the United States. Inflation persistence is mostly driven by wages and other input prices. Prices are stickier in the euro area than in the U.S.A., but there is no evidence of general downward consumer price rigidity in the euro area, with the exception of the service sector. According to Gnan, heterogeneity in the frequency of consumer price changes across products is more relevant than across countries. Perceived inflation should be taken seriously by monetary policymakers for two reasons: First, public satisfaction (or discontent) with the central bank's performance hinges

[1] Most of the papers presented at the workshop were prepared in the context of the Eurosystem Inflation Persistence Network (IPN), a research network with participating researchers from euro area NCBs and the ECB which was established to study the patterns and determinants of inflation persistence in euro area countries.

on perceptions of its credibility as a guardian of price stability, rather than on facts about it. Second, inflation expectations are likely to be influenced by perceived inflation, rather than official current or past inflation rates. Inflation perceptions are thus also likely to influence wages and actual inflation as well as sacrifice ratios. Within the past 200 years, there was never a time in Austria when inflation reached levels persistently and significantly different from zero until the 1960s.

In the first session, which dealt with microdata, *Alfred Stiglbauer* (OeNB) presented a paper co-authored with Josef Baumgartner (Austrian Institute of Economic Research (WIFO)), Ernst Glatzer and Fabio Rumler (OeNB). The paper analyzed stylized facts on price changes in Austria based on individual price records collected for the Austrian CPI. On average, consumer prices in Austria are constant for 11 to 14 months with strong heterogeneity across sectors and products. Prices for energy products and unprocessed food change more often than e.g. service prices. Stiglbauer further argued that price increases occur slightly more often than price decreases, the average size of price increases being 11% and that of price decreases 15%. The probability of a price change increases, the longer a price quote has been unchanged and the higher the inflation rate in the relevant product category since the last price change has been. In his discussion, *Johannes Hoffmann (Deutsche Bundesbank)* referred to evidence which indicates that shops with greater price variability also show higher prices. Thus, more frequent price adjustments need as such not necessarily be preferable. He emphasized that studies on price-setting behavior should differentiate between regular and temporary price changes, as done in the presented paper.

In his joint work with Jerzy D. Konieczny (Wilfrid Laurier University, Ontario), *Fabio Rumler (OeNB)* investigated why decision-makers choose to act on a time-regular basis (e.g. adjust every six weeks, etc.) or on a level regular basis (e.g. change interest rates by 0.25%, etc.), even though such behavior appears suboptimal. In their paper, the authors attribute time-regular and level-regular behavior to adjustment cost heterogeneity. They show that, given cost heterogeneity, the likelihood of adopting time- or level-regular policies depends on the shape of the benefit function: the flatter it is, the more likely is regular adjustment. The empirical results provide strong support for the model: the lower the conditional frequency of price changes is in a given market, the higher is the incidence of time- and state-regular adjustment.

Claudia Kwapil (OeNB) presented a paper co-authored with Josef Baumgartner (Austrian Institute of Economic Research (WIFO)) and Johann Scharler (OeNB) which analyzes the price-setting behavior of Austrian firms based on survey evidence. The paper's main result is that long-term customer relationships are a major source of price stickiness in Austria. Companies refrain from price adjustments (especially in response to demand shocks) because they do not want to jeopardize their customer relationships. Kwapil furthermore presented evidence suggesting that the price response to various shocks is subject to asymmetries. In

his discussion of the above paper *Thomas Mathä (Banque centrale du Luxembourg)* compared the Austrian results with those from other euro area countries and pointed out several more questions worth investigating.

In the second session, which dealt with inflation persistence at the sectoral and macroeconomic levels, *Josef Baumgartner (WIFO)* presented univariate autoregressive (AR) models in which the sum of the AR coefficients provides a measure of inflation persistence. He produced evidence for three structural breaks (in the mid-seventies, mid-eighties and mid-nineties) in the inflation process in Austria. If these structural breaks are taken into account, persistence measures decrease sharply. Baumgartner also investigated the influence of the data frequency, the treatment of seasonality, the estimation methods and the aggregation level of the CPI on both the evidence of structural breaks and the degree of inflation persistence. In his comments on Baumgartner's presentation, *Markus Knell (OeNB)* emphasized the careful treatment of seasonal adjustment in the paper. Most other papers neglect this topic, although it can have an essential impact on results (as shown in the above paper). Moreover, he judged the univariate approach applied in the paper as a reasonable and useful instrument for gaining a first impression of the main properties of inflation and price index data. He added, however, that the estimates of the persistence parameter can be biased because of the stickiness of real shocks in the economy. A multivariate approach could take care of this problem.

Fabio Rumler (OeNB) analyzed price stickiness at the macroeconomic level within the framework of an open-economy New Keynesian Phillips Curve (NKPC) model. He extended the existing literature by incorporating three different factors of production (domestic labor, imported and domestically produced intermediate goods) into a general NKPC model. According to his results, structural price rigidity is systematically lower in an open-economy specification than in a closed-economy version. This indicates that, when firms face more variable input costs, they tend to adjust their prices more frequently. However, when the model is estimated in its general specification including domestic intermediate inputs, price rigidity increases again compared to the open-economy specification without domestic intermediate inputs. In his discussion of Rumler's presentation, *Johann Scharler (OeNB)* compared the estimates of the model's structural parameters with estimates frequently found in the literature and questioned whether the differences matter economically. He argued that the different values for the parameters do not matter much for the response of the output gap to a monetary shock. However, depending on the specification used, the effect on inflation can change significantly.

In the third session, *Helmut Stix (OeNB)* presented a study on the discrepancy between actual inflation and the inflation perceived by the general public around the time of the euro cash changeover. Stix argued that this discrepancy can in part be attributed to the fact that people's perception of inflation seemed to be based

mainly on the prices of frequently purchased goods, which rose faster after the cash changeover than those of other goods. Furthermore, consumers perceive price increases more strongly than price reductions. This perception seems to have been reinforced by the fact that consumers expected prices to rise as a result of the euro cash changeover and that they used outdated schilling reference prices when comparing prices in euro. Thus, perceived inflation proved to be unexpectedly persistent: It was not before the beginning of 2005 that the gap between perceived inflation and actual inflation was more or less closed. *Erich Kirchler (University of Vienna)* argued that the lower nominal euro values (in all EMU Member States except Ireland) may have made products appear cheaper because of the low nominal values. Furthermore, the difference between cheap and expensive products may have seemed smaller and, therefore, the more expensive product was chosen more easily. Consumers, however, did not attribute this behavior to their own spending habits but externalized it and blamed it on the euro.

In the concluding panel discussion representatives of Austrian research institutions and social partner organizations offered their reading of the findings presented at the workshop. *Karl Aiginger (WIFO)* discussed some implications of the results for competition and structural policy. He emphasized that frequent price changes have both advantages and disadvantages. Price changes increase the uncertainty under which economic decisions are made, and uncertainty can reduce consumption and investment. On the other hand, price changes are important signals of changes in costs and productivity. Weighing the advantages and disadvantages of price flexibility, he argued that more frequent price changes than those currently observed in Austria would be beneficial. Since the average frequency of price changes of currently once per year is truly the minimum and as price changes that become necessary after long periods of rigidity are relatively large. Companies' hesitation to adjust prices rapidly to changing cost or demand conditions reflects a lack of aggressiveness in seeking market opportunities. Moreover, as evidence shows, it is far more common among Austrian and European firms to react to cost developments than to take advantage of variations in demand. Aiginger concluded structural adjustments are delayed and innovations are less profitable than in the United States.

Günther K. Chaloupek (Austrian Chamber of Labour) argued that inflation persistence has decreased substantially since the first and second oil price shocks. This means that no or almost no second-round effects, which tend to prolong or even intensify the original inflation impulse, are to be expected. From his viewpoint, this suggests that the latest inflation developments should be watched calmly and that the ECB should not further increase interest rates. Chaloupek also pointed out that he doubts the neoclassical orthodoxy which states that perfect (upward and in particular downward) price flexibility is optimal under all circumstances. He cited Keynes who argued that falling prices can have serious negative consequences for companies and consumers. Therefore, Chaloupek

suggested to devote more research effort to the problem of deflation. These efforts should, in particular, focus on determining the level of low inflation at which deflationary developments start to occur at the micro level (i.e. for individual firms).

Harald Kaszanits (Austrian Federal Economic Chamber) pointed out that, in Austria, prices are particularly sticky in the services, healthcare and education sectors, i.e. those sectors which are largely administered by public authorities. In order to induce more price flexibility in these sectors, he proposed to further liberalize and deregulate these markets by opening them up to private entrepreneurs and/or by encouraging public-private partnerships. Regarding the role of wages in the determination of prices, Kaszanits argued that wages usually increase at regular intervals and decrease only very rarely, which induces downward rigidity of prices in labor-intensive sectors such as services. To allow more (downward) price flexibility in these sectors he suggested to carry out labor market reforms aiming at more flexible payment schemes; he also emphasized the importance of wage restraints for favorable inflation developments.

Martin Zagler (Vienna University of Economics and Business Administration and European University Institute Florence) emphasized that the finding that there is downward flexibility in prices implies that there are no mechanisms to prevent a majority of prices to fall, and therefore to prevent periods of deflation. According to Zagler, monetary policy needs to react to this insight by also introducing a lower bound for inflation in its price stability objective. In this context, he interpreted the adjustment of the ECB's definition of price stability in 2003 – which before had been "below 2%" and now reads "below, but close to, 2%" – as an important policy change designed to prevent periods of deflation. In Zagler's view the finding that prices react differently to cost and demand shocks requires a reassessment of monetary policy. For instance, in the case of a positive supply shock as triggered by the new economy and downward sticky prices, there would be ample scope for expansionary monetary policy. In the case of a business cycle upturn (which would represent a positive demand shock), prices – according to the research findings – should not react immediately to improved demand conditions and, thus, monetary policy could be accommodative without the danger of increasing inflation.

Ernest Gnan (OeNB) argued that structural reforms which enhance price flexibility and reduce inflation persistence not only serve the aim of enhancing long-term potential growth but may also have beneficial consequences in terms of smoother business cycles. Research findings which show that prices are frequently cut, particularly in response to low demand, weaken the case for pursuing an inflation objective well above zero, due to downward price rigidity. However, significant service price and wage downward rigidities are important qualifications. Increased wage flexibility and stronger competition in the euro area would support higher price flexibility, not least in the service sector. As inflation variability is more costly if inflation persistence is high, central banks should put greater weight

on inflation stabilization in economies with higher inflation persistence. A central bank's inflation track record can itself influence price setting and inflation persistence. In the light of uncertainty about the degree of inflation persistence, robust monetary policy should rather err on the side of higher inflation persistence. Turning to Austria, Gnan summarized that inflation persistence is relatively high, that price flexibility is intermediate and that the frequency of price decreases in Austria is above the euro area average.

"Stubborn" Inflation in Austria?
Introduction and a Very Long-Term View

Jesús Crespo Cuaresma
University of Vienna
Ernest Gnan[1]
Oesterreichische Nationalbank

1. Introduction

Price setting and inflation perception are topics which attract interest well beyond the narrow circles of central banks and academia. Public debate about oil distributors' pricing policy or the heated discussion about the mostly just perceived price impact of the cash changeover to the euro are just two recent examples of how relevant the development of prices continues to be in public perception. Until recently, empirical knowledge about pricing behaviour was surprisingly limited though. Lack of available data was partly responsible for this.

In consideration of inflation rates hovering above 2% despite weak economic growth over recent years, the Eurosystem set out to explore the reasons underlying this "persistence" of inflation by establishing the "Inflation Persistence Network (IPN)". In parallel, other economists joined forces with psychologists to explore how people's perceptions of inflation – as opposed to official, statistically measured price developments of consumer baskets – are formed. The Oesterreichische Nationalbank (OeNB) has conducted a considerable body of research over the past two years in these two areas, mainly with a focus on the Austrian situation, some for the euro area as whole. The purpose of this workshop and proceedings volume is to present the findings to the Austrian economic policy community and to possibly draw some policy conclusions.

This article is structured as follows. First, the motivation for the study of inflation persistence and price rigidity is discussed. Next, various data sources and analytical approaches are discussed. Third, the terms inflation persistence and price

[1] We appreciate useful comments by Claudia Kwapil, Fabio Rumler and are greatful to Elisabeth Augustin and Beate Resch for excellent research assistance.

rigidity are defined and distinguished from each other, and measurement issues are raised. Fourth, eleven stylized facts on inflation persistence and price rigidity for the euro area as a whole, as they emerged from the IPN, are summarised, in order to put results on Austria, presented in later articles in this volume, in perspective. Then, the role of perceived inflation and its relevance for monetary policy is explained. Finally, a very long-term view on inflation and inflation persistence in Austria is presented, which raises some interesting questions about some commonly accepted stylised facts with respect to inflation and inflation variability.

2. Why Study Inflation Persistence and Price Stickiness?

Studying empirically price-setting behaviour can be useful for monetary and economic policy making in various ways. In the first place, it serves as a test for the various theories of price setting currently used in economic models. By selecting empirically valid theories, it will eventually allow to build forecasting and policy simulation models better fit to the actual behaviour of the economy. In a similar way, these insights will also allow to better understand the nominal and real effects from various shocks. This can help, for one thing, to design a monetary policy strategy better capable to support the achievement of price stability, through reducing inflation volatility and stabilising inflation expectations. For another, it can help to make more appropriate ongoing monetary policy decisions. So, there are obvious benefits for monetary policy in the euro area.

Moreover, comparing reactions of the economy to various shocks for different degrees of inflation persistence and price stickiness can also suggest desirable structural features of an economy, and thus inform possible general directions for structural policies which affect price formation. Such implications can be relevant in general, for the EU's and euro area's structural policy agenda (e.g. Lisbon Agenda) and for economic policy in the individual countries.

Standard economic models (e.g. Smets and Wouters, (2003)) predict that stickier prices will increase the persistence of output deviations from potential after shocks. Furthermore, strong differences in inflation persistence due to different price stickiness among euro area countries would entail asymmetric effects on the various euro area countries even from fully symmetric shocks and different transmission of the single monetary policy on inflation and growth in the various euro area economies. Recommendations on structural policy measures to influence price and wage setting behaviour with a view to achieving more symmetrical economic responses to shocks and to monetary policy could emerge.

Finally, at the level of the individual country and an individual national central bank, a clearer understanding of shocks and their nominal and real economic effects should help to put together better informed and more accurate forecasts of inflation and real economic developments. This has benefits for both, national

policy makers, e.g. for fiscal policy, and for economic agents at large, to the extent that it were to reduce decision uncertainty.

3. Various Data Sources and Analytical Approaches

Phenomena of inflation persistence and price rigidities can be analysed at various levels of the economy. Major innovations from the research presented at this workshop include, first, the exploitation of various sources for micro data, i.e. information on individual consumer prices or individual firms' price setting, be it through the use of individual consumer price data or through questionnaires to enterprises.

Table 1: Various Data Sources and Analytical Approaches, as Reflected in the Structure of the Workshop

Block 1: Micro level		**Block 2: Macro/sectoral level**		**Block 3: Economic psychology**
Micro CPI	**Firm-level surveys**	**Macro time series**	**Structural Models of Inflation Dynamics**	**Survey data on inflation perceptions and expectations**
Baumgartner, Glatzer, Rumler, Stiglbauer: *The Dynamics of Individual Consumer Price Data for Austria* **Konieczny, Rumler:** *Regular Adjustment: Theory and Evidence*	**Kwapil, Baumgartner, Scharler:** *The Price-Setting Behavior of Austrian Firms: Some Survey Evidence*	**Baumgartner:** *Inflation Persistence in Austria – First Results for Aggregate and Sectoral Price Series*	**Rumler:** *Estimates of the Open Economy New Keynesian Phillips Curve for Euro Area Countries*	**Stix:** *Perceived Inflation and the Euro:* *Why High? Why Persistent?*
Panel Discussion: Policy conclusions				

Second, these micro-level studies are supplemented by macroeconomic studies, using time-series approaches, on the one hand, and structural models (based on an open economy hybrid New Keynesian Phillips Curve), on the other. Third, in an interdisciplinary approach involving insights from economic psychology, survey data on inflation perceptions and expectations which summarize the "consumer's view" are introduced. The combination of these three complementary strains of research should allow to draw more informed policy conclusions. The various data sources and approaches are also reflected in the structure of the workshop (table 1).

4. Some Conceptual Issues: Inflation Persistence versus Price Stickiness

Price stickiness is a commonly used concept in economics. Inflation persistence is less well known. It is important to distinguish the two concepts.

Price stickiness can be defined as the tendency of prices to be changed infrequently. This can be due to various reasons. First, various frictions may discourage price changes that would actually be appropriate. If this hampers an adjustment of relative prices, it entails welfare losses. If price stickiness entails slow adjustment of the general price level to economic shocks, it can imply higher costs in terms of losses of output. Second, price stickiness can also reflect stable inflation expectations. If the commitment and ability of monetary policy to maintain price stability is perceived to be credible, there is less reason to change prices frequently. Finally, infrequent adjustments of prices can reflect a conscious pricing policy of firms to please customers, who may regard frequent price changes as a kind of cheating or wish to avoid the search cost involved with frequent price changes.

Inflation persistence is defined as the tendency of inflation to converge slowly towards its long-run value following shocks. The long-run value of inflation is in principle implied by the monetary policy regime. It can take the form of an implicit or explicit inflation target. Importantly, this long-run value may change over time. Take the following reduced-form model of inflation, with π_t being inflation in period t and μ_t being a shock:

$$\pi_t = (1-\rho)\pi^* + \rho\pi_{t-1} + \mu_t$$

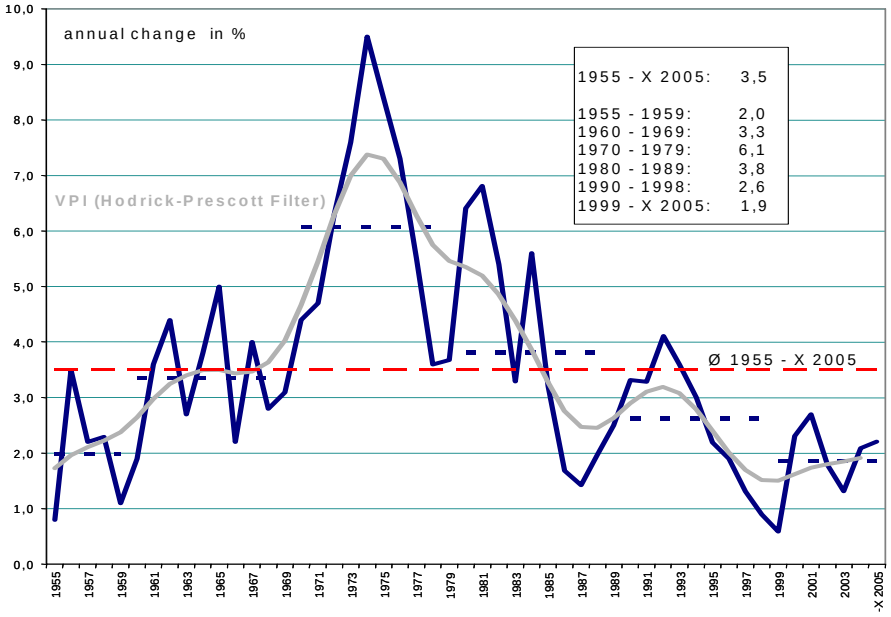
Inflation persistence in this model is estimated by the parameter ρ, which can be described as the sum of the parameters on lags of inflation in an autoregression of inflation. The bigger ρ, the more inflation is influenced by its own past values, and the more slowly it returns to its long run value π^*. A bigger ρ thus implies higher inflation persistence. The extreme case with $\rho=1$ represents a situation where shocks to inflation persist indefinitely and thus inflation does not return to the long-run equilibrium value after a shock.

When estimating inflation persistence, a crucial issue is how to determine the "long-run average" inflation rate. If the central bank's inflation target or definition of price stability were explicitly given, this would be a trivial issue. In practice, however, inflation targets are not always known explicitly. Explicit, publicly announced inflation targets or definitions of the price stability objective have only become wide-spread over the past 10 or 15 years. Particularly for time series going back further into the past and for those monetary policy regimes for which also today no quantitative definition of price stability has been published, "long-run inflation" needs to be assessed empirically. If it is assumed to be unchanged for very long time periods, say decades, actual inflation will take longer after shocks to return to this long-run inflation; estimated inflation persistence will thus be bigger. Conversely, if "long-run inflation" is assumed to change more frequently over time – to some extent in line with actual inflation – then estimated inflation persistence will be smaller. Thus, estimations of inflation persistence are heavily influenced by the researcher's inferences about the underlying monetary policy regimes and inflation objectives, besides many further econometric issues, which may also heavily influence the estimated measures for inflation persistence (see, e.g., Robalo-Marquez, (2004)). Two commonly used approaches to address the issue of changing inflation objectives are the identification of regime breaks, on the one hand, and the use of time-series smoothing methods, on the other. The more frequent regime changes are allowed or the more closely the smoothed "long-term inflation" follows actual inflation, the smaller estimates of inflation persistence tend to be. Chart 1 illustrates how strongly inflation for Austria varied over the last half century. Note also that it is not clear at all what the inflation objective in Austria was during the second half of the 20th century, prior to participation in the euro area.

Inflation persistence can have various sources. An illustrative way to conceptualize these sources is the hybrid New Keynesian Phillips Curve (see e.g. Rumler, in this volume). The equation states that inflation (the change in the price level p) in period t depends on inflation in the previous period, expectations of inflation in the next period, on marginal costs mc_t and on a shock u_t.

$$\Delta p_t = \gamma \Delta p_{t-1} + (1-\gamma) E_t \Delta p_{t+1} + \kappa\, mc_t + u_t$$

Chart 1: Inflation in Austria



Source: Statistics Austria.

Based on this formula, three sources of inflation persistence have been distinguished in the IPN (see, e.g., Angeloni et al., (2005b)). First, "*extrinsic inflation persistence*" can be described as the persistence inherited from the driving fundamentals of inflation, such as real marginal cost (real wages, real cost of capital…) or the output gap; it is influenced by degree of price stickiness, which in turn affects κ, the slope of the Phillips Curve or, in other words, the elasticity of inflation with respect to changes in marginal cost. Second, "*intrinsic inflation persistence*" describes the dependence of inflation on its own past; it is not driven by fundamentals and is captured in the above equation by γ, a measure of the backward lookingness of price formation. Intrinsic inflation persistence can, for instance, arise from (backward-looking) inflation indexation of contracts or from "rules of thumb" price setting by firms. Finally, "*expectations-driven inflation persistence*" arises if some kind of "learning" behaviour rather than fully rational expectations slows the return of inflation to its target. For example, assuming less than perfect information, price setters may take time to learn about the nature of a shock, which may lead to a gradual and more persistent response of inflation to a shock.

Estimations of price rigidity can be grouped into two branches of methods. On the one hand, micro studies of price-setting behaviour often measure the frequency

(the percentage) of price changes per unit of time (e.g. one month) or the average duration of prices. The higher the frequency or the shorter the duration, the more flexible prices are. On the other hand, structural approaches measure price rigidity by means of a parameter in the New Keynesian Phillips Curve (see e.g. Rumler, in this volume).

5. Inflation Persistence and Price Stickiness in the Euro Area – Some Stylized Facts

Research in the IPN has yielded a number of interesting stylized facts on inflation persistence and price stickiness in the euro area.

First, inflation persistence seems to have fallen over the nineties in many OECD countries including the euro area (cf. Angeloni et al., (2005a)), although this is hard to prove econometrically (see O'Reilly et al., (2004)). *Second*, inflation persistence in the euro area is moderate and similar to the U.S.A. (Álvarez et al., (2005b), Gadzinski et al., (2004)). *Third*, inflation persistence in the euro area appears to be mostly extrinsic, i.e. it is driven by the persistence of its determinants, such as wages and input costs (Álvarez et al., (2005b)). *Fourth*, recent estimates of New Keynesian Phillips Curves show that forward-looking expectations generally dominate over backward-looking behaviour (Rumler, in this volume). Expectations-driven inflation persistence turns out to be low in the euro area: inflation expectations are ell anchored to the inflation objective. *Fifth*, estimates of intrinsic inflation persistence suggest that the latter is currently low in the euro area (Levin et al., (2004))

Sixth, prices are stickier in the euro area than in the U.S.A. (see eg. Galí et al., (2001a), (2001b)), in a New Keynesian Phillips Curve the responsiveness to marginal cost or the output gap is lower (table 2). Note, however, that this may (partly) also be due to lower inflation in the euro area as compared to the U.S.A. (lower inflation requires less frequent price changes).

Table 2: Price Stickiness in the Euro Area versus the United States

	Measure of price stickiness	Euro area	U.S.A.
CPI	% of prices changed each month	15.1	24.8
	Average duration *(months)*	13.0	6.7
	Median duration *(months)*	10.6	4.6
PPI	% of prices changed each month	20.0	n.a
Surveys	% of prices changed each month	15.9	20.8
	Average duration *(months*)	10.8	8.3
New Keynesian Phillips Curve	Average durations *(months)*	13.5–19.2	7.2–8.4
Internet prices	% of prices changed each month	95.5	94.7

Source: Álvarez et al. (2005b). For methodolical details and references to the various studies underlying this table see there.

Seventh, there is no evidence of general downward consumer price rigidity in the euro area. 42% of consumer price changes are price reductions. Importantly, however, downward price rigidity in the service sector is considerably higher. *Eighth*, consumer price increases and decreases are sizeable at 8% and 10% respectively. Price reductions are even slightly bigger than increases (Dhyne et al., (2005); see table 3).

Table 3: Share and Average Size of Consumer Price Increases and Decreases

Sector	Unprocessed food	Processed food	Energy	Non-energy industrial goods	Services	Total
Share of price increases	54	54	54	57	80	58
Size of price increases	15	7	3	9	7	8
Size of price decreases	16	8	2	11	9	10

Source: Dhyne et al. (2005), pp. 20 and 22. Results are based on a sample of 50 products.

Ninth, there is considerable heterogeneity in the frequency of consumer price changes across products. Prices for energy and unprocessed food are changed frequently, those for non-energy industrial goods and services are changed rather infrequently. *Tenth*, heterogeneity across countries is less important than across products or sectors. To the extent that there is cross-country heterogeneity, it is partly related to differences in consumption structure and different statistical treatment of sales (see Dhyne et al., (2005); Lünnemann et al., (2004)).

Table 4: Average Percentage of Consumer Prices Changed Each Month

CPI	Unprocessed food	Processed food	Non-energy industrial goods	Energy (oil products)	Services	Total (country weights)
Euro area	28.3	13.7	9.2	78.0	5.6	15.1
U.S.A.	47.7	27.1	22.4	74.1	15.0	24.8

Source: Dhyne et al. (2005) for the euro area, Bils and Klenow (2004) for the U.S.A. Results for the euro area are based on a sample of 50 products. ES: no energy products included.

Eleventh,, the IPN brought interesting and important insights on the motives which drive producer pricing behaviour in the euro area (Fabiani et al., (2005)). Questionnaires sent to enterprises confirmed that the existence of implicit contracts, explicit contracts, cost-based pricing and coordination failure are able to explain producer pricing behaviour best. By contrast, menu costs, information costs and pricing thresholds turned out to be comparatively unimportant reasons for not changing prices. It also turned out that enterprises react asymmetrically to different types of shocks: Cost shocks were considered more important for price increases, while weakening demand or stiffer competition were quoted as being more important for price reductions. Finally, input prices were shown to drive producer price flexibility. Thus, in branches with high labour input prices are more sticky, while branches with a high raw material input and products at low stages of production witness more frequent price adjustments (see Álvarez et al., (2005a)).

6. The Role of "Perceived Inflation"

The concept of "perceived inflation" has been widely discussed in recent years. It refers to the notion that – whatever official, statistically measured inflation figures state – economic agents might have a different individual perception of inflation.

Particularly in the wake of the changeover from national currencies to the euro, perceptions of inflation had a tendency to deviate more strongly from official, statistically measured consumer price inflation than otherwise. Such perceptions can not be observed directly but have to be estimated, e.g. on the basis of consumer surveys (see e.g. Fluch et al., (2005)), which in itself entails a number of conceptual issues.

The important point is that economic agents' behaviour is ultimately not influenced by "reality" (as for instance approximated by official statistical data) but rather by their own perceptions of reality. At the level of the individual, this may be due to individual consumption baskets different from the one used in statistical measurement. This should, however, equal out for the economy as a whole. But it may also reflect the way in which perceptions are formed, an issue which is studied by (economic) psychology. Systematic biases in price perceptions may also affect inflation perceptions in the aggregate. This has several important implications.

First, the central bank's ability and credibility to maintain price stability is assessed by economic agents not on the basis of statistically measured HICP inflation but by their perception of inflation and its change over time. Public satisfaction or discontent with the central bank's performance thus hinges on perceptions, rather than "facts".

Second, inflation expectations are thus also likely to be influenced by perceived, rather than official current and past inflation (besides other factors). Commonly used models of inflation, which nowadays often include a term of inflation expectations, do not capture this important and complex channel of inflation expectations formation. Inflation perceptions are thus also likely to influence wages and actual inflation as well as sacrifice ratios.

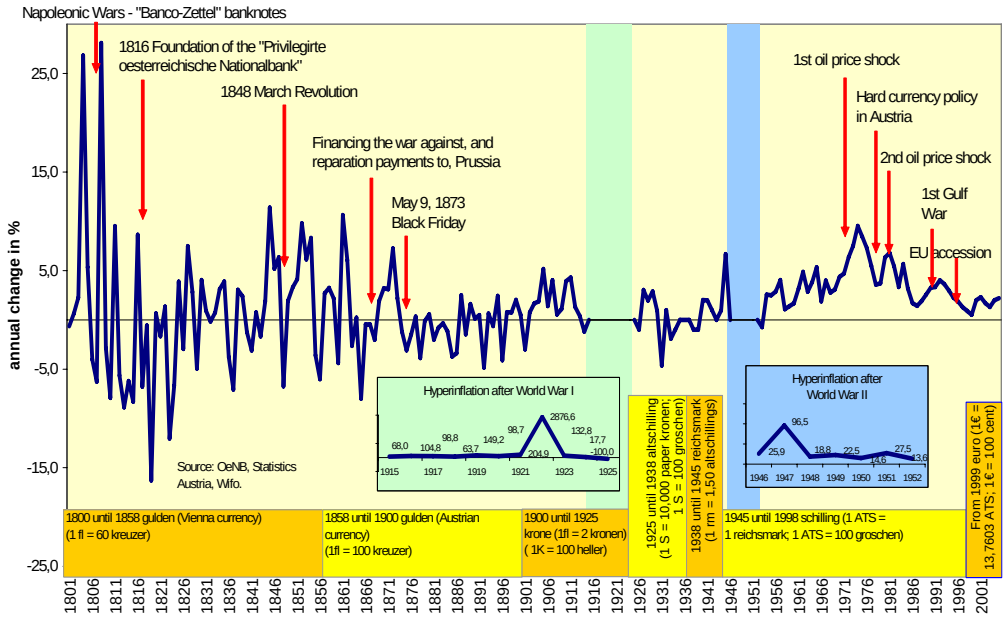
Understanding the psychology of perceived inflation is thus crucial for inflation forecasting, for the design of a monetary policy strategy and for the ongoing conduct of monetary policy. It should also feed into the central bank's communication with the public and motivate central bank educational activities. In short, it is no use to label inflation perceptions as "right" or "wrong". Psychological features of the formation of perceptions can only be taken as a starting point for the central bank to work with.

7. Inflation and Inflation Persistence in Austria – A Very Long-Term View

A brief look at the past 200 years of the history of inflation in Austria (see chart 2) yields a number of interesting insights. First, currencies and monetary regimes do not last forever. Before the euro was introduced in Austria, Austria had six currencies since 1800. Three of them (gulden (Vienna currency), gulden (Austrian

currency), Austrian schilling) lasted for roughly half a century each. Others, such as the krone, the Altschilling or the Reichsmark, lasted for a quarter of a century or less.

Chart 2: Inflation in Austria since 1800



Source: Statistics Austria; Pech (2002), Pressburger (1966), Schubert (2005).

Second, inflation varied sharply over the last 200 years. Most notably, it reached nearly 2900% and 100%, respectively, at the peaks in 1922 and 1947 during two periods of hyperinflation. But it also reached 25% or more in the aftermath of the Napoleonic Wars and 10% or more in several years around the middle of the 19th century and in the aftermath of the first oil price shock in the 1970s (a period commonly labelled the "Great Inflation" in the U.S.A.). Particularly in the 19th century negative inflation was very common, often prevailing over extended periods of time. The deflation around 1930 was quite short and of a small magnitude – in terms of the fall in the price level – compared to the experiences in the 19th century. Third, the major sources of high inflation were wars. The "Great Inflation" was noteworthy in the sense that comparatively high inflation was generated without such an emergency situation but as a result of expansionary monetary policy in the aftermath of a cost push shock. Central bank independence has long been considered as a way to avoid excessive money creation and the

erosion of the value of money. However, the history of the Oesterreichische Nationalbank, particularly during the 19th century, shows (see, e.g. Pressburger, (1966), Schubert, (2005)) that the multiple moves to grant the central bank higher independence were never long-lasting once the government faced financing problems, triggering yet further waves of inflation. More recently, price stability in Austria has benefited from accession to the EU and participation in the euro area.

A simple econometric exercise can be carried out in order to assess the dynamics of inflation persistence in Austria for the last two centuries. We fit a simple autoregressive model for the inflation series using 20-year overlapping windows, and report the estimates of the autoregressive parameter (measuring "short run persistence") and the unconditional expectation of the process (measuring "long run inflation").2

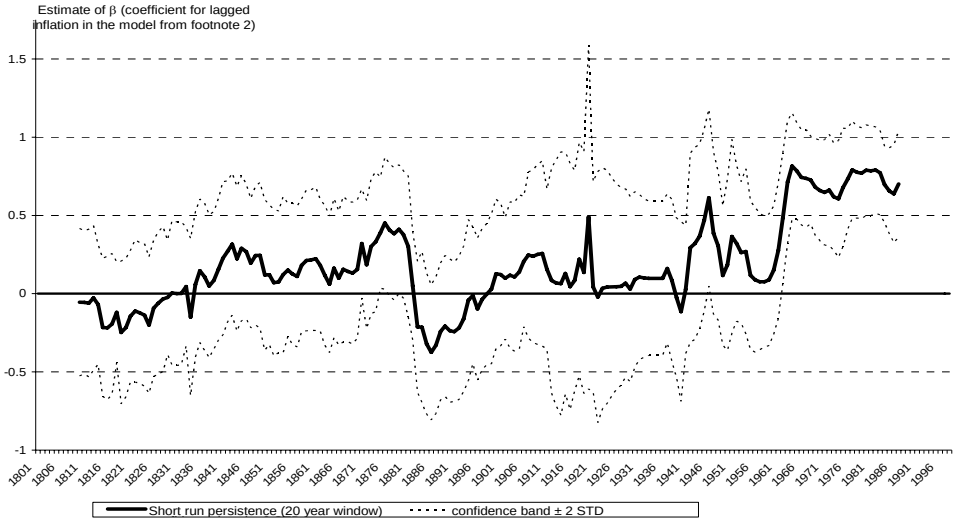
Chart 3 presents the estimates of the short run persistence measure for the period studied (together with confidence bands entailing twice the standard deviation of the estimate) and yields the interesting conclusion that only from the mid 1960s has inflation become significantly persistent. For the earlier subsamples, the persistence estimates tend to be insignificantly different from zero. The estimates of the long run average inflation show that the unconditional expectation of the simple data generating process for inflation used is only significantly positive in a systematic fashion from the 1960s onwards, coinciding with the appearance of significant short run persistence in the series.

This finding fits well with the evolution of long-run average inflation (as estimated as the unconditional expectation of the above autoregressive model). Only from the 1950s did inflation become significantly different from zero for an extended period of time.

Chart 5 shows long run inflation average together with the evolution of inflation volatility over the past two centuries (excluding hyperinflation episodes). Inflation volatility was relatively high during the first two decades of the 19th century, reached another peak around the middle of the 19th century, and fell steadily until the end of the century. Interestingly, inflation volatility has not changed too much since the late 19th century up to recently.

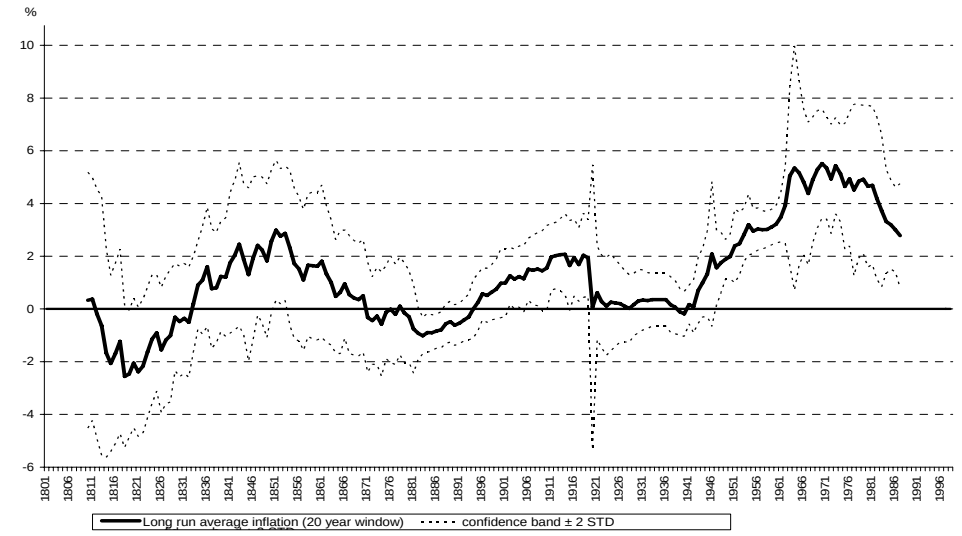
[2] The model used is $\pi_t = \alpha + \beta\pi_{t-1} + u_t$, where the error term is assumed to be white noise. The short run persistence is measured by the estimate of β and long run average inflation is measured by the estimate of $\alpha/(1-\beta)$. All the estimations were carried out eliminating the hyperinflation episodes.

Chart 3: Inflation Persistence in Austria – a Relatively Recent Phenomenon



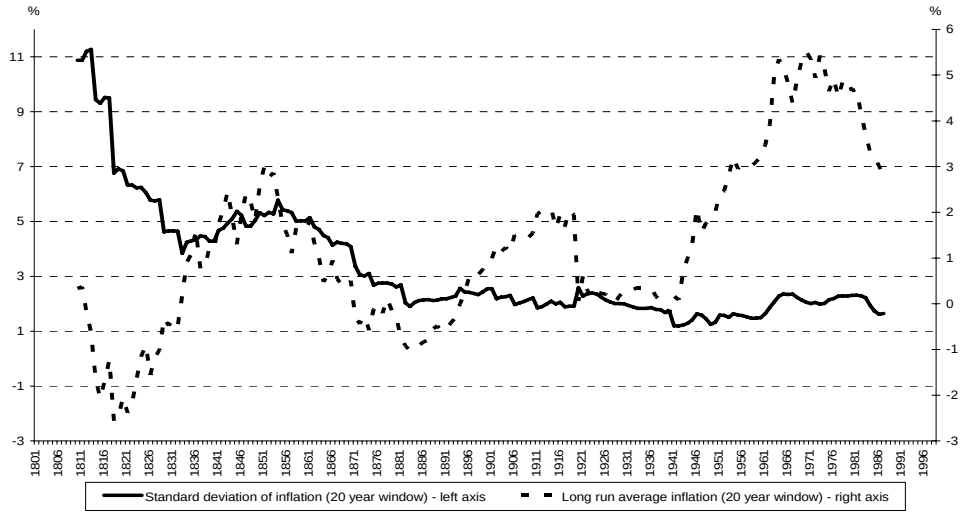
Source: OeNB.

Chart 4: Long-Run Average Inflation became Significantly Different from Zero in Austria only from the Mid 20th Century



Source: OeNB.

Chart 5: Long-Run Average Inflation and Inflation Volatility in Austria since 1800



Source: OeNB.

A second, potentially even more interesting observation relates to the often quoted stylized fact of a positive relation between the level and the volatility of inflation which is found when comparing across countries. According to the chart below, when considering very long spans of time, the Austrian data reflect opposing trends in the first and second moment of the series. If we concentrate on shorter time spans, a positive correlation between the two series was observable during much of the 19th century, but broke down in the first part of the 20th century. After World War II, the positive correlation reappears.

8. Summary and Conclusions

This article has argued that empirical studies of price stickiness and inflation persistence can be useful for monetary policy design and implementation, for designing structural policies aimed at smoother shock absorption by euro area economies and for achieving better informed inflation and growth forecasts. In the context of the euro area Inflation Persistence Network, the OeNB conducted studies at the macro as well as the micro levels to investigate price-setting behaviour both at the consumer and producer price levels. A study on consumers' formation of inflation perceptions supplemented this work.

The distinction between price stickiness and inflation persistence was highlighted, as were important assumptions underlying any estimation of inflation

persistence. Various sources of inflation persistence were identified on the basis of an illustrative hybrid New Keynesian Phillips Curve.

The article summarized a number of policy relevant findings for the euro area, as found by the IPN: Inflation persistence in the euro area has fallen over the 1990s and is moderate – similar to the United States. Its sources are mostly extrinsic, i.e. due to behaviour of cost factors, such as wages and other input prices. Prices were shown to be stickier in the euro area than in the U.S.A., i.e. they respond less to changes in marginal cost or the output gap. Importantly, there is no evidence of general downward consumer price rigidity in the euro area, with the exception of the service sector. Heterogeneity in the frequency of consumer price changes across products is empirically more relevant than heterogeneity across countries. Implicit contracts, explicit contracts, cost-based pricing and coordination failure are, according to enterprises' own assessment, important explanatory factors for firms' pricing behaviour best. By contrast, menu costs, information costs and pricing thresholds appear to be less relevant for not changing prices. Cost shocks were considered more important for price increases, while weakening demand or stiffer competition were quoted as being more important for price reductions. Finally, input prices were shown to drive producer price flexibility. Thus, in branches with high labour input prices are stickier, while branches with a high raw material input witness more frequent price adjustments.

The article argued further that "perceived inflation" is a phenomenon to be taken seriously by monetary policy makers for two reasons: First, public satisfaction or discontent with the central bank's performance hinges on perceptions, rather than "facts", about its ability and credibility to maintain price stability. Second, inflation expectations are likely to be influenced by perceived, rather than official current and past inflation; inflation perceptions are thus also likely to influence wages and actual inflation as well as sacrifice ratios. The psychology of perceived inflation is thus crucial for forecasting, for the design of a monetary policy strategy and for the ongoing conduct of monetary policy. It should feed into the central bank's communication with the public and motivate central educational activities.

A final look at the past 200 years of inflation in Austria showed quite extreme developments, ranging from two periods of hyperinflation to protracted periods of negative inflation rates. Interestingly, the only period when inflation became persistently and significantly different from zero was from the 1960s of the 20th century (leaving aside the two periods of hyperinflation after WW I and II). We could not generally confirm the often quoted stylized fact of a positive relation between the level and the volatility of inflation, which is found in cross-country studies, for the very long run dynamics of Austrian inflation. Further studies will have to be conducted to refine these results using more powerful econometric techniques.

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The Dynamics of Individual Consumer Price Data for Austria [1]

Josef Baumgartner[2]

Austrian Institute of Economic Research

Ernst Glatzer

Fabio Rumler

Alfred Stiglbauer

Oesterreichische Nationalbank

Abstract

In this paper a data set with price records collected for the computation of the Austrian CPI is used to estimate the average frequency of price changes and the duration of price spells to provide empirical evidence on the degree and characteristics of price rigidity in Austria. Depending on the estimation method, on average, prices are unchanged for 11 to 14 months. We find a strong heterogeneity across sectors and products. Price increases occur only slightly more often than price decreases. For both cases the typical size of the weighted average price change is quite large (11% and 15%, respectively). Like in related contributions we find that the aggregate hazard function is decreasing with time. Apart from

[1] We thank Statistics Austria for providing the data and especially Paul Haschka and Alexandra Beisteiner for valuable information on the data. This study has been conducted in the context of the 'Eurosystem Inflation Persistence Network (IPN)'. We are indebted to the members of this network, especially to Steve Cecchetti, Emmanuel Dhyne and Johannes Hoffmann. We also thank Jerzy Konieczny, Michael Pfaffermaier, Thomas Url, Christoph Weiss, the participants of the Annual Meeting of the Austrian Economic Association 2005 and an anonymous referee for valuable comments. The views expressed in this paper are those of the authors and do not necessarily reflect those of the Oesterreichische Nationalbank (OeNB) or the Eurosystem. All remaining errors and shortcomings are our responsibility alone

[2] Corresponding author. Austrian Institute of Economic Research (WIFO), P.O. Box 91, 1103 Vienna, Austria, +43 1 798 26 01, ext. 230, Josef.Baumgartner@wifo.ac.at.

heterogeneity across products and price setters, this is due to oversampling of products with a high frequency of price changes. Accounting for the unobserved heterogeneity in estimating the probability of a price change with a panel logit model (with fixed elementary product effects), we find a small but positive effect of the duration of a price spell on the probability of a price change. We also find that during the euro cash changeover period the probability of price changes was higher.

JEL classification: C41, D21, E31, L11
Keywords: Consumer prices, sticky prices, frequency and synchronization of price changes, duration of price spells

1. Introduction

The frequency of price changes or its counterpart the duration for which prices remain unchanged, play a major role in the assessment of the impact of various shocks on the economy. Most macroeconomic models assume sluggish price and/or wage adjustment to generate real effects of monetary policy at least in the short run. The literature on the microeconomic foundation of price stickiness is vast (see Ball and Mankiw, (1995), Taylor, (1999) for an overview). However, due to the lack of individual price data and/or a restrictive practice of Statistical offices with respect to the use of the data for academic research, the empirical evidence on the relevance and patterns of price stickiness is sparse.

Several papers have shown that for some products or product groups prices remain unchanged for many months. Cecchetti (1986), who looked at 38 U.S. news-stand magazine prices from 1953 to 1979, reported 1.8 to 14 years (!) since the last price change. Kashyap (1995), who studied the price changes of 12 mail order catalogue goods, found that on average prices were unchanged for 14.7 months. A series of papers by Lach and Tsiddon (1992, 1996) analyzes the price-setting behavior of firms by looking at the prices of 26 food products at grocery stores. However, all these studies faced the problem of small samples including only a (very) limited number of products and one has to make extremely strong assumptions on the sectoral (or product group) homogeneity for economy wide generalizations of their results.

Bils and Klenow (2004) used a much broader set of unpublished individual price data collected by the Bureau of Labor Statistics (BLS) for the calculation of the U.S. consumer price index (CPI). They found much more frequent price changes of consumer prices in the U.S.A. than the studies mentioned above. For about half of the consumption goods, prices remain constant for less than 4.3 months. They also found that the frequency of price changes differs dramatically across goods.

For euro area countries until recently very limited evidence on this issue was available, notable exceptions being Campiglio (2002) on Italy, Suvanto and Hukkinen (2002) on Finland, and Aucremanne et al. (2002) on Belgium. Thanks to the initiative of the Eurosystem Inflation Persistence Network (IPN) for 10 of the 12 euro area countries micro data evidence on frequencies of price changes and the duration of prices based on CPI data is now available. Dhyne et al. (2005) provide a summary of the research efforts in the analysis of individual consumer price data within the IPN.[3]

In this paper we examine the frequency of consumer price changes in Austria, using a unique data set of individual price quotes collected for the calculation of the Austrian consumer price index. The major aim is to analyze the degree and characteristics of the nominal rigidity present in Austrian consumer prices and trying to explain some factors influencing this rigidity.

We find that the average (median) duration of price spells is 14 (11) months, but that the duration varies considerably across sectors and products. Like in similar studies, we find that the aggregate hazard function for all price spells is decreasing with time which is at odds with all relevant price-setting theories. However, apart from heterogeneity across products and price setters, one important reason for this is aggregating over product types with different spell duration. We show that – using an appropriate weighting scheme – the aggregate hazard function has its most marked spike at the duration of one year. Kaplan-Meier estimates of hazard functions display substantial heterogeneity across goods and product types. Taking into account the unobserved heterogeneity in estimating the probability of a price change with a panel fixed effects logit model, we find a small positive but highly significant effect of the duration of a price spell on the probability of a price change. We also find that in the months before and after the euro cash changeover the probability of price changes is higher than in other periods.

The paper is organized as follows. In section 2 we introduce the micro dataset on which our analysis is based. The methodology of our analysis and the empirical results which summarize the vast information in the data are presented in section 3. There we present estimates for the frequency of price changes and the duration of price spells and additionally address the issue of the synchronization of price changes within product categories. To describe and explain the stylized facts of price setting in Austria we present hazard rates and run panel logit regressions in section 4. The paper concludes with a summary of the main results.

[3] For detailed country results see Aucremanne and Dhyne, (2004A) for Belgium, Dias et al. (2004) for Portugal, Baudry et al. (2004) for France, Álvarez and Hernando (2004) for Spain, Fabiani et al. (2004) for Italy, Jonker et al. (2004) for The Netherlands, Vilmunen and Paloviita (2004) for Finland and Hoffmann and Kurz-Kim (2005) for Germany.

2. The Data

For investigating individual price dynamics in Austria, we use a longitudinal micro data set of monthly price quotes collected by Statistics Austria which is used to compute the national index of consumer price (CPI). The sample spans over the period from January 1996 to December 2003 (96 months) and contains between 33,800 (1996) and 40,700 (2003) elementary price records per month. The first half of our observation period coincides with the sample of goods included in CPI 1996 goods basket. In the period from 2000 to 2003 our data are based on a revised goods basket (CPI 2000). Overall, our dataset contains about 3.6 million individual price quotes which cover roughly 90% of the total Austrian CPI.[4] The main portion of price quotes is collected in 20 major Austrian cities.

Each price quote consists of information on the product category, the date, an outlet identifier as well as on the packaging (quantity) of an item. As the product category we define the products at the elementary level which are contained in the CPI basket (e.g. milk). Our original dataset includes a total of 639 such products categories. For each product category the product variety denotes the specific variety and brand of the product. For confidentiality reasons the dataset has been made anonymous with respect to the variety and brand of the product, i.e. we do not have any information on the brand.

With the information on the date (t), the outlet (k) and the product category (j) we can construct a *price trajectory* $P_{jk,t}$, that is a sequence of price quotes for a specific product belonging to a product category in a specific outlet over time. A *price spell* is defined as the sequence of price quotes (for a specific product in a specific outlet) with the same price.

For the calculation of the descriptive statistics all price quotes are converted into prices per unit in order to account for package changes and temporary quantity promotions. The prices around the cash changeover to the euro have been converted into common currency to make them comparable over the cash changeover.

Concerning the price changes associated with promotions or (seasonal) sales we decided to follow a dual approach: In the baseline version of the results we treat promotions and sales as regular price changes which terminate a price spell. However, it can be argued that these price changes merely reflect noise in the price

[4] Tobacco products, cars, daily newspapers and mobile phone fees were not included in our data set for confidentiality reasons by Statistics Austria. After some data manipulations and exclusions the coverage of our data set reduces to about 80% of the total Austrian CPI. A detailed description of some data issues and manipulations that are required prior to the statistical analysis can be found in Annex I. There we discuss the temporal unavailability of price observations, imputed prices, outliers, aggregate products, the revision of the CPI goods basket in January 2000, sales, product replacements, product weights and censoring of price spells.

setting process and are not due to changes in fundamental price determining factors (as e.g. monetary policy and business cycle developments) and therefore they should be ignored from the viewpoint of monetary policy analysis. Therefore, we also provide an alternative set of results in section 3 without taking into account the price changes induced by temporary promotions and sales.

3. Methodology and Descriptive Empirical Results

3.1 The Frequency of Price Changes and the Duration of Price Spells

As measures to assess the degree of price rigidity or flexibility at the micro level we use the average frequency of all price changes and the implied duration of price spells. For each product category *j*, the frequency of price changes (F_j) is computed as the ratio of observed price changes to all valid price records.[5] Thus, the measure F_j is an average incorporating price changes of all firms where the product *j* has been recorded and over all periods of time. The implied duration of price spells could be calculated as the inverse of the frequency of price changes $T = \frac{1}{F}$.

However, for this estimator to be consistent homogenous observations in the cross-sectional dimension are required. Another issue to be considered for the derivation of the implied duration of price spells is the discrete timing of observations: We observe only one price per month and implicitly assume, if we observe a price change, that the price change occurred at the end of the month and the price remained unchanged for the rest of the month. Relaxing this assumption and allowing for continuous timing and assuming that the durations of price spells follow an exponential distribution, the *implied average duration* of price spells can be estimated as

$$T_j^{F,avg} = \frac{-1}{\ln(1 - F_j)} \tag{1}$$

[5] Here the frequency of price changes (F) is computed directly from the data and the duration of price spells (T) is derived indirectly from the frequency. Alternatively, the duration of price spells could be calculated directly from the price trajectories and the frequency could be derived implicitly. We decided to use the first approach (which could be called "frequency approach") because it uses the maximum amount of information possible, implying that it can be used even if the observation period is very short and if specific events, such as the revision of the CPI basket or the euro cash changeover, need to be excluded from the analysis. In addition, it does not require an explicit treatment of the censoring of price spells. For a robustness check we also calculated the frequencies and durations following an alternative method ("duration approach"). The results, which are included in the working paper version of this paper, are quite similar (see Baumgartner et al., (2005)).

and the *implied median duration* as

$$T_j^{F,med} = \frac{\ln(0.5)}{\ln(1-F_j)}. \quad (2)$$

These expressions are unbiased estimates of the mean and median duration of price spells in continuous time under the assumption of a constant hazard rate within a month (see Baudry et al., (2004), and Bils and Klenow, (2004)). In tables 1 and 2 the results aggregated on the COICOP[6] and product type level are presented.

Price rigidity varies considerably: On average, 15% of all prices are changed every month, which implies an average (median) duration of price spells of 14 (11) months (see table 1). Unprocessed food and energy products display a rather high frequency of price changes (24% and 40%) and thus a short implied duration (6.5 and 8.3 months, respectively). Within these categories seasonal food products and fuels of different types show the highest frequency of price changes.[7] Due to the continuous time assumption to derive formula (1) and (2), for these products the implied durations are smaller than one month, although the observation frequency is monthly. However, this is not unreasonable since fuel prices are indeed changed with a very high frequency – sometimes even on a daily basis. In contrast, some service items as well as products with administered prices display a (very) low frequency of price changes and, on average, a duration which is almost three times as long as for unprocessed food. For example, banking, parking and postal fees show an estimated average duration of 50 months or longer.

The patterns of price adjustment in Austria across product groups are consistent with those found for other European countries. Also for the aggregate, the duration of price spells and the frequency of price changes are similar to the other countries as they are close to the average of all euro area countries considered (see Dhyne et al., (2005)).

If we analyze price increases and decreases separately, we realize that prices increase slightly more often than they decrease: the frequency of price increases is 8.2% compared to 6.6% for price decreases. Exceptions from this pattern can be found in the category communication (especially personal computers), where price decreases appear much more frequent than price increases.

[6] COICOP stands for "Classification Of Individual COnsumption by Purpose" (see Statistics Austria, (2001B)).

[7] Results on individual products are available from the authors upon request.

Table 1: Frequency of Price Changes by COICOP Classification and Product Type (Weighted Average of the Entire CPI Basket)

	Frequency of price changes	Average duration of price spells	Median duration of price spells	Frequency of price increases	Frequency of price decreases	Average price increase	Average price decrease
By COICOP							
COICOP 01: Food and non-alcoholic beverages	17,3%	7,9	7,9	9,1%	7,9%	16,9%	18,7%
COICOP 02: Alcoholic beverages and tobacco	14,6%	6,5	5,9	7,4%	7,0%	14,6%	14,9%
COICOP 03: Clothing and footwear	12,0%	9,4	7,9	6,4%	5,0%	23,1%	33,7%
COICOP 04: Housing, water, gas and electricity	11,2%	14,7	11,3	6,9%	4,0%	6,6%	8,7%
COICOP 05: Furnishing & maintenance of housing	6,9%	17,8	16,0	4,1%	2,5%	9,3%	13,6%
COICOP 06: Health care expenses	5,6%	18,8	19,7	4,4%	1,1%	4,0%	6,7%
COICOP 07: Transport	36,5%	11,2	9,6	18,8%	17,7%	8,3%	8,8%
COICOP 08: Communications	8,9%	16,0	10,5	1,8%	6,9%	15,5%	26,0%
COICOP 09: Leisure and culture	24,2%	15,8	11,2	12,3%	11,2%	11,1%	12,3%
COICOP 10: Education	4,5%	23,2	20,2	4,1%	0,4%	4,9%	0,5%
COICOP 11: Hotels, cafés and restaurants	8,3%	19,3	21,3	5,4%	2,6%	7,3%	8,4%
COICOP 12: Miscellaneous goods and services	7,1%	18,7	15,2	4,9%	2,0%	7,6%	11,4%
By Product type							
Unprocessed food	24,0%	6,5	7,5	12,6%	11,1%	19,6%	22,0%
Processed food	12,8%	8,5	7,9	6,8%	5,8%	14,8%	16,1%
Energy	40,1%	8,3	4,8	20,7%	19,3%	5,1%	4,4%
Non energy industrial goods	10,2%	13,7	11,5	5,4%	4,3%	13,2%	18,6%
Services	12,6%	19,4	18,5	7,4%	5,0%	8,1%	10,9%
Total	15,1%	14,1	11,1	8,2%	6,6%	11,4%	14,7%

Frequency: Average proportion of prices changes per month, in % - Duration: in months.
Sample period: January 1996 – December 2003.

Concerning the size of price changes, price increases and decreases appear to be quite sizeable when they occur. The average price increase is 11% whereas prices are reduced on average by 15%. Especially for clothing and footwear (due to seasonal sales) and again for communication and electronic items (personal computers) price decreases are very pronounced.

As has been mentioned before, the results on the frequencies of price changes and the implied duration of price spells are also computed *without sales and promotions*. Corresponding results are shown in table 2. For all product groups the frequencies of price changes have to be smaller (or equal) compared to the figures in table 1. It also turns out that the average size of price changes is smaller without sales and promotions reflecting the fact that price cuts due to seasonal sales especially in the clothing sector are usually quite sizeable. As expected, these effects are most pronounced for food and alcoholic beverages where temporary promotions are a common practice to attract new customers, as well as for clothing and footwear where end of season sales are usual to clear inventories. For the latter category the average price decrease (in absolute terms) is almost 15 percentage points lower if sales are disregarded.

3.2 The Frequency and Magnitude of Price Changes over Time

When looking at the frequency of price changes over time we can see that there is a clear seasonal pattern visible in chart 1: The spikes in January 1998, 1999, 2001, 2002 and 2003 indicate that most prices are changed in January.[8] Starting with the year 2000 price changes have been more frequent than before which coincides with higher aggregate inflation in the period 2000–2003 than in the period 1996–1999. However, one must bear in mind that from 2000 on a new CPI basket forms the basis of our data set.

Apart from this shift in 2000, there is no trend in the frequency of price changes visible over the period considered. Furthermore, price increases and decreases show a marked seasonal pattern and their frequencies appear to be closely related.

We have calculated not only the frequency of price changes but also the size of the price changes for each period in time. Chart 2 plots the weighted average of the absolute size of all price changes as well as the magnitudes of price increases and decreases over time. The graph reveals a strong seasonal pattern especially for price decreases: These appear to be more pronounced in January and February as well as in July and August which reflects end-of-season sales usually taking place in that period of the year.

[8] Note that price changes in January 2000 have been excluded from the analysis (see Annex 1).

Table 2: Frequency of Price Changes by COICOP Classification and Product Type (Weighted Average of the entire CPI basket – without Sales and Promotions)

	Frequency of price changes	Average duration of price spells	Median duration of price spells	Frequency of price increases	Frequency of price decreases	Average price increase	Average price decrease
By COICOP							
COICOP 01: Food and non-alcoholic beverages	11,3%	13,0	13,9	6,1%	4,8%	12,3%	13,3%
COICOP 02: Alcoholic beverages and tobacco	8,0%	12,1	11,9	4,1%	3,6%	10,3%	10,0%
COICOP 03: Clothing and footwear	8,5%	12,5	11,1	4,7%	2,9%	16,3%	19,2%
COICOP 04: Housing, water, gas and electricity	10,5%	15,2	11,3	6,6%	3,7%	6,5%	8,5%
COICOP 05: Furnishing & maintenance of housing	5,9%	19,5	17,1	3,5%	2,0%	7,8%	11,1%
COICOP 06: Health care expenses	5,5%	19,1	19,7	4,4%	1,0%	4,0%	6,9%
COICOP 07: Transport	34,4%	11,5	10,4	17,7%	16,6%	8,2%	8,5%
COICOP 08: Communications	8,1%	16,4	10,5	1,5%	6,5%	21,4%	26,2%
COICOP 09: Leisure and culture	21,3%	17,2	11,7	10,8%	9,7%	10,7%	11,6%
COICOP 10: Education	4,5%	23,2	20,4	4,0%	0,4%	4,9%	0,5%
COICOP 11: Hotels, cafés and restaurants	7,7%	19,7	21,9	5,1%	2,3%	7,3%	7,8%
COICOP 12: Miscellaneous goods and services	6,4%	21,1	15,5	4,6%	1,7%	6,5%	8,7%
By Product type							
Unprocessed food	17,4%	10,6	12,5	9,2%	7,7%	15,0%	16,4%
Processed food	7,1%	14,3	14,0	4,0%	2,8%	10,4%	10,8%
Energy	37,9%	8,6	5,5	19,6%	18,2%	5,1%	4,5%
Non energy industrial goods	8,4%	15,7	13,7	4,5%	3,2%	10,6%	13,5%
Services	11,6%	20,2	19,3	6,9%	4,5%	8,2%	10,5%
Total	12,8%	16,1	14,0	7,0%	5,3%	9,6%	11,5%

Frequency: average proportion of prices changes per month, in % - Duration: in months.
Sample period: January 1996 – December 2003.

Consequently, also price increases display a seasonal pattern as the price decreases due to sales are usually reversed in the following period implying higher price increases in March and September, but this pattern appears to be less clear-cut than that of price decreases. The most striking observation from the figure is the decrease in the size of price changes in the second half of 2001 reaching a low of less than 10% in January 2002 and increasing again thereafter. This development is clearly attributable to the euro cash changeover which obviously induced many small price changes when prices had to be converted from the old to the new currency. In addition, the size of price increases and the size of price decreases turned out to be roughly equal in January 2002 which is in contrast to the seasonal regularity of larger decreases than increases normally observed in January. Disregarding the smaller than average price changes in 2001 and 2002, there is no upward or downward trend visible in the development of the size of price changes in chart 2 with the average magnitude of price changes fluctuating around 15% most of the time.

Taking together, the evidence for the frequency and the size of price changes in charts 1 and 2 we find that in the period surrounding the cash changeover (from about mid 2001 to mid 2002) consumer prices were adjusted more frequently but by smaller amounts than in other times. In addition, price adjustment with respect to both the frequency and the size of price changes was quite symmetric during the cash changeover period. This implies that our dataset – to the extent that it is representative for the total CPI – does neither suggest a sizeable positive nor negative impact of the cash changeover on aggregate inflation.

3.3 Synchronization of Price Changes

For each product the *synchronization of price changes* ($SYNC_j$) is measured by the index proposed by Fisher and Konieczny (2000) which is given as the ratio of the empirical standard deviation of the frequency of price changes for product category *j* to the theoretical maximum standard deviation in the case of perfect synchronization of price changes

$$SYNC_j = \frac{\sqrt{\frac{1}{\tau - 1}\sum_{t=2}^{\tau}\left(F_{jt} - F_j\right)^2}}{\sqrt{F_j\left(1 - F_j\right)}} \tag{3}$$

where τ is the total number of periods for which the ratio is calculated. Perfect synchronization of price changes occurs when either all stores change their price at the same time or none of them changes a price. Consequently, synchronization of price changes is high if the synchronization ratio is close to 1 and low if it is near 0. Separate synchronization ratios for price increases and decreases are also computed.

Chart 1: Frequency of Price Changes over Time, Weighted Average (in %), and Aggregate Inflation (Right Axis)

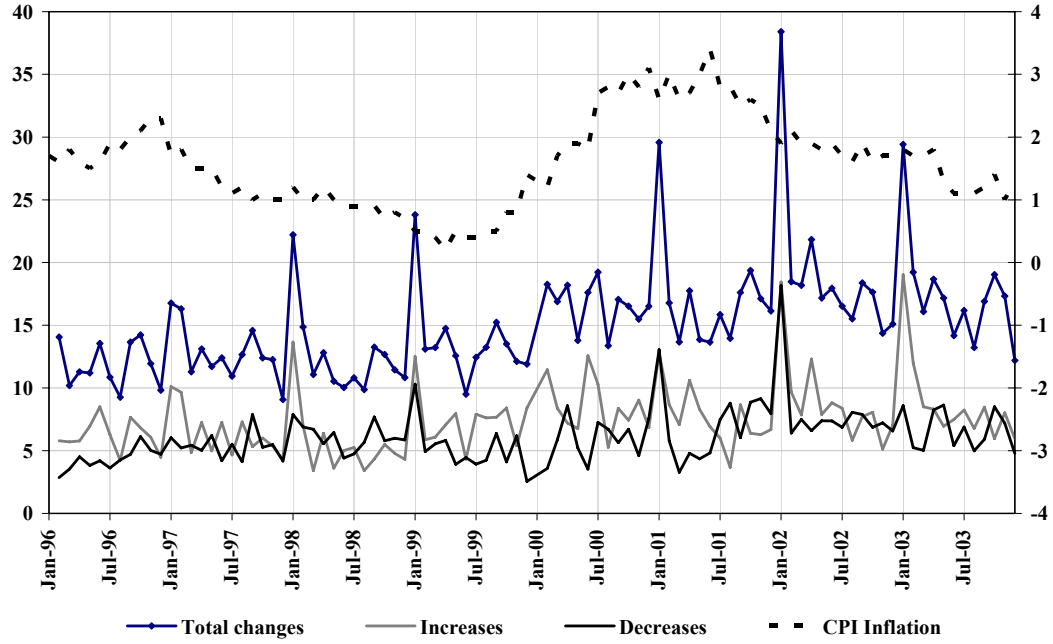
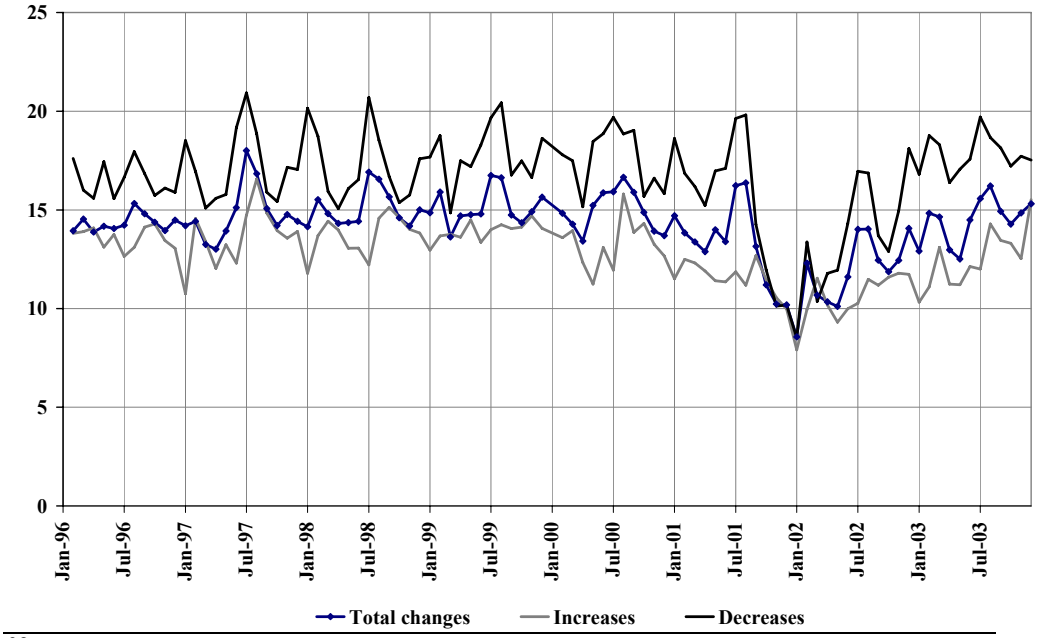


Chart 2: Size of Price Changes Over Time, Weighted Average (in %)



The results in table 3 show that the average synchronization ratio of price changes for all products amounts to 42% which constitutes an intermediary degree of price synchronization. However, this number masks the substantial heterogeneity across sectors and products: There is a wide range from 20% for alcoholic beverages to 87 and 94% for health care and communication items, respectively. Prices in education and health care are regulated to a large extent, and in most cases these changes are price increases.[9] For food items the synchronization ratios are also very low, with an average of 21%. Furthermore, we observe that the synchronization ratio is generally higher for price increases than for decreases. This could reflect price changes that are triggered mainly by supply shocks, as the observed asymmetry is especially pronounced for energy products.

With the exception of alcoholic beverages and clothing and footwear the results calculated without the price changes induced by sales and promotions are very similar. As expected, for these products the exclusion of promotions and seasonal sales results in a synchronization ratio for price decreases which is considerably lower (by 4 and 7 percentage points, respectively) compared to the results including sales and promotions.

4. The Probability of Price Changes

As is shown in the previous section price setting is very heterogeneous among products and also within a product group. To gain further insight in the determination of the frequency of price changes we present estimates of hazard functions and regression results of a panel logit model for the probability of a price change. For similar studies for other euro area countries see Álvarez and Hernando (2004) for Spain, Baudry et al., (2004) and Fougère et al. (2004) for France, Aucremanne and Dhyne (2004B) for Belgium, Dias et al. (2005) for Portugal and Jonker et al. (2004) for the Netherlands.

[9] The synchronization ratios for price increases and decreases are based on calculations without accounting for product replacements because price changes cannot seriously be divided into price increases and decreases in this case. As a consequence, the value for all changes (with replacements) need not necessarily lie within the range given by ratios for increases and decreases for each product category.

Table 3: Synchronisation Ratios by COICOP Classification and Product Type (Weighted Average of the Entire CPI Basket)

	Synchronisation ratio of price changes		Synchronisation ratio of price increases		Synchronisation ratio of price decreases	
By COICOP	all prices	without sales	all prices	without sales	all prices	without sales
COICOP 01: Food and non-alcoholic beverages	21,1%	21,8%	21,2%	22,6%	19,9%	19,5%
COICOP 02: Alcoholic beverages and tobacco	20,3%	22,2%	16,6%	18,1%	23,5%	27,3%
COICOP 03: Clothing and footwear	26,0%	26,5%	18,9%	17,4%	22,8%	15,9%
COICOP 04: Housing, water, gas and electricity	53,6%	53,7%	58,3%	58,6%	39,9%	39,1%
COICOP 05: Furnishing & maintenance of housing	27,7%	28,3%	25,5%	25,8%	21,2%	21,4%
COICOP 06: Health care expenses	86,7%	86,4%	84,0%	83,6%	54,6%	55,2%
COICOP 07: Transport	51,4%	52,0%	54,9%	54,5%	56,5%	56,8%
COICOP 08: Communications	93,8%	93,9%	85,3%	79,8%	91,7%	91,8%
COICOP 09: Leisure and culture	51,1%	49,3%	51,3%	49,9%	42,9%	41,4%
COICOP 10: Education	80,8%	80,7%	81,7%	81,6%	44,7%	44,7%
COICOP 11: Hotels, cafés and restaurants	30,9%	31,0%	29,0%	28,9%	25,4%	25,2%
COICOP 12: Miscellaneous goods and services	50,1%	50,3%	47,6%	47,8%	36,5%	36,2%
By Product type						
Unprocessed food	20,5%	20,9%	22,7%	23,8%	22,4%	21,0%
Processed food	21,3%	22,4%	19,6%	21,2%	18,9%	19,8%
Energy	51,6%	51,9%	62,7%	62,7%	49,1%	47,9%
Non energy industrial goods	34,2%	34,6%	30,8%	30,4%	28,3%	26,6%
Services	58,6%	58,1%	55,8%	54,6%	45,4%	44,9%
Total	41,9%	42,0%	40,4%	40,0%	34,2%	33,2%

Sample period: January 1996 – December 2003.

4.1 Kaplan-Meier Estimates of Survivor and Hazard Functions

In the following, we present Kaplan-Meier estimates of the survivor and hazard functions for all products and separately for product groups. Particular emphasis is given to the question how the weighting of spell observations influences the results. The Kaplan-Meier estimator is a non-parametric estimate of the survivor function *S(t)*, the probability of "survival" of a price spell until time *t*. For a dataset with observed spell lengths $t_1,\ldots,t_k$ where *k* is the number of distinct failure times (time until a price change) observed in the data, the Kaplan-Meier estimate at any time *t* is given by

$$\hat{S}(t) = \prod_{j|t_j \le t} \left(\frac{n_j - d_j}{n_j} \right) \tag{4}$$

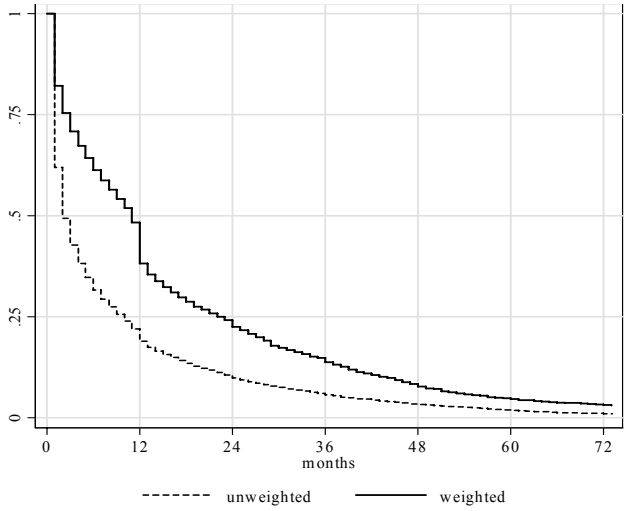
where n_j is the number of price spells "at risk" of exhibiting a price change at time t_j and d_j is the number of price changes at time t_j. The product is calculated over all observed spell durations less than or equal to *t* (see, for example, Cleves et al., 2002). The interpretation of the survivor function is as follows: For each analysis time *t*, the step function gives the fraction of price spells which have durations of *t* months or more.

Chart 3 shows two versions the Kaplan-Meier estimate of the survivor function for all price spells of all elementary products in our data. The dashed line is the "unweighted" survivor function whereas the solid line is "weighted" in a sense that will be explained in a moment. Note that the dashed line in chart 3 decreases very quickly during the first months which means that most price spells have a low duration.

The survivor function shown by the dashed line gives equal weight to each price spell. This implies that its shape is dominated by elementary products exhibiting a high number of spells, i. e. which have short durations.

Table 4 gives values for quantiles (25th percentile, the median and 75th percentile of the spell durations, respectively) for COICOP categories and product types separately. The table also shows the number of spells per category and compares the share of spells to the weights in the CPI baskets. Both classifications indicate clearly that COICOP food items have a much higher share of spells (59%) than indicated by their CPI weight (17%). Non-energy industrial goods and services, on the other hand, contribute a comparably small share of spells but much higher CPI weights.

Chart 3: Aggregate Survivor Function



Dias et al. (2005) show formally how the relatively higher share of spells of product categories with higher frequencies of price changes creates a bias when estimating the duration of price spells. They suggest, as one way to solve this problem, to use only a fixed number of spells per product category. As the authors note themselves such a sampling scheme does not use all the available information and will hence not be efficient. As an alternative, we apply a weighting scheme where (1) each product category is weighted with the inverse of the total number of price spells for that product category which ensures that each product category has the same weight in the results; (2) in addition, we attach to each product category its CPI weight. This is the basis for our "weighted" Kaplan-Meier estimates of survivor and hazard functions. Adjustment (1) makes a big difference because the enormous weight of food products is reduced whereas step (2) changes the picture not very much.

The solid line in chart 3 shows the survivor function where each spell was re-weighted as described. Compared to the previous version this new survivor function is shifted upwards. Moreover, it has a marked drop at a duration of twelve months which indicates that prices that change every year are an important phenomenon. Table 4 shows that the unweighted median duration over all spells is merely 2 months which is mainly due to the short duration of food item price spells. The weighted median over all products categories is 11 months which is approximately the same result as obtained by the frequency approach in section 3. According to the weighted survivor function, for almost half of all products

(adjusted for different CPI weights), prices are adjusted at a frequency of less than once a year.

The hazard rate based on the Kaplan-Meier estimator is displayed in chart 4.[10]Panel (a) represents the unweighted version. As expected, its overall shape is decreasing with time. But it also displays peaks, for example at durations of 12, 24, and 36 months, respectively which suggests that a substantial portion of firms change their prices at fixed intervals. Unconditional aggregate hazards which are decreasing with analysis time are a typical result of duration studies on micro CPI data (see Fougère et al., (2005), Álvarez et al., (2004) and Dhyne et al., (2005)). At first sight, this result is puzzling in the light of price-setting theories, as it could be interpreted that a firm will have a lower probability to change its price the longer it has been kept unchanged.

However, there are several explanations for the decreasing shape of the hazard function. All focus on the heterogeneity of price setters or products. Apparently, a major reason for the decreasing hazard function is the oversampling problem described above, namely that product categories with a high frequency of price changes and thus a higher number of spells wrongly suggest that the probability of a price change is highest after 1, 2, or 3 months (such as in panel (a) of the figure). Panel (b), however, shows that after re-weighting the likelihood of a price change is highest 12 months after the last price change.

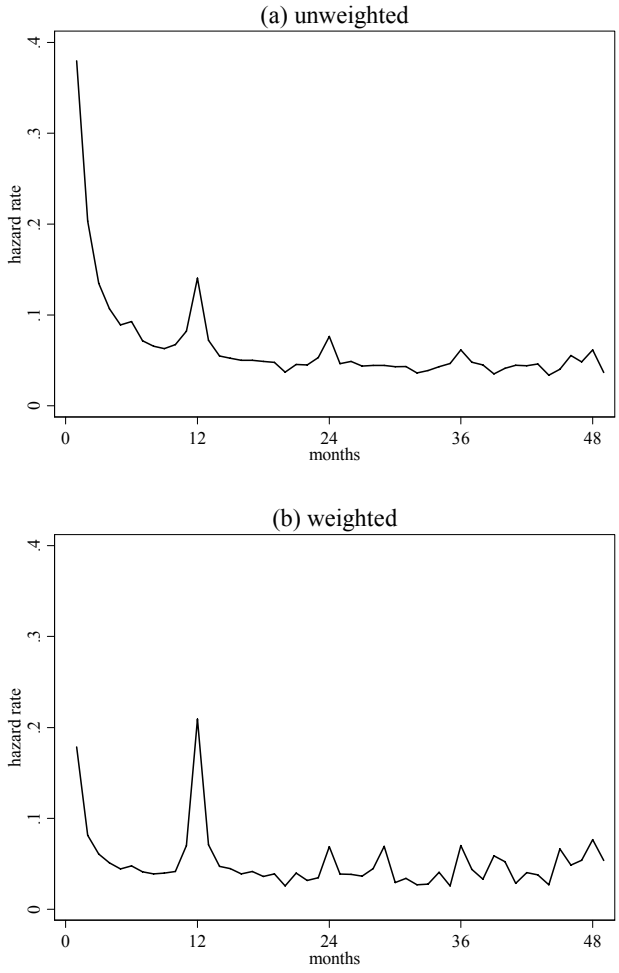
[10] The hazard rate is estimated as d_j / n_j, i. e. the rate at which spells are completed after duration t.

Table 4: Spell Durations – Kaplan-Meier Estimates (Weighted and Unweigthed)

	no. of spells (completed or right-censored)	share of spells	share of product categories	Average CPI weight	unweighted			weighted		
					25p	median	75p	25p	median	75p
By COICOP										
COICOP 01: Food and non-alcoholic beverages	214.650	58,6%	20,7%	16,9%	1	2	5	1	3	10
COICOP 02: Alcoholic beverages and tobacco	12.000	3,3%	1,7%	1,7%	1	3	9	1	3	9
COICOP 03: Clothing and footwear	26.049	7,1%	8,9%	9,2%	2	7	24	4	10	29
COICOP 04: Housing, water, gas and electricity	10.005	2,7%	6,4%	12,6%	1	2	7	4	11	20
COICOP 05: Furnishing & maintenance of housing	17.019	4,6%	11,7%	11,4%	3	9	22	6	12	32
COICOP 06: Health care expenses	1.478	0,4%	4,1%	3,3%	9	12	24	12	12	26
COICOP 07: Transport	34.283	9,4%	9,7%	9,9%	1	1	10	1	5	13
COICOP 08: Communications	462	0,1%	2,5%	3,5%	2	4	11	10	11	n. def.
COICOP 09: Leisure and culture	18.234	5,0%	15,2%	13,0%	1	5	18	2	10	28
COICOP 10: Education	299	0,1%	1,7%	0,7%	12	12	24	12	12	24
COICOP 11: Hotels, cafés and restaurants	16.819	4,6%	6,1%	8,7%	2	8	22	7	15	29
COICOP 12: Miscellaneous goods and services	15.043	4,1%	11,3%	9,1%	3	11	19	11	12	24
By Product type										
Unprocessed food	140.953	38,5%	9,4%	7,1%	1	2	3	1	2	7
Processed food	85.697	23,4%	13,0%	11,6%	1	3	10	1	4	12
Energy	29.348	8,0%	2,8%	9,4%	1	1	2	1	2	9
Non energy industrial goods	68.768	18,8%	41,5%	37,0%	2	8	20	4	12	25
Services	41.575	11,4%	33,3%	34,9%	3	11	22	8	12	28
Total	366.102	100,0%	100,0%	100,0%	1	2	10	3	11	22

Note: Left-censored spells and spells with gaps have been dropped.

Chart 4: Aggregate Unconditional Hazard Function

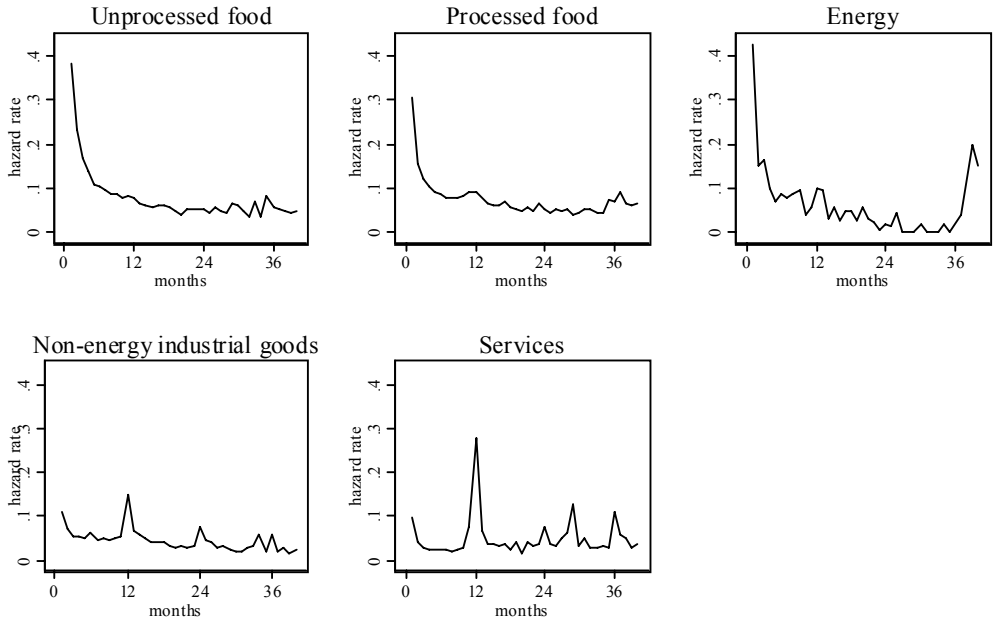


An additional reason for downward sloping hazard functions comes from aggregating firms with different (time-dependent) price-setting behavior. As Álvarez et al. (2004) point out, the aggregation of different types of time dependent price setters almost always leads to a decreasing aggregate hazard function. Another related rationale for falling hazards is that the CPI is the result of the aggregation of heterogeneous products: For some products, prices are adjusted infrequently (e. g. services) whereas for others many price changes are observed (e. g. energy). Even if there is no oversampling of products categories, the hazard function may still be decreasing. For example, Dias et al. (2005) and Fougère et al.

(2005) only use one spell per product in the estimation of hazard functions, but in both cases the hazard functions are still declining.

Hazard rate estimates for different product groups (chart 5) show some interesting patterns: For example, for services the hazard is highest when the duration is approximately 1 year. The corresponding hazard function also displays noticeable spikes at 24, 36, and 48, months, respectively. Energy items, on the other hand, have a very high hazard when the spell duration is low. Non-energy industrial goods have high probabilities of price changes both at short durations and after one year whereas, for both unprocessed and processed food, the hazard rates are highest at short durations.

Chart 5: Aggregate Hazard Functions by Procuct Type



Weighted estimates (see text).

4.2 Logit Estimates

In order to control for unobserved characteristics of individual units (i) we estimate a panel logit model with fixed elementary product effects, where an elementary product is the combination of the product category (j) and the outlet code (k), taking into account product and store replacements (see Annex I.2). The cross-section dimension (j*k) is indexed by (i). This allows us to control for the fact that

within the same product category firm A can adjust its price more or less frequently than firm B. For the estimation all left-censored price spells (as well as spells with gaps) are excluded because some explanatory variables like the duration of a price spell and the accumulated inflation for a product category since the last price change are not defined when the starting date of the spell is unknown.

As in Cecchetti (1986) and Aucremanne and Dhyne (2004B), we specify the following fixed effects conditional logit model.[11] The dependent variable is binary indicating the occurrence of a price change *next month* (or at the end of the current period t, Y_{it}=1),

$$\Pr(Y_{it} = 1 \mid \mathbf{x}_{it}) = F(\boldsymbol{\beta}'\mathbf{x}_{it} + \alpha_i) \tag{5}$$

with

$$\begin{aligned} \boldsymbol{\beta}'\mathbf{x}_{it} = \; & \beta_0 + \beta_1 * TAU_{it} + \beta_2 * INF\_ACC\_J_{it} + \beta_3 * ATTR_{it} + \beta_4 * LDW_{it} \\ & + \beta_5 * LSIZE\_UP_{it} + \beta_6 * LSIZE\_DW_{it} + \sum_{h=1}^{5} \beta_{6+h} * DURh_{it} \\ & + \sum_{h=1}^{2} \beta_{11+h} * EUROh_{it} + \sum_{h=1}^{11} \beta_{13+h} * MONTH\_h_{it} \\ & + \sum_{h=2}^{7} \beta_{23+h} * YEAR\_h_{it} + \beta_{31} * DUM\_12\_99_{it} + \beta_{32} * DUM\_00\_03_{it} \end{aligned} \tag{6}$$

and i = 1,...,N is the cross-section dimension (the number of elementary products), $t = 1,...,T_i$ is the time-series dimension, α_i are the fixed effects and F represents the cumulative logistic distribution function

$$F(z) = \frac{\exp(z)}{1 - \exp(z)}. \tag{7}$$

As explanatory variables we included several state and time dependent variables described below. The duration of price spells (TAU) gained a lot of attention in related studies, as the sign of its coefficient reflects the panel data estimate of the direct time effect which was described by the hazard functions in the previous section. We argued there that the downward sloping hazard functions are a consequence of aggregating over (very) heterogeneous products. After controlling for unobserved heterogeneity with a fixed effects model we therefore expect a positive sign for the coefficient of the duration of price spells.

As another state dependent explanatory variable we included the absolute value of the accumulated sectoral rate of inflation for the product category (j) to which the elementary product (i) belongs (INF_ACC_J). For each elementary product at time (t) the sectoral inflation rate is accumulated over the period since its last price change. This variable is a proxy for the relative price position of outlet (k) selling product (j) to the average of all other outlets selling a product of the same category. Therefore, if the accumulated inflation increases, on average the competitors already increased their prices, whereas outlet (k) held its price unchanged, which

[11] See Baltagi (2001, chapter 11) for a discussion of the properties of panel logit models.

puts it in a better position to increase its price without losing customers. Consequently, for this variable our expectation is also a positive coefficient.

We consider the impact of common commercial practices (as psychological pricing, sales and promotions) on the price-setting behavior by including dummy variables reflecting that a price was set in attractive terms[12] (ATTR) and the direction of the last price change (LDW = 1, if the last price change was a price decrease), respectively. For attractive prices we expect a dampening effect on the probability of a price change, i. e. a negative sign for this coefficient. If the last price change was a price reduction a reversion of this action with the next price adjustment becomes more likely therefore a positive sign for the coefficient of LDW is expected.

In addition, two variables reflecting the impact of the magnitude of a price change, defined as the absolute value of the last price change (LSIZE), are included: LSIZE_UP (defined as LSIZE*(1-LDW)) contains the size of price increases and LSIZE_DW (defined as LSIZE*LDW) measures the size of price reductions. If the last price change was a large price increase we expect that more time will elapse till the next price change, so the coefficient for LSIZE_UP should be negative. For a large price decrease, usually due to a promotion or a sale, we expect that this action is soon reversed, which should increase the probability of the occurrence of a price change in the next period, i. e. the coefficient of LSIZE_DW should be positive.

The hazard functions in charts 4 and 5 highlight the fact that there are local modes at specific durations, noteworthy 1, 6, 12, 24 and 36 months. We interpret this fact as some kind of truncated Calvo or Taylor pricing behavior and try to capture this with a set of dummy variables (DUR_*h*).

Two variables capture the effects of the euro cash changeover: one dummy for the direct effect in January 2002 (EURO1), and a second defined over the period 6 months before and 5 months after the month of the changeover in January 2002 (EURO2). In addition, several indicator variables for time dependent aspects as the seasonal pattern (monthly dummies MONTH_*h*) and yearly dummies (YEAR_*h*) to control for structural and/or cyclical economic effects not captured by other variables are included. To control for effects due to the revision of the CPI basket

[12] Attractive prices are defined for ranges of prices in order to take account of different attractive prices at different price levels: (i) from 0 to 10 ATS (Austrian Schilling) all prices ending at x.00, x.50 and x.90, (ii) from 10 to 100 ATS all prices ending at xx0.00, xx5.00 and xx.90, (iii) from 100 to 1,000 ATS prices ending at xx0.00, xx5.00 and xx9.00 and xxx.90 ATS and (iv) exceeding 1,000 ATS all 10, 100, 1,000 multiples of the prices in the previous range have been defined as attractive. If this definition is met, ATTR = 1, otherwise ATTR = 0. An equivalent rule has been defined to identify attractive prices in euro after the cash changeover.

in January 2000 dummy variables are included (DUM_12_99 = 1 in December 1999 and DUM_00_03 = 1 for the period January 2000 to November 2003).[13]

The estimation results are reported in table 5. We present the estimated marginal effects (slope) defined as the first derivatives of the probability function with respect to the explanatory variables, evaluated at the mean of the variables ($\overline{X}$) and its significance levels (p-value). The reference probability is a price change in January 1996.

The probability of a price change slightly increases the longer a price quote has been unchanged. An increase in the duration of a price spell (TAU) by one month increases the probability of a price change by roughly 0.6 percentage points. We interpret this result as evidence that, after controlling for unobserved heterogeneity at the elementary product level, (slightly) increasing hazard rates are obtained through a direct duration impact.

In addition, there is an indirect duration effect working through the role of the accumulated inflation variable as the sign of the coefficient for the accumulated inflation (INF_ACC) is positive as one would expect, i. e. the probability of a price change increases as inflation in the same product category rises. An increase in the accumulated monthly rate of inflation (of the same product category) by 1 percentage point increases the probability for a price change by 0.3 percentage points.

Attractive prices (ATTR) reduce the probability to change prices and the opposite is true for the dummy indicating that the last price change was a price reduction (LDW). Both results are in line with commercial practices, especially with promotions and seasonal sales. The size of the last price increase (LSIZE_UP) has no effect on the probability of a price change, where as the probability of a price change is higher the larger the last price decrease (LSIZE_DW) was: if the last price decrease was (in absolute terms) 1 (10) percentage points larger the probability of a price change to occur next period is 0.4 (4) percentage points higher. This finding is consistent with the practice of promotions and sales, as large temporal price reductions are usually quickly reversed by (large) price increases.

[13] In addition to the variables discussed, we experimented with other state dependent variables as the industrial production index, the aggregate consumer price index (both variables included either as month-on-month or year-on-year rates of change) and a tax variable. But none of these variables showed any significant effect.

Table 5: Probability of Price Change – Conditional Fixed Effects Logit Model

	Slope	p value	$\overline{X}$
TAU	0.006	0.00	8.26
INF_ACC_J	0.003	0.00	1.08
ATTR	-0.047	0.00	0.64
LDW	0.063	0.00	0.35
LSIZE_UP	0.000	0.82	8.83
LSIZE_DW	0.004	0.00	5.49
DUR1	0.110	0.00	0.20
DUR6	0.019	0.00	0.05
DUR12	0.225	0.00	0.02
DUR24	0.136	0.00	0.01
DUR36	0.094	0.00	0.00
EURO1	0.215	0.00	0.01
EURO2	0.036	0.00	0.14
MONTH_1	-0.056	0.00	0.08
MONTH_2	-0.105	0.00	0.08
MONTH_3	-0.076	0.00	0.08
MONTH_4	-0.107	0.00	0.08
MONTH_5	-0.109	0.00	0.08
MONTH_6	-0.105	0.00	0.09
MONTH_7	-0.135	0.00	0.09
MONTH_8	-0.078	0.00	0.09
MONTH_9	-0.099	0.00	0.09
MONTH_10	-0.100	0.00	0.09
MONTH_11	-0.150	0.00	0.09
YEAR_2	-0.042	0.00	0.10
YEAR_3	-0.065	0.00	0.13
YEAR_4	-0.090	0.00	0.13
YEAR_5	-0.019	0.00	0.13
YEAR_6	0.002	0.40	0.14
YEAR_7	0.014	0.00	0.16
D_12_99	0.058	0.00	0.01
D_00_03	-0.070	0.00	0.58

Dependent variable: Y = 1 if a price change occurs in the next month
No. of observations: 1,579,553 LR (b=0, p-value)= 0.000, log likelihood = -470,488
No. of groups: 44,192 elementary products, LR (pooling, p-value) = 0.000
Slope: dy/dx at the mean of the explanatory variable
Reference: January 1996 (MONTH_12, YEAR_1)

Concerning the time-dependent and Taylortype phenomena mentioned above, our logit estimates reinforce this evidence: especially for the duration of 12 months and to a lesser extent for durations of 1 month, 2 and 3 years we find a higher probability of a price change. For the euro cash changeover the time dummies are indicating a higher probability of a price change in January 2002 (EURO1), and less so in the 6 months before and 5 months after the month of the euro introduction as a physical means of payment (EURO2).

There is a strong seasonal pattern in the price-setting process. The probability that prices change next month is highest in December (the reference month) as the coefficients for all monthly dummies are negative and highly significant. Aucremanne and Dyhne (2004A,B), Baudry et al. (2004), Jonker et al. (2004), Dias et al. (2004) report similar results for other euro area countries. Furthermore, the seasonal dummies are also jointly highly significant, further indicating the importance of time-dependent elements in the price-setting process.

The establishment of a new CPI basket in January 2000 and the thereby introduced new definitions and reporting practices had a significant impact on the probability of a price change. It resulted in an almost 6 percentage points higher price change probability in January 2000 (D_12_99) whereas for the whole period January 2000 to December 2003 (D_12_99 + D_00_03) this probability was 1.2 percentage points lower compared to the first four years in the sample.[14]

To summarize: although some time dependent aspects can be observed in the data, our evidence does not support pure time dependent representations of the price-setting process (as Calvo, truncated Calvo or Taylor contracts) at the micro CPI level, as some of the state dependent variables have a significant effect on the probability of a price change.

5. Conclusions

In this paper we analyze the patterns and determinants of price rigidity present in the individual price quotes collected to compute the Austrian CPI. We calculated estimates for the average frequency of price changes and the duration of price spells for 639 product categories.

We find that consumer prices change quite infrequently in Austria. The weighted average (median) duration of price spells for all products is 14 (11) months. The sectoral heterogeneity is quite pronounced: Prices for services, health care and education change rarely, typically approximately once per year. For the product types food, energy (transport) and communication prices are adjusted on average every 6 to 8 months. Promotions and sales have a considerable impact on

[14] One has also to take into account that the effects due to different business cycle conditions as well as the average annual rate of inflation are captured by the yearly dummies.

the frequency of price adjustments for food, clothing and footwear, where temporal promotions and end-of-season sales are a common practice. With respect to the synchronization of price changes a similar sectoral pattern occurs as for the durations of price spells: The prices of products with a longer duration are also adjusted in a more synchronous way.

Price increases occur slightly more often than price decreases. Price increases and decreases are quite sizeable when they occur: on average, prices increase by 11% whereas prices are reduced on average by 15%. Especially for clothing and footwear (due to seasonal sales) and for communication and electronic items price decreases are very pronounced (34% and 26%, respectively).

Like in similar studies, we find that the aggregate hazard function for all price spells is decreasing with time (i.e. the duration of a price spell) which would be at odds with most price-setting theories. However, this is to a large extent a consequence of aggregating over product types with different spell durations. A re-weighted version of the hazard function which ensures that each product category basically has the same weight (and adjusted for CPI weights) is not monotonously decreasing, but has its most marked spike at a duration of 1 year which indicates that for a substantial proportion of all goods infrequent price adjustment occurs. Using Kaplan-Meier estimates of hazard functions, we show that there is substantial heterogeneity across goods and product types: Energy and unprocessed food show high hazards during the first months. For services, on the other hand, the hazard is highest after one year.

In contrast to other European studies, we find a positive and significant effect of the duration of a price spell on the probability of a price change if we account for unobserved heterogeneity in a panel logit model with fixed elementary product effects. We observe also a positive link between the probability of a price change and the accumulated inflation at the product level. Additionally, we find a pronounced seasonal pattern and a negative impact on the probability to change a price if it is currently set as an attractive price. During the period associated with the euro cash changeover the probability to change prices was higher.

Although some time dependent aspects have a significant impact on the probability of a price change, our evidence does not support pure time dependent representations of the price-setting process at the outlet level, as some of the state dependent variables also show a significant influence on the probability to observe a price change.

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Annex: Data Issues

1. Imputations, Exclusions, Outlier Adjustment and Revision of the CPI Goods Basket

In the case of temporal unavailability of a price quote the price has been imputed with the previous price quote for at most one month. Filling the (one-month) gaps

of missing observations mitigates the problem induced by censored price spells (see next sub-section). In case the price quote was unavailable for more than one month it has not been imputed, because the chance of missing an unobserved price change becomes more and more likely with the duration of missing observations.

On the other hand, individual prices quotes which were imputed by the statistical office due to temporal and seasonal unavailability of an item were excluded from our data set, however with the disadvantage of creating additional censored spells. We do not regard them as true price observations but as "pseudo observations", which unintentionally would introduce an upward bias in the estimation of the duration of price spells.

Some products which display systematically unrealistic price movements were removed as outliers from the data set mainly on a judgmental basis. The nature of these products as outliers was reflected by the fact that they all displayed *average* price increases or decreases of more than 60%, some of them considerably more (according to the log price difference, $\ln(P_{jk,t}) - \ln(P_{jk,t-1})$). On this basis, 14 products (e.g. kindergarten fees, public swimming pool, refuse collection, public transport day ticket) have been excluded representing a weight of 1.4% in the total CPI. In addition, very large individual price changes exceeding a pre-defined threshold value have been identified as outliers and disregarded in the analysis. We applied a combined rule specifying an absolute value for the log price change and a distribution dependent upper and lower bound as the threshold for outliers. Specifically, all individual price changes with $\left|\ln(P_{jk,t}) - \ln(P_{jk,t-1})\right| \geq 1$ as well as those exceeding the upper and lower quartile of the distribution of price changes plus 3 times the interquartile range have been defined as outliers. This rule turned out to be a rather conservative way of outlier detection such that only a few observations had to be excluded.

In addition, based on information from Statistics Austria, 14 products whose price quotes already contain aggregated information have been removed for the purpose of our analysis as they do not represent price quotes on the micro level (e.g. rents and operating costs for houses are derived from the microcensus of Austrian households, and a few medical services are obtained from the social insurance institution). After the exclusion of these products together with the outlier products, individual price quotes for 639 product categories are included in our data consisting of a total of 1,888 product varieties and 49,766 combinations of product categories (j) and outlet codes (k), covering 80% of the Austrian CPI.

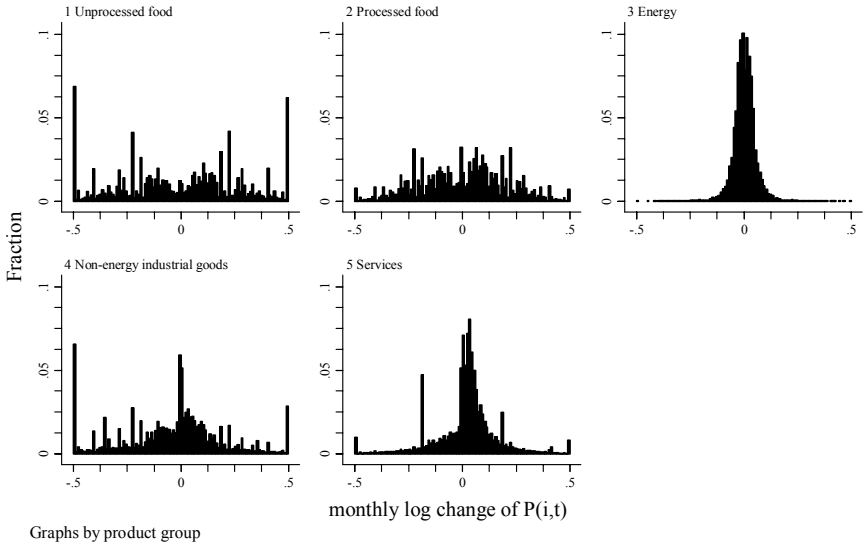
The chart shows the price change distribution where observations of zero price changes (which would produce very large spikes of 70% or more) were dropped. The five histograms differ considerably: Goods in the unprocessed food and processed food categories have a comparably large dispersion of price changes with especially unprocessed food items being characterized by many large price changes. A similar observation can be made for non-energy industrial goods.

Services and energy goods have a much smaller variance of price changes. The distribution for energy is almost symmetric, whereas for services it is markedly skewed towards positive price changes.

With the introduction of a *revised goods basket* for the CPI data collection in January 2000 (see Statistics Austria, 2000A, 2000B, 2001B), definitions and reporting practices were changed for many products. This makes a comparison of prices reported in December 1999 and January 2000 unfeasible for many products. As a consequence, all price changes from December 1999 to January 2000 have been disregarded in the computation of the descriptive statistics, given the large number of products affected by the revision of the Austrian CPI basket. In the econometric analysis in section 4 these price changes have not been excluded but have been accounted for by a dummy variable.

As regards the panel structure of the data, the most common case is that the records span the full period from January 1996 to December 2003 (46.1% of all combinations of product categories and outlets). Because our data contain two CPI baskets, many such combinations show up only from Jan. 1996 to Dec. 1999 (1996 CPI basket; 10.8% of all products-outlet combinations) or from Jan. 2000 to Dec. 2003 (2000 CPI basket, 14.1% of all combinations). Other patterns (including price trajectories with gaps) account for the rest.

Chart : Price Change Distribution within Product Groups



Note: Price changes with absolute values of more than 0.5 were replaced by -0.5 and +0.5, respectively. Bin width 0.01. 374,143 total observations (zero values are excluded).

2. Sales, Censoring, Product Replacement and Weighting

The information in our data set allows us to identify observations that are flagged as sales. In order to exclude price changes induced by flagged sales from our analysis, we replaced all flagged sales prices with the last regular price, i.e. the price before the sale or promotion started. As the reporting of sales and promotions is generally up to the interviewer and therefore cannot be expected to be complete and consistent across all products, we additionally tried to identify also those temporary price promotions which have not been coded as sales. We define "unflagged" temporary promotions and sales as a price sequence $P_{jk,t-1}$, $P_{jk,t}$, $P_{jk,t+1}$, where $P_{jk,t-1} = P_{jk,t+1}$, and $P_{jk,t-1} \neq P_{jk,t}$, i.e. price changes that are reversed in the following period. As in the case of flagged sales, the price changes induced by unflagged promotions and sales have been excluded from the analysis by replacing all identified prices ($P_{jk,t}$) with the preceding regular prices ($P_{jk,t-1}$).[15]

At the beginning and at the end of the sample period all price trajectories are *censored*, as we do not know the true starting date of the first price spell and the ending date of the last price spell. A price spell is left (right)-censored if the date of the beginning (end) of the spell is not observed, and double-censored if both the start and the end date of the spell are unknown. Censoring entails a downward bias in the estimation of the duration of price spells, as longer spells are more likely to be censored.

The products underlying the price observations are sometimes *replaced* in the database by others for two reasons: When a product is no longer available in a particular outlet (attrition), it is usually replaced by another product of the same product category which terminates the price spell (and the trajectory). However, products are sometimes also replaced due to the sampling strategy, e.g. when Statistics Austria defines another elementary product to be more representative for the product category. Unfortunately, we have no information on the nature of the product replacements, in particular not if they are forced or voluntary. According to Statistics Austria, the major part of product replacements in our database are forced replacements due to attrition, therefore we count the end of each price spell associated with a product replacement as a price change.

For the estimation of the hazard functions and the panel logit regression in section 4 left-censoring constitutes a serious problem as the starting date of the spell is not defined. For each elementary product, the first observed price spell is

[15] Flagged and unflagged sales and promotions are a quite common feature in the data, in particular in the food and clothing sectors. Overall, about 4% of all prices in our data set are flagged as sales prices while the share of prices identified as unflagged sales and promotions amounts to about 1.5% of the total number of observations. The effect of excluding all price changes that are due to (flagged and unflagged) sales and promotions can be assessed by comparing the results in tables 4 and 5 (see section 3.1).

left-censored because we cannot know for how long the price has been unchanged. For the same reason every spell after a product replacement is also regarded as left-censored. This comes close to "stock sampling" which constitutes a sample selection problem. A way to overcome this bias is to omit all left-censored spells from the estimation. Then only those spells are considered where we know exactly when the spell started. This is also called "flow sampling" and does not constitute a selection problem if at least one price change for every elementary product is observed (see Dias et al., (2005)). After dropping left-censored spells, we are left with a dataset that consists of 42,832 product-outlet combinations, contributing to 366,102 price spells or 1,879,929 monthly price observations.

Product-outlet combinations, however, are not identical to "elementary products" as defined in section 2 because they do not consider product and store replacements which occur quite often. For the panel logit regressions below we construct a subject variable which should correspond closely to the definition of an elementary product over time: In any case where a product or a store replacement is observed we change the identifier of the product-outlet combination. This results in 72,892 elementary products which is considerably higher than 42,832, the number of different product-outlet combinations.

In order to compute aggregate measures of the statistics described in section 3 and for the weighted hazard rates in section 4, we applied the same *weighting scheme* that is used to calculate the CPI. As these weights are not defined at the individual store level, we use an unweighted average over price records within a product category. All statistics at the elementary products level are then aggregated to 12 COICOP groups and 5 product types based on the CPI weights. As our data set spans over two goods baskets (1996, 2000) and the products included do not completely coincide, the average weights of the two weighting schemes are used, with a weight of zero at times when an elementary product was not included in the respective CPI basket. The individual weights which initially do not sum to one as not 100% of the CPI is covered in our sample, are then rescaled such that the sum of the weights equals 1 and the relative weights among the goods are preserved.

For a more in-depth discussion of some of the data issues the reader is referred to the working paper version of this paper (Baumgartner et al., (2005)) downloadable from the ECB homepage www.ecb.int.

Comment on "The Dynamics of Individual Consumer Price Data for Austria"

Johannes Hoffmann

Deutsche Bundesbank[1]

1. Motive for the Study

The study of Baumgartner, Glatzer, Rumler and Stiglbauer was conducted under the aegis of Research Group 2 (Analysis of Individual Consumer Price Data) of the Eurosystem Inflation Persistence Network, where inflation persistence was to be pinpointed at the level of individual price data. Prior to this, individual data from the consumer price statistics had been made available by a number of statistical authorities in Europe for the purpose of studying the effect of the changeover of prices from the national currencies to the euro. This exercise in itself provided a number of highly informative insights into price-setting behaviour.

Even at first glance, however, the data revealed that there was no inflation persistence at the level of individual prices. Most prices do not change too often (non-economists, however, consider a rate of 10% per month as quite frequent!) but when they do change, the changes are quite substantial. For example, a price change of 7% is usually followed by a considerable number of months without further adjustments. The research interest of RG2 was therefore concentrated on the statistical description and the economic explanation of price rigidities. Thus, price rigidity – rather than inflation persistence – became the focus of interest. Inflation persistence was understood to be the result of the interaction of many individual decisions but it was not modelled or empirically studied within RG2.

2. Methods

The Austrian study presents summary statistics on price-setting behaviour at the consumer level and looks for explanations. It records the average frequency and

[1] Economics Department, Macroeconomic Analysis and Projections Division. The opinion expressed in this comment is that of the author and may differ from the views of the Deutsche Bundesbank.

size of price changes, the average duration of price spells as well as hazard rates (i.e. the probability that a price that has not been changed for x months will be changed in the following month). Particular importance is attached to adequate weighting, which is done in an exemplary and consistent manner.

In this connection, adequate weighting is important because the number of price quotes per product in the CPI sample is not proportional to the importance of the respective products in private consumption expenditure and because there are pronounced differences in the dynamics of the individual prices. This applies, in particular, to hazard rates, which – when naïvely calculated using unadjusted and unweighted raw data – would be misleading from a statistical point of view owing to the substantial heterogeneity in price adjustment.

To explain the differences in the individual price dynamics, the authors use a logit model in which the entire time-invariant heterogeneity, whether observable or not, is absorbed by fixed effects. This is unfortunate in so far as the effects of time-invariant heterogeneity on price adjustment – for example, whether a price is regulated, to which business type it relates etc. – can no longer be observed. An alternative would be to pool the observations, weigh them adequately and model the duration non-parametrically. Thus, it should be possible to handle unobserved heterogeneity (as well as some other problems) without resorting to a fixed-effects approach (Dias et al., 2005).

The variable of the logit model explains the probability of price changes. This would be entirely appropriate if price changes of similar size took place only in one direction (up or down). However, since price changes occur in different directions and are of varying size, an additional distinction should be made at least between price increases and price reductions. Just like Stahl (2005), one might even go one step further and consider four different "transitions": a price increase following a price increase, a price reduction following a price increase, a price reduction following a price reduction, a price increase following a price reduction. Such a differentiation would the obvious choice if a sequence of price changes in one direction is presumed to have causes which differ from those of a sequence of adjustments in the opposite direction.

3. Results

The key result of all the RG2 studies is heterogeneity. There are sectors with "frequent" and with "rare" price changes, as well as sectors where the price changes are "large" and "small". Moreover, the sectors where frequent price changes occur are not always the ones with small price changes; nor are the sectors with infrequent price changes always the ones where price changes are large. Furthermore, there are significant differences in price-setting behaviour even within narrowly defined product groups. This heterogeneity is characteristic not only of Austria but also of all euro area countries (Dhyne et al., 2005).

Using the fixed-effects logit model, the authors find that the probability of a price change is higher the longer a price has been unchanged, and also if the inflation rate has increased, if a price was not "attractive", and always in January and exactly one year later. Thus, there is a combination of time-dependent and state-dependent price-setting behaviour.

Studies of this kind do not provide a proper "explanation" for price-setting behaviour. In this respect, the Austrian study does not differ from the studies of the other euro area countries. This lack of proper "explanations" is due to the fact that at the individual data level there is hardly any sufficiently disaggregated information on price-driving factors. Only for Germany it was possible to approximate the most important input prices from the producer and import price statistics for a small number of products (Hoffmann and Kurz-Kim, 2006).

4. Interpretation

The major result of the different European studies on price-setting behaviour at the consumer level is that prices of many products are not changed frequently. This gives rise to the question of whether these prices are inefficiently rigid.

First of all, it can be established that menu costs are "real", which is why there is an "optimum" degree of price rigidity, as less sticky price setting would require additional resources (in a wider sense). In line with this rationale, one might try to obtain information on the size of the menu costs from the data on the input and sales price behaviour, as Davis and Hamilton (2004) did.[2]

Secondly, as early as in the mid-1940s, the U.S. agricultural economist Frederick Waugh posed the question "Does the consumer benefit from price instability?". And, in a widely acknowledged paper, he answered this question in the affirmative (Waugh, 1944). A consumer, for example, will prefer a price varying between EUR 5.00 and EUR 15.00 to a fixed price of EUR 10.00 if there are minimum intertemporal substitution possibilities. This result is still quoted sometimes in discussions on the pros and cons of price variability.

In the very same year, Paul Samuelson pointed out the shortcomings of Waugh's ideas in a paper that was published only very much later (Samuelson, 1972). In the above-mentioned example, the representative average price weighted with purchasing frequencies would not be EUR 10.00 but lower and, in an extreme case, it would amount to exactly EUR 5.00. The economically relevant alternative to a variable price, however, is precisely this weighted average price. Consumers would be better off if the price were constantly at the level of the weighted average price. Thus, it has to be concluded, consumers do benefit from price stability! From this point of view, Waugh's theorem merely implies that inherently instable prices

[2] Davis and Hamilton found, however, that menu costs are not the major reason for price rigidities in U.S. wholesale petrol prices.

(such as those of weather-dependent agricultural products) should not be artificially stabilized.

However, if suppliers vary their prices at short notice without a compelling reason it may be assumed that they are trying to maximize their profits by means of intertemporal price discrimination (inter alia Varian, 1980). A study for the U.S.A., in fact, has demonstrated that the prices in retail outlets pursuing an everyday low-price strategy were on average almost 10% lower than prices in shops embracing high-low pricing (Hoch et al., 1994; with special offers prices are still lower by 5%!) Ho et al. (1998), too, report that shops with higher prices show greater price variability.

For this reason, it is extremely important that studies on price-setting behaviour differentiate between regular and temporary price changes, as Baumgartner, Glatzer, Rumler and Stiglbauer (in this volume) did, because more frequent price adjustments are not always preferable!

Another consideration directly follows the observation that prices are changed quite rarely if the overall price level is almost stable. Then, the costs of even moderate inflation might be substantial, either because the price changes occur too frequently or, in the absence of more frequent price changes, relative prices might be distorted and would send out incorrect signals (Ball and Romer, 2003).

5. Summary

In Research Group 2 (Analysis of Individual Consumer Price Data) of the Eurosystem Inflation Persistence Network we have learned much about the frequency and size of price changes as well as other regularities involved in price-setting behaviour. Baumgartner, Glatzer, Rumler and Stiglbauer contributed significantly to this endeavour, as may be inferred from the reviewed paper. The primary objective of RG2 of the IPN, however, had actually been a different one, i.e. inflation persistence. In the end, even the reasons for and consequences of price "rigidities" have been explained only in rudiment. Much remains to be done.

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Regular Adjustment: Theory and Evidence[1]

Jerzy D. Konieczny
Wilfrid Laurier University

Fabio Rumler
Oesterreichische Nationalbank

Abstract

We ask why, in many circumstances and many environments, decision-makers choose to act on a *time-regular* basis (e.g. adjust every six weeks, etc.) or on a *state-regular* basis (e.g. change an interest rate by 0.25%, etc.), even though such an approach appears suboptimal. The paper attributes regular behaviour to adjustment cost heterogeneity. The reasons for this heterogeneity are discussed. We show that, given the cost heterogeneity, the likelihood of adopting regular policies depends on the shape of the benefit function: the flatter it is, the more likely, *ceteris paribus*, is regular adjustment. In general, however, there is no clear relationship between the degree of cost and benefit function heterogeneity and the incidence of regular adjustment. We provide sufficient conditions under which the less frequent are adjustments, the greater is the incidence of regular policies.

To test the model we use a large Austrian data set, which consists of the direct price information collected by the statistical office and covers 80% of the Consumer Price Index (CPI) over eight years. We run cross-sectional tests, regressing the proportion of attractive prices and, separately, the excess proportion of price changes at the beginning of a year and at the beginning of a quarter, on various conditional frequencies of adjustment, inflation and its variability, dummies for good types, and other relevant variables. The results provide strong support for the model: the lower is the conditional frequency of price changes in a given market, the higher is the incidence of time- and state-regular adjustment.

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1. Introduction

"The Federal Reserve on Tuesday raised U.S. interest rates [by 0.25%] a 14th straight time." Reuters, January 31, 2006.

In many circumstances and in many environments, decision-makers choose to act on a regular basis and, in particular, on a calendar-regular basis (e.g., once a week, on the first day of each quarter, etc.) even though such an approach appears suboptimal. Similarly, some decision-makers appear to prefer some values of the variables under their control (e.g. prices ending with a 9, interest rates which are multiples of 0.25% etc.). The above quote provides a good example. Over the last year and a half the Federal Reserve raised the federal funds rate from 1% to 4.5%. It did so by raising the rate by 1/4% at every, regularly scheduled, policy meeting. The focus of this paper is to analyze a simple explanation of such behaviour.

A common feature of the environments in question is their dynamic structure. The policymaker(s) maximizes a stream of benefits, which depends on the values of some state variables. Over time these values change, or *deteriorate*.[2] The policymaker can reset the state variables but doing so involves a cost. Therefore adjustment is infrequent.

The motivation and focus of the paper is nominal price adjustment at the firm level. In this application, a firm posts the nominal price for the product(s) it sells. Due to general inflation the real price falls over time. The real price can be reset by choosing and posting a new value of the nominal price. But similar problems arise in many other environments. Therefore we begin by describing issues related to regular adjustment using examples from various potential applications. In section 2 we set up the theoretical model in general terms. We then refocus our analysis on the issue of optimal pricing policies, testing the model using a large set of pricing data.

Several further examples of this environment follow:

1. *Wage adjustment*. Under general inflation, the purchasing power of contractually-set wages declines over time and can be increased in a new contract.
2. *Machinery refurbishing.* The capital stock deteriorates over time due to physical use or obsolescence. It is improved by refurbishing or replacing the machinery.
3. *Inventory reordering*. A firm holds an inventory of the product(s) it sells. The level of the inventory falls over time. It is replenished by a new delivery.

[2] Alternatively, the current values of the state variables are constant while the optimal values drift over time. These problems are similar and so we will focus mostly on environments with constant optimal values.

4. *Monetary policy.* The Central Bank sets the interest rate appropriate for the current conditions. Over time the match between the current and the optimal value deteriorates. The interest rate can be readjusted through a decision of the Bank's policy-making body.
5. *Fiscal policy.* The fiscal authority sets spending and taxation priorities in the budget. Over time the desired fiscal structure changes. It is reset in a new budget.
6. *Financial reporting and shareholders meetings.* Financial reports allow investors to evaluate firm's prospects. Over time the quality of the information held by investors declines; also, management may follow strategies that benefit them rather than shareholders. The information is refreshed in financial reports; shareholder meetings help realigning the interests of management and shareholders.
7. *Information*. Newspapers and magazines allow the public to update their information. New events lead to its deterioration. A new issue brings the information up to date.
8. *Elections.* An election aligns the preferences of the government and the population. Over time the preferences diverge. A new election allows realigning the preferences.
9. *Monitoring patients.* A patient's visit allows the physician to undertake a proper course of action. Over time the health of the patient or the effectiveness of the treatment may decline. A repeat visit allows the doctor to review and adjust the treatment.

These problems are fairly common. As discussed below, they often lead to state-*contingen*t adjustment policies. The decision maker monitors the state variable and applies the control whenever it has deteriorated to the threshold point. Hence the timing of adjustment does not depend solely on time and, in general, adjustments are not regular.

In practice, however, we observe many cases where controls are applied at specific moments of time. U.S. grocery stores adjust prices on Wednesdays (Levy et al., 1997); drugstores adjust prices on Fridays (Dutta et al., 1999). Seasonal sales are held every January and July. Many firms get regular deliveries; machinery is often refurbished on a regular basis. Labour contracts are signed for a fixed number of years. Financial reporting is quarterly and shareholders meet yearly. Magazines and newspapers appear with fixed frequency. In most political systems elections are held regularly. Medical associations provide guidelines on the frequency of checkups and so on.

In many cases some decision-makers follow regular policies while others do not. While some firms change prices at predetermined dates, others follow state-contingent optimal pricing policies (Cecchetti, 1986). Car firms offer incentives on a state-contingent basis (depending on inventory levels). Machinery is often refurbished when predetermined technical requirements are met. Many firms

follow just-in-time delivery schedules, leading to inventory deliveries that are not regular. Outsiders receive financial information at equally spaced intervals but internal information flow is often organized on just-in-time basis. In political systems based on the British parliamentary tradition the timing of elections can be chosen by the government.

Even when the policy is formally regular, it sometimes contains specific provisions for deviating from the schedule if needed. Firms may hold extraordinary shareholder meetings, the interest rate may be changed between the regular meetings of the policy makers, the government may introduce a mini-budget and so on. Recent examples of such special arrangements are Proposition 8 in California, and the Constitution of Venezuela, which allow an early election.

Furthermore, policymakers sometimes switch between regular and irregular policies. Several years ago the Bank of Canada moved from weekly to less frequent meetings. Car producers switched to just-in-time delivery policies. List prices for cars are no longer set for a year; most airlines nowadays use sophisticated pricing schedules etc.

Finally, some policymakers follow different policies for different activities. Paper versions of newspapers are published regularly, but electronic versions are not.[3] Some supplies may be obtained regularly while others are procured on just-in-time basis. Doctors set regular, routine visits for some patients but not for others, etc.

Understanding of regular policies is important as they reduce flexibility by limiting the ability of the policymaker to react to past, current and future events. It is important to note that the distinction between expected and unexpected events is not crucial here. Once the system is set up to adjust on a regular basis, the policymaker may not be able to alter the course of action for a range of both expected and unexpected changes. For example, a political system that uses regular elections may not be able to react to predictable changes in the environment if the politicians are unable to master enough votes to change the constitution.

The explanation of these phenomena we propose here is simple. Adjustment of the state variable is costly, but the adjustment costs are not constant over time (or over values of the state variable). They are lower at some points of time (or at, or to, some values of the state variable). When the lower values of the costs occur regularly, for some policymakers regular adjustment dominates the state-contingent policy that would have been optimal if costs were homogeneous.

The proposed explanation may, at first thought, appear trivial. But it is no different than the explanations, popular in economics, of infrequent changes based on the presence of adjustment (or *menu*) costs. The logic of the menu cost approach is as follows. If price adjustment were costless, nominal prices would have been changing continuously. Since they do not, adjustment must be costly. Moreover,

[3] We are grateful to Magdalena Konieczna for suggesting this example.

such costs are easily identified. The theoretical task then becomes to explain the observed pattern of behaviour under the assumption that price adjustment is costly.

We follow the same logic here. If adjustment costs were always the same, observed behaviour would not be regular. Elections would be held when the difference between the government's and the population's preferences crosses certain thresholds; a firm would order new delivery when its inventory falls below a certain level; newspapers would be published after a sufficient amount of events worth writing about has taken place etc. But since adjustments are regular, their cost cannot be constant. Moreover, the benefits of regular behaviour are easily identified. It allows planning and organization of activities, enhances the reputation of the decision-maker and so is, in general, less costly than irregular behaviour.

We start the paper by showing an existence result: when the costs of adjustment are lower at regular moments of time, an optimizing policymaker will (except in unlikely circumstances), sooner or later, take advantage of the lower costs. In general, however, there is no clear relationship between the degree of cost heterogeneity and the incidence of regular adjustment. We then show that, given the cost heterogeneity, the likelihood of adopting regular policies depends on the shape of the benefit function: the flatter it is, the more likely, *ceteris paribus*, is regular adjustment. We provide sufficient conditions under which the less frequent are adjustments, the greater is the incidence of regular policies.

The model is applied to nominal price adjustment. The distinction between the time contingent, regular nominal price adjustment policies as in Fischer (1977) and in Taylor (1980), and state-contingent policies as in Sheshinski and Weiss (1977) is crucial, given their different implications for effectiveness of monetary policy (Caplin and Spulber, (1989), Caplin and Leahy, (1992)).

There are two aspects of regular nominal price adjustment we are interested in: time-regularity and state-regularity. A disproportionate proportion of price changes takes place at the beginning of periods, rather than within periods. Several studies in the Inflation Persistence Network (IPN) report a high proportion of prices are held constant for a year (see Álvarez et al. (2005) for Spain, Aucremanne and Dhyne (2005) for Belgium, Baudry et al. (2004) for France, Baumgartner et al. (2005) for Austria, Dias et al. (2005) for Portugal, Veronese et al. (2005) for Italy, Lünnemann and Mathä (2005) for Luxembourg, Hoffmann and Kurz-Kim (2005) for Germany). Konieczny and Skrzypacz (2002) report that, in price data collected three times a month, over a half of all changes take place in the first 10 days of a month. Similarly, several IPN studies, as well as Levy et al. (2006) find a large proportion of prices charged are *attractive* prices.[4]

[4] Attractive prices – which sometimes are also called threshold prices or pricing points – include psychological prices (prices ending in 9), fractional prices (prices which are convenient to pay, such as 1.50) and round prices (defined as whole number amounts, such as 10.00).

To test the model we use a very large Austrian data set, which consists of the direct price information collected by the statistical office and covers about 80% of the CPI over eight years. We run cross-sectional tests, regressing the proportion of attractive prices and, separately, the excess proportion of price changes at the beginning of a year and at the beginning of a quarter on various conditional frequencies of adjustment, inflation and its variability, dummies for good types, and other relevant variables. The results are consistent with model's implications: the lower is, in a given market, the conditional frequency of price changes, the higher is the incidence of time- and state- regular adjustment.

The paper is organized as follows. The model is analyzed, and empirical predictions described, in the next section. In section 3 we discuss the empirical evidence. The last section concludes.

2. The Model

We consider a class of optimization problems where the value of instantaneous benefits depends on state variables that change over time. At any moment the policymaker can adjust the values of the state variables by incurring discrete costs. More formally, the instantaneous value of the benefits is $\tilde{B}[\vec{x}(t), \vec{y}(t), \vec{a}]$, where $\vec{x}(t)$ is a vector of state variables, $\vec{y}(t)$ is a vector of exogenous variables and $\vec{a}$ is a vector of parameters.. This formulation implies that the benefit function depends on time only indirectly.

We assume that $\tilde{B}[\vec{x}(t), \vec{y}(t), \vec{a}]$ is twice continuously differentiable and has a unique global maximum:

Assumption 1:
For every t , $\vec{y}(t), \vec{a}$ there exists $\vec{x}^*(\vec{y}(t), \vec{a})$ such that, for every $\vec{x}(t) \neq \vec{x}^*$:
$\tilde{B}[\vec{x}(t), \vec{y}(t), \vec{a}] < \tilde{B}[\vec{x}^*, \vec{y}(t), \vec{a}]$

Assumption A1 implies that, as long as $\vec{y}$ and $\vec{a}$ do not change, the optimal instantaneous values of the state variables are constant. The policymaker would like to maintain the state variables continuously at the level $\vec{x}^*$ or, if that is not possible, to keep them close to $\vec{x}^*$. Changes in $\vec{x}(t)$ over time will be called the *deterioration* of the state variables. The policy maker can adjust $\vec{x}(t)$ at any time

to any desired level (perhaps within some bounds), but doing so involves a discrete cost.[5]

The cost of adjusting the state variable, suggested by the examples above, includes the time, or the opportunity cost of the time needed to set up the decision-making process (e.g. organizing an election and counting votes, the doctor's and the patient's time etc.), the time needed to make and implement the decision (e.g. the time needed to set up and implement a new budget, union/employer bargaining time etc.), physical resources (e.g. new machinery, printing a new price list etc.) and non-time opportunity costs (e.g. potentially beneficial decisions forgone due to election campaign duties, foregone output whenever production is affected by the refurbishing process etc.).

To simplify the analysis, and in line with earlier literature (Scarf, (1960), Sheshinski and Weiss, (1977)), we assume that the cost is lump-sum: independent of the size or of the frequency of adjustment. This is a reasonable assumption in some cases (elections, shareholder meetings, monetary policy decisions, printing a new price list etc.).[6]

In general, the optimal solution to the optimization problems described above is *state-contingent*. The policymaker observes the values of the state variables and, when they reach certain thresholds, incurs the discrete cost and adjusts them to new, optimally chosen levels. State-contingent policies imply, generally, adjustment at intervals of differing length. Thresholds, as well as the new values of state variables are computed optimally and can take on any values (from an admissible range).

In many environments, however, we observe behaviour inconsistent with state-contingent policies: adjustment often takes place at regular intervals and some values of the state variables are chosen more often than others. This paper therefore focuses on adjustment policies, which we call regular policies. We distinguish between *time-regular* policies, which involve adjustment on a regular basis (e.g. a firm orders new inventory every 52 days, monetary policy decision making body meets every six weeks, machinery is refurbished once every two years etc.) and *state-regular* policies, in which newly chosen values of the state variables belong to a small subset of all possible values (e.g. inventory is ordered by a truckload, a firm selects new prices ending in a nine: 0.69, 0.79 etc.) or when the thresholds are specific numbers (e.g. a hedge-fund manager's compensation rule changes if the

[5] In an equivalent problem, the optimal values change over time and the goal of the policymaker is to maintain the state variable as close as possible to the drifting optimal value, given the adjustment costs.

[6] Adjustment costs often include, in addition, a component which depends on the size of adjustment (refurbishing machinery, delivering a mini-budget etc.). We do not consider such cases here.

return exceeds 20% per year).[7] An important subset of time-regular policies are *calendar time-regular* policies, which involve adjustment at calendar-related intervals (e.g. an election is held every four years on the Tuesday next after the first Monday in November, a new price list is issued once a year etc.) or where the time of applying the control is related to the calendar (e.g. sales are held at the beginning of each January and each July)

To make the analysis tractable we make several simplifying assumptions:

Assumption 2:
Over the relevant range, and for any values of $\vec{y}(t), \vec{a}$, the effect of the vector $\vec{x}(t)$ on the benefit function $\tilde{B}[\vec{x}(t), \vec{y}(t), \vec{a}]$ can be completely summarized by a single state variable $x(t)$.[8] i.e. there exists $B[.]$ such that
$B[x(t), \vec{y}(t), \vec{a}] \equiv \tilde{B}[\vec{x}(t), \vec{y}(t), \vec{a}]$ and,
for every t , $\vec{y}(t), \vec{a}$ there exists $x^*(\vec{y}(t), \vec{a})$ such that, for every $x(t) \neq x^*$:
$B'[x(t), \vec{y}(t), \vec{a}] \cdot [x^* - x(t)] < 0$.
where $B'[.]$ denotes the derivative of the benefit function with respect to its first argument. Assumption A2 means that the problem is equivalent to one in which the benefit function is a smooth, quasiconcave function of a single state variable.

The crucial assumption, which differentiates the model from earlier literature, is that the cost of adjusting $x(.)$ may depend on time or/and on the level of x. We now consider the former case; the latter is similar and is discussed below.

To make matters as simple as possible, we divide time into periods and assume that the cost of adjustment can take on only two values: high, c_h , and low, c_l The cost is equal to the high value whenever adjustment takes place within a period; it is equal to the lower value at the end of each period. Some notation will be helpful. Let $\Im \equiv \{\tau_0, \tau_1, ...\}$ consist of the ends of each period. The interval $\{\tau_{i-1}, \tau_i\}$, i=1, 2… will be called *period i*. Whenever the adjustment takes place at $t \in \Im$, its cost is c_l . Such adjustment will be called regular adjustment and the *incidence of regular adjustments* will be the proportion of all adjustments which are regular.

Assumption 3:
The cost of adjustment is:

[7] What we call time-regular policy is usually called a time-contingent policy. For clarity we avoid the latter term; this allows us to distinguish between state-regular and state-contingent policies.

[8] A somewhat stronger restriction is that all but one (say, the first) of the elements of the vector of state variables $\vec{x}(t)$ are fixed, i.e. $\vec{x}(t) \equiv (x(t), x_2^0, x_3^0, ..., x_k^0)$.

$$c(t) = c_h + I(t) \cdot (c_l - c_h), \quad c_h \geq c_l \tag{1}$$

where $I(t)$ is an indicator function, given by:

$$I(t) = \begin{cases} 1 & \text{for } t \in \Im \\ 0 & \text{for } t \notin \Im \end{cases} \tag{2}$$

As the focus of the paper is regular behaviour, we further assume that periods are of the same length, i.e. τ_i's are evenly spaced over time:

$$\tau_i = \tau_0 + n \cdot \tau, \quad n = 1, 2, ... \tag{3}$$

Obviously, the larger is the difference between the high and low values of costs, the more tempting is regular adjustment and so a large value of c_h - c_l makes the problem trivial. Therefore we are careful not to make any assumptions about the size of the difference. All results hold even if the c_h - c_l is arbitrarily small.

In this paper we concentrate on the simple nonstochastic case. In particular:

Assumption 4:
The state variable $x(t)$ is assumed to change over time at a constant rate:[9]

$$x(t) = x(t_0) \cdot e^{-\alpha(t-t_0)} \tag{4}$$

Without loss of generality, we assume $\alpha>0$.

At the time of the first adjustment the policymaker's goal is to pick the sequences of times of adjustment and the new values of the state variable, $W \equiv \{x_0, (t_1, x_1), (t_2, x_2), ...\}$ so as to maximize the present value of the benefits:

$$\underset{\{t_i\}_{i=0}^{\infty}, \{x_i\}_{i=0}^{\infty}}{\text{maximize}} \quad PV(W) = \sum_{i=0}^{\infty} \left\{ \int_{t_i}^{t_{i+1}} B[x_i e^{-\alpha(t-t_i)}, \vec{y}(t), \vec{a}] e^{-\rho t} dt \; - \; c(t) e^{-\rho t_{i+1}} \right\} \tag{5}$$

where $PV(W)$ denotes the present value of policy W, t_0 is the time of the first adjustment, ρ is the discount factor, and the first adjustment is assumed to be costless.[10]

[9] As already mentioned, an equivalent problem is when the optimal value of the state variable changes over time and adjustments are needed to keep the actual value close to the optimal value. This problem can be converted into the time–dependent problem by normalizing the drifting optimal value by its trend.

[10] As we consider the nonstochastic case here, we omitted expectations from equation (5).

We start the analysis by summarizing the well-known case when $\vec{y},\vec{a}$ do not change over time and the cost of adjustment is constant and equal to its higher value, i.e. $c_l=c_h$. To differentiate this case from the main one, the choices under this assumption are denoted with a " ˆ ".

Lemma 1

Let $\hat{W}^* \equiv \left\{\hat{x}_0^*,(\hat{t}_1^*,\hat{x}_1^*),(\hat{t}_2^*,\hat{x}_2^*),...\right\}$ denote the optimal policy, and $\hat{T}^* = \left\{\hat{t}_1^*,\hat{t}_2^*,...\right\}$ denote the set of the optimal adjustment times, when $c_h=c_l$. Then:

$\hat{W}^*$ is recursive: $\forall i : \hat{x}_i^* = x^*$ and , for all i $\hat{t}_{i+1}^* = \hat{t}_i^* + \Delta\hat{t}^*$. Also, $\hat{W}^*$ is unique. [11] Finally, $\hat{B}(\hat{x},\vec{y},\vec{a}) - \hat{B}(\hat{x}e^{-\alpha\Delta\hat{t}},\vec{y},\vec{a}) = \rho c_h$
The proof is essentially the same as in Sheshinski and Weiss (1977).

Next, we consider the case when $c_l < c_h$. Proposition 1 below shows sufficient conditions under which, when $c_l < c_h$, it is optimal for the policymaker to take advantage of the lower adjustment costs. The proof is based on the following approximation of real numbers with rational numbers:

Lemma 2

For every
$x, K > 0$ there exist integers N_1, N_2 such that $N_2 \le K$ and $\left|N_2 x - N_1\right| < 1/K$

Proof: see Niven (1961).

The lemma can be applied to the problem considered here by setting $x = \Delta\hat{t}^* / \tau$. It implies that, if the policymaker follows a policy of adjusting once every $\Delta\hat{t}^*$ (which is optimal when costs of adjustment are constant), eventually an adjustment will take place arbitrarily close to the end of a period. Given the notation, N_2th adjustment will be within $1/K$ of the end of period N_1.

Since N_2th adjustment is close to the end of a period, the firm needs to alter its timing just a little to take advantage of the lower end-of-period adjustment costs. It will do so as long as the reduction in adjustment costs exceeds the loss in benefits. Obviously, as already mentioned, we do not want the result to depend on the difference c_h - c_l . A sufficient condition for the results to hold regardless of the

[11] Note that, since the optimized present value of benefits may be negative, no additional restrictions are placed on the values of the parameters and the momentary benefit function B.

size of c_h - c_l is that the slope of the benefit function be bounded; this is the motivation for assumption (b) below:

Proposition 1

Let $W^* \equiv \left\{x^*_0,(t^*_1,x^*_1),(t^*_2,x^*_2),...\right\}$ denote the optimal policy, and $T^* = \left\{t^*_0,t^*_1,t^*_2,...\right\}$ denote the set of the optimal adjustment times, when $c_l<c_h$.

Assume:

(a) $c(t)$ meets (1)–(3);

(b) for every $\vec{y},\vec{a}$ there exists $A<\infty$ such that, for every t: $\left|B'(x(t))\right| < A$;

(c) the time of the first adjustment $t_0 \in \Im$.

Then $\left\{T^* \setminus \{t_0\}\right\} \cap \Im \neq \varnothing$.

Proof

Without loss of generality let the time of the first adjustment be $t_0 = \tau_0$. The proof is by contradiction. Assume that $T^* \cap \Im = \{t_0\}$. Therefore, by Lemma 1, the set of optimal adjustment times is $\hat{T}^*$, with $\hat{t}^*_0 = \tau_0$. By Lemma 2, setting $A=K$, there exist two positive integers N_1 and N_2 such that:

$$N_2\Delta\hat{t}^* - N_1\tau < (1/\rho)\ln(c_h/c_l) \tag{6a}$$

$$N_2\Delta\hat{t}^* - N_1\tau < \rho\left(c_h - c_\ell\right)/(2A) \tag{6b}$$

When (6) are met we have:

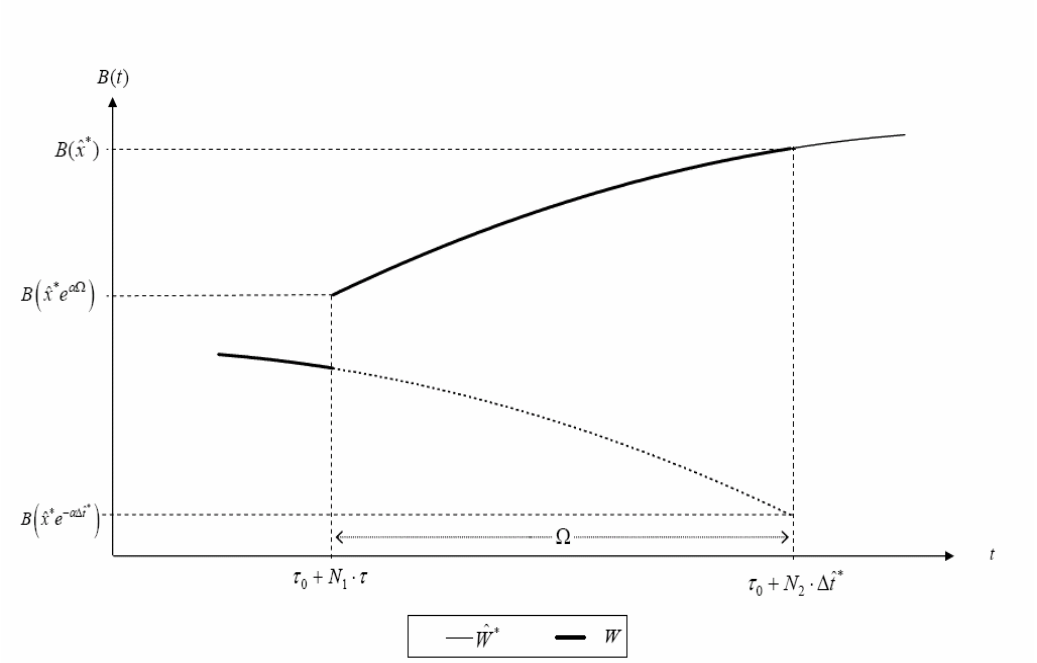
$$PV(\hat{W}^*) < PV\left((\tau_0,\hat{x}^*),...,(\tau_0+(N_2-1)\Delta\hat{t}^*,\hat{x}^*),(\tau_0+N_1\tau,\hat{x}^*e^{-\alpha\Omega}),\tau_0+(N_2+1)\Delta\hat{t}^*,\hat{x}^*),...\right) \le PV(W^*)$$

where $\Omega = N_2\Delta\hat{t}^* - N_1\tau$. The second inequality follows from the fact that the middle policy need not be optimal for $c_l < c_h$. ■

Proposition 1 is illustrated in chart 1. It describes the situation in which the N_2th adjustment falls $\Omega = N_2\Delta\hat{t}^* - N_1\tau$ after the end of period N_1. To take advantage of the lower adjustment costs, the policymaker accelerates the N_2th adjustment to

$\tau_0 + N_1 \cdot \tau$ from $\tau_0 + N_2 \cdot \Delta\hat{t}^*$. Under policy *W*, she follows $\hat{W}^*$ until $\tau_0 + N_1 \cdot \tau$, when she adjusts *x* to such a value that, from $\tau_0 + N_2 \cdot \Delta\hat{t}^*$ on, *W*= $\hat{W}^*$. Inequalities (6) provide sufficient conditions[12] for the present value of *W* (the middle term in the above inequality) exceeds the present value of $\hat{W}^*$.

Chart 1: Profits as a Function of Time



Proposition 1 shows that, when the adjustment costs vary over time as postulated in *Assumption 3* and the first adjustment is at the beginning of period 0 ($t_0 \in \Im$.), under general conditions the policymaker would, sooner or later, take advantage of the lower costs of adjustment. Assumption (c) requires a discussion. If the time of the first adjustment $t_0 \notin \Im$, it is possible that the policymaker will never take advantage of lower adjustment costs. This would be the case if, for example,

[12] Inequalities (6) provide sufficient conditions also for the case when adjustment is delayed.

$\Delta\hat{t} = i \cdot \tau$ (i.e. when the optimal time between adjustments under constant costs is an integer number of periods) and the difference between c_l and c_h is small.

In many environments, however, $t_0 \notin \Im$ is an unlikely outcome. This is because the timing of the whole sequence of subsequent adjustment times, $T^* \setminus \{t_0\}$, often depends on the time of the first adjustment. For example, the timing of subsequent visits to a doctor is set relative to the initial visit, the timing of elections is set relative to the first election, dates of subsequent delivery depend on initial delivery and so on.[13] From now on we will assume that $t_0 \in \Im$.

We now characterize the optimal policy W^*. By Proposition 1, at least one time of adjustment under *W** coincides with the end of a period. To set notation, assume that the first such adjustment is the *N*th adjustment, and it takes place at the end of period *k*. Denote such a policy as $W^*_{N,k}$. This means that, under $W^*_{N,k}$, $t^*_N = \inf\left\{\{T^* \setminus \{t_0\} \cap \Im\right\} = \tau_k$,

It is easy to see that, for a given benefit function and adjustment costs, the optimal policy need not be unique. It is possible that $\tau_k < \hat{t}^*_N < \tau_{k+1}$ and that $PV(W_{N,k}) = PV(W_{N,k+1})$, i.e. the policymaker is indifferent between accelerating or delaying the *N*th adjustment.

The analysis of multiple equilibria in the current framework is complex. We therefore assume that, if $PV(W_{N,k}) = PV(W_{N,k+1})$ then $W^* = W_{N,k}$, i.e. whenever two policies yield the same present value of benefits, the policymaker chooses the policy with earlier adjustments.

Proposition 2

(a) W^* is recursive:

$$W^* = \left\{\left[(\tau_0, x^*_0), (t^*_1, x^*_1), ..., (t^*_{N-1}, x^*_{N-1})\right], \left[(\tau_k, x^*_N), (t^*_{N+1}, x^*_{N+1}) ..., (t^*_{2N-1}, x^*_{2N-1})\right], ...\right\}$$

(b) for every i: $t^*_{i+1} - t^*_i = t^*_1 - \tau_0$

[13] In environments in which the timing of adjustment is dictated by custom this need not be the case. For example a clothing store which opens in June may not be willing to have a sale shortly after the opening.

Proof

W^* can be written as: $W^* = \left\{\left[(\tau_0, x_0^*),(t_1^*, x_1^*),...,(t_{N-1}^*, x_{N-1}^*)\right], W^*(\tau_k^+)\right\}$, where $W(\tau_k^+)$ is the remainder of the optimal policy from period τ_k forward. Since W^* is optimal and unique, by the principle of optimality $W(\tau_k^+)$ is the solution to the problem of maximizing the present value of the benefits, starting in period τ_k. But this problem is identical to the original problem, as can be checked by substituting, $t'_i = t_{i-N}^*$. Therefore, $t_{2N}^* = \tau_{2k}$ and for every *i* such that $N < i < 2N : t_i^* \notin \Im$. The proposition follows by induction.
The proof of part (b) is straightforward. ■

Proposition 1 shows an existence result: as long as the benefit function is not too steep, and subject to the discussion above, the timing of at least some of the adjustments will be dictated by the heterogeneous adjustment costs.

While the result in Proposition 1 is interesting, it has little empirical content, especially given the fact that the starting point of the analysis is the observation that many policies are, indeed, regular: some prices are changed at the beginning of the year, firms sometimes order a delivery of multiple truckloads etc..

The crucial question arising in this framework is the empirical incidence of adjustment at times in $\Im$, i.e. the proportion of all adjustments that are done at the beginning of a period (say, in January). By proposition 2, every 1/*N*th adjustment is in $\Im$ since the first adjustment in $\Im$ is the *N*th adjustment and the optimal policy W^* is recursive. Of particular interest is the special case $T^* \subseteq \Im$, i.e. when *N*=1 and the firm never pays c_h.[14] This incidence depends on two types of factors. The first is the empirical distribution of the exogenous variables $\vec{y}$ and of the parameters $\vec{a}$ across observations; the second is related to the shape of the benefit function *B*[.] and the difference $c_h - c_l$. The first type of factors determines the empirical distribution of the optimal length of time between adjustment under constant adjustment costs, $\Delta\hat{t}_i^*$; the second type determines the willingness of a policymaker to shift adjustment time to the end of a period to take advantage of the lower cost.

The existence result in Proposition 1 provides little information on the second question. Furthermore, whatever information it provides may be quite misleading. Consider a given problem in which $t_0 = \tau_0$ and $\Delta\hat{t}^*$ is a well-defined, continuous function of the exogenous variables $\vec{y}$ and the parameter vector $\vec{a}$. Assume further that, for some specific values of the exogenous variables and parameters, $\vec{y}_0$

[14] Of course, T^* may be a proper subset of $\Im$ (i.e. $T^* \subset \Im$) when N=1, for example if the optimal adjustment frequency is once every two periods.

and $\vec{a}_0$, we have $\Delta\hat{t}^* = \tau$, i.e. under constant adjustment costs it is optimal for the policymaker to adjust at the end of the period. In this case the policy is completely regular (*N*=1) in a neighbourhood of $(\vec{y}_0, \vec{a}_0)$ but *N*>1 outside this neighbourhood. Since there is, in general, nothing special about $(\vec{y}_0, \vec{a}_0)$, the resulting policy is regular just by coincidence.

As a more specific example, assume that *B*=*B*(*x*,*a*), i.e. the benefit function depends on the state variable and one parameter. Assume that the parameter is observable and its value is positively related to $\Delta\hat{t}^*$. This is the setup considered by Sheshinski and Weiss (1977), where *B*[.] is the real profit function of a monopolist, *x* is the real price and *a* is the inflation rate. Adjustment costs vary as postulated here. A researcher studies six policymakers and the observable parameter *a* is distributed across policymakers in such way that their (unobservable) optimal period of adjustment under constant cost, $\Delta\hat{t}_i^*$, are equal 10+*i*/32 months, *i*=15,…,20. Assume also that the difference between the high and low level of adjustment costs is small so that they never depart from *W**. Then, as the researches studies policymakers ordered by *a*, she observes the following incidence of regular policies: 1/8, 1/32, 1/16, 1/32, 1/2, 1/32. While the monthly frequency of price changes varies between 9.41% and 9.55%, the proportion of regular prices varies between 3.13% and 50%. Seemingly small changes in the parameter *a* have dramatic, nonmonotonic effects on the incidence of regular policies. This issue is, essentially, a number problem that is irrelevant to the questions considered here. We return to it below.

As we are interested in the reasons for different incidence of regular adjustment between policymakers, the question is what property of the benefit function determines the willingness of the policymaker to take advantage of the lower adjustment costs. The idea is straightforward. The policymaker faces a trade-off between the saving on the adjustment cost, and the profits foregone by not following *W**. The loss depends on how far profits decline as the time of adjustment varies. This, in turn, depends on the slope of the benefit function. A benefit function that is, at a given distance from its maximum, flat, makes the loss small and so the policymaker is willing to vary adjustment time to lower the adjustment cost. Definition 1 describes this intuition more precisely:

Definition 1

For any two twice continuously differentiable concave functions *f, g* such that there exists $x_0 : f'(x_0) = g'(x_0) = 0$, *f* is *more strongly concave* than *g* if and only if, for all *x*: $f''(x) - g''(x) < 0$.

Before we proceed it is useful to define precisely when a policymaker will deviate from the optimal policy *W** (i.e. the policy that she would have followed if adjustment costs were constant) to take advantage of the lower costs. We call it the *shift range.*

Definition 2

The shift range, S_i , is the interval $\left\{\tau_i - a_i\,,\tau_i - b_i\right\}$ such that, if and only if $\tau_i - a_i < \hat{t}_j^* < \tau_i + b_i$, the policymaker moves the *j*th adjustment at τ_i to save on adjustment costs.

In other words the policymaker moves the timing of adjustment to the end of period *i* if and only if the optimal timing under constant adjustment costs falls in the shift range. The size of the shift range S_i determines the willingness of the policymaker to take advantage of the lower adjustment costs at τ_i .

Proposition 3

Let B^1 and B^2 be two benefit functions, $\Delta\hat{t}^{*1}$, $\Delta\hat{t}^{*2}$ be the respective optimal times of adjustment when the costs of adjustment are constant and S_i^1, S_i^2 be there respective shift ranges. If B^1 is more strongly concave than B^2 then:

(a) $\Delta\hat{t}^{*1} < \Delta\hat{t}^{*2}$
(b) $S_i^1 \subset S_i^2$

Proof

The benefit from extending $\Delta\hat{t}^*$ is to reduce the expenditure on adjustment costs; the loss is due to the fact that it increases the range of $x(t)$ between adjustments. The optimality of $\Delta\hat{t}^{*1}$ under B^1 means that, under constant adjustment costs, the loss and benefit are equal. Under B^2 the benefit is the same but, since B^1 is more strongly concave than B^2, the cost is smaller. Hence $\Delta\hat{t}^{*1}$ is not optimal under B^2 and, for $\Delta\hat{t}^* = \Delta\hat{t}^{*1}$, $PV(B^2)$ is increasing. This proves (a).

To prove (b) assume $\hat{t}_j^{*1} \in S_i^1$ so that $t_j^{*1} = \tau_i$, i.e. under B^1 the optimal policy involves shifting *j*th adjustment to the end of period *i*. Assume now that $\hat{t}_k^{*2} = \hat{t}_j^{*1}$, i.e. under constant costs the *k*th adjustment under B^2 coincides with the *j*th adjustment under B^1, $k<j$. Since B^1 is more strongly concave than B^2, the benefit of

shifting adjustment time from $\hat{t}_k^{*2} = (\hat{t}_j^{*1})$ to τ_i under B^2 exceeds the benefit under B^1. Therefore $t_k^{*2} = \tau_i$ which implies $S_i^1 \subset S_i^2$. ■

Propositions 1 and 3 summarize what can be said unequivocally about the incidence of regular policies. As long as $t_0 \in \Im$, regular behaviour is observed even under arbitrarily small difference between c_h and c_l. The smaller is the curvature of the benefit function, the less frequent are adjustments and the wider are shift ranges. This means that if, under constant adjustment costs, two policymakers would make adjustment at the same time, the policymaker who adjusts less frequently is more likely to move the adjustment to the end of the period.

It would be incorrect to conclude that Proposition 3 implies that the less frequent is adjustment, the greater is the incidence of regular policies. This is because there is, in general, no reason for adjustments to occur simultaneously. For example, assume that $\Delta\hat{t}^{*1} = \tau$ and $\Delta\hat{t}^{*2} = 10.5\,\tau$. Then, even though B^2 is much flatter than B^1, the adjustment policy under B^1 is completely regular, while, as long as $c_h - c_l$ is not too large, only every second adjustment under B^2 is at the end of a period.

There is no easy way around this number problem. One solution is to assume that there are many policymakers who differ with respect to the (unobserved) parameter a, which is distributed across policymakers in such a way that the following (sufficient) conditions are met:

Assumption 5:

(a) the empirical distribution of $\Delta\hat{t}^*$ on $\{\tau_{i-1}, \tau_i\}$ is independent of i;

(b) $\max_i(\Delta t_i) - \min_i(\Delta t_i) >> \tau$

Under the first assumption, the probability of finding a policymaker for whom the timing of the kth adjustment, $k\Delta\hat{t}^*$, is within a given distance from the end of the period is the same for all periods. This means that the proportion of adjustments at the end of a period would be larger the further away is the period from τ_0. The second assumption is needed so the effect of truncation of the range of $k\Delta\hat{t}^*$ "averages out".

Condition A5 (a) is not met in practice due to truncation of the range of $k\Delta\hat{t}^*$ both from below and above. The truncation from below is due to the fact that, first, $\Delta\hat{t}^*$ is bounded away from zero under lump-sum costs but $\Delta\hat{t}^*$ is not bounded away from above from τ, 2 τ, …The truncation from above is due to the fact that the

limited length of the sample makes it impossible to observe policies $W^*_{N,k}$ for which $k\tau$ exceeds the length of the sample. Therefore it is possible for results of empirical tests of the model to be dominated by the number problem. This makes it difficult to interpret rejections of the model since the empirical tests of the model is a joint test of the relationship between benefit function shape and the incidence of regular policies as well as the fact that the number problem is "averaged out" in the data set.

Of course the number problem becomes irrelevant if the results of empirical tests are consistent with the model.

3. Empirical Evidence

We now turn to testing the implications of the model. Empirical testing requires cross-sectional (across policymakers) data on the frequency of adjustment and on the incidence of regular adjustment. Furthermore, the range of the adjustment frequencies in the data needs to be large for the pattern implied by the model to dominate the idiosyncratic actions of firms, i.e. to overcome the number problem.

To test the model we use a very large Austrian data set. It is the data set analyzed in Baumgartner et al. (2005) who studied the stylized facts of price setting in Austria.[15] It contains monthly price quotes collected by the Austrian statistical office, which are used in the computation of the Austrian CPI. The sample spans the period from January 1996 to December 2003 (96 months) and contains about 40,000 elementary price records per month. Overall, the data set contains about 3.6 million individual price quotes and covers roughly 80% of the total Austrian CPI. Each record includes, in addition to the nominal price, the information on the product category, date, outlet (shop) and packaging type.

Testing the model involves the comparison of price behaviour across policymakers. Applied to the pricing set-up, the policymaker is a monopolistic (or monopolistically competitive) seller. She chooses the timing of adjustment as well as the nominal prices to maximize real profits, subject to lump-sum (*menu*) costs of changing nominal prices.

We identify a "policymaker" with a product category, i.e. products at the elementary level included in the CPI basket (e.g. milk), rather than an individual store/product pair. Treating individual store/product pair as a policymaker would require calculating the average frequency of price changes from few observations, especially for stores which change prices infrequently. We need a large number of price changes to compute the conditional frequencies used in the empirical testing. Thus, we implicitly assume that firms operating on the same market (selling the

[15] They describe the data and some manipulations which have been carried out prior to the statistical analysis in detail.

same product) share the same profit function and that the heterogeneity in the profit function is across markets. The original data set (used in Baumgartner et al., 2005) contains a total of 668 product categories. We excluded 151 product categories with administered prices, excessive price changes and products for which we had data for several varieties.[16]. This leaves 517 product categories for our analysis.

The average product category frequency of price changes is between 0.8% per month (chipboard screws) and 91% per month (package holidays). The substantial differences in adjustment frequency and the large number of product categories are promising indications that the number problem may, indeed, "average out".

The main element of the model that determines the incidence of regular policies is the heterogeneity in the curvature of the profit function. Since the curvature is not observable in our data, a direct test of the model is not possible in our framework. However, an indirect test of the model can be performed with other variables of the model, which are observable, acting as instruments for the unobservable variable. This is done by regressing the incidence of regular policies on a set of variables for which the curvature of the profit function implies a certain cross-relation as described in the previous section. If the coefficient signs in this regression are in line with the cross-relations implied by the model, we interpret this as an empirical support of the model. In our case the average frequency of price changes serves as the instrument.

The data allow us to analyze the incidence of both time-regular and state-regular policies. We define a time-regular policy as price adjustment at the beginning of the year, and, separately, as price adjustment at the beginning of a quarter. We will refer to such policies as *seasonal* price setting. State-regular policies involve choosing *attractive* prices: prices that end in a nine or round prices. The definition (values) of attractive prices are in the appendix. The testing involves the analysis of the cross-sectional relationship between the frequency of price adjustment and the excess proportion of seasonal price setting or the excess proportion of attractive prices.

The analysis of this relationship raises the issue of causality. Our model implies that infrequent price changes and high incidence of regular policies coincide because of a common causing characteristic (flat profit function). On the other hand, existing studies in the Inflation Persistence Network imply causation from what we call regular policy to the frequency of price changes. In the data set we are using, Baumgartner et al. (2005) find that the probability of price adjustment, conditional on the last price being an attractive price, is lower than the

[16] We eliminated all products with an average size of price changes of more than 50%.We suspect that, in such cases the definition of the product (on which no direct information is available in the data set) has been changed during the sample period. For some product categories the data set contains prices for several varieties (for example car insurance for different types of cars). These prices are usually changed jointly and so, in such cases, we included only the price for the variety with the highest CPI weight.

unconditional probability. Similar results have been documented by Álvarez and Hernando (2004) for Spain, by Aucremanne and Dhyne (2005) for Belgium, by Veronese et al. (2005) for Italy, by Lünnemann and Mathä (2005) for Luxembourg, by Hoffmann and Kurz-Kim (2005) for Germany and by Dhyne et al. (2005) for a panel of euro area countries. This means that, if we simply looked at the relationship between the frequency of price changes and the incidence of attractive prices, we may discover a negative relationship where causality goes from the proportion of attractive prices to low price changing frequency: in markets in which the proportion of attractive prices is high, the average frequency of price changes will be low.

In order to overcome this potential problem of reverse causality in our regression we have to define a measure for the frequency of price changes that is independent of the proportion of attractive prices. This can be done by conditioning the frequency of adjustment on, separately, attractive and non-attractive prices: for product category *i* we calculate the average conditional frequency of a price change given that the last price is an attractive price, denoted F_i^{att}, as well as the conditional frequency of price changes given that the last price is not an attractive price, denoted F_i^{natt}. We then use both conditional frequencies in the regression as explanatory variables. The use of both conditional frequencies avoids the results being dominated by the mixture of attractive and other prices in the given market.

We suppose the same is true for seasonal price setting: the probability of price adjustment conditional on the previous adjustment taking place at the beginning of the year would be lower than the unconditional probability of adjustment. Therefore we adopt the same approach in the regressions explaining the incidence of seasonal price setting using, as explanatory variables, both the conditional frequency of price change if the last price change was at the beginning of the year/quarter, denoted F_i^{seas}, and the conditional frequency if it was not at the beginning of the year/quarter, denoted F_i^{nseas}.

The estimated regression equations are:

$$Attr_i = f\left(F_i^{att}, F_i^{natt}, \vec{x}_i\right) \tag{7a}$$

$$Seas_i = f\left(F_i^{seas}, F_i^{nseas}, \vec{x}_i\right) \tag{7b}$$

where $Attr_i$ is the proportion of prices in market *i* that are attractive, $Seas_i$ is the proportion of price changes that take place at the beginning of a year (quarter) and $\vec{x}_i$ is the vector of other explanatory variables which are explained below.

We first discuss the results for state-regular policies, i.e. policies under which the price charged is an attractive price. The empirical implementation of the testing

requires a definition of attractive prices. There is no universal approach to defining attractive prices. Since results are sensitive to the definition of the phenomenon to be explained, it is important to find a sensible definition of attractive prices, even though it is clear that any definition would be debatable, given its subjective nature. We chose to adopt a broad definition that tries to capture all prices which are used by any firm or retailer as attractive prices. This comes at the risk of classifying too many prices as attractive. We think this is less problematic than missing important attractive prices. We require that the (percentage) differences between attractive prices be not affected by the order of magnitude of the prices (i.e. if 15.90 is an attractive price, so is 159 and 1,590). This is important in our data set as it encompasses the replacement of the Schilling with the euro, which involved the reduction of prices by roughly an order of magnitude (the exchange rate was 13.7603 Schillings/euro). In addition, our definition is specifically tailored to the Austrian retail market as it takes account of the common pricing practices observed there (e.g. prices ending in 75 are not used as attractive prices in Austria). An explanation of the principles of our definition and (an excerpt of) a list of attractive prices are in the appendix. With our definition, the average proportion of attractive prices in the data is 60.7%.

The cross-sectional variations of the share of attractive prices is explained by the variation in the frequency of price changes, conditional on the last price being an attractive price and, separately, on the last price not being an attractive price, the size of price changes and a number of control and dummy variables to account for other factors influencing the incidence of attractive prices. The conditional frequencies of price changes are expected to have a negative effect on the share of attractive prices because, as implied by the model, firms with a relatively flat profit function will change their prices less frequently and will be more likely to choose attractive prices. Similarly, firms with a flat profit function will also change their prices by a larger amount implying that (controlling for inflation) the size of price changes is positively related with the share of attractive prices in the cross section of products.

The control variables include the average price level in the product category, the rate of inflation and its variability (measured by its standard deviation) and the share of sales prices. If attractive prices are more relevant at lower price levels (i.e. for cheaper goods), the average absolute price in a product category should be related negatively to the share of attractive prices. This variable also serves as a check if our definition of attractive prices is reasonable. The coefficient on the average product-specific inflation is expected to be negative since the higher is the average inflation rate in the product category, the more frequent are price changes and the smaller is the share of attractive prices. The model has no implication for the standard deviation of inflation but, in general, we would expect the coefficient to be negative. First, the empirical relationship between inflation and its variability is positive. Second, and perhaps more importantly, in more volatile environment

firms can be expected to adopt more flexible policies. Finally, the incidence of attractive prices may be affected by temporary promotions and end-of-season sales; casual observation suggests that these prices are often attractive, and so we include the share of sales prices and promotions in each product category as another control variable in the regressions.

The regression results for the share of attractive prices as the dependent variable are shown in table 1. Note that the share of attractive prices is a fractional response variable (it is bounded between 0 and 1), which implies that estimating a linear model is not appropriate. A common approach in this case, which we follow here, is to transform the dependent variable to the log-odds ratio, $\log\left(\frac{Attr_i}{1-Attr_i}\right)$ which is not bounded, and run an OLS regression on the transformed variable[17]. In order to get the marginal effect of each variable on the dependent variable, the regression coefficients, β_k, have to be converted back by the formula $\frac{dy}{dx} = \beta_k \, \overline{Attr}\left(1-\overline{Attr}\right)$ which usually is evaluated at the sample mean. The results in table 1 are quite consistent with the model. The frequency of price changes (conditional on the last price being an attractive price, F_i^{att}) has a negative impact on the share of attractive prices, as predicted by the theoretical model, and this effect is significant at the 10% level. Specifically, the marginal effect implies that, if the conditional frequency increases by one percentage point, the share of attractive prices is decreased by 0.75 percentage points. The conditional frequency if the last price was not an attractive price (F_i^{natt}), however, has a positive impact on the share of attractive prices. While the model clearly implies a negative sign for the first conditional frequency, F_i^{att}, its implications for F_i^{natt} are less clear. The sign could be negative if the conditioning of the frequency is empirically not relevant. A positive sign is reasonable F_i^{natt} if we assume that firms have a strong incentive to follow an attractive pricing policy, i.e. if they have a very flat profit function, but for some reason sometimes deviate from that policy and choose price that is not attractive. But if they do so, they quickly return to an attractive price afterwards, which increases the conditional probability of a price change when the last price was not attractive.

[17] The log-odds model has been criticized for delivering marginal effects that may be inconsistent. An alternative approach used in Dhyne et al. (2005) is the quasi-maximum likelihood (QML) approach proposed by Papke and Wooldridge (1996). It involves directly estimating a non-linear model of the explanatory variables and maximizing its likelihood function based on a Bernoulli distribution. We also performed estimations according to this approach, but the results (available upon request) are very similar.

Table 1: Explaining the Share of Attractive Prices

Variable	Long Sample (96-03)		Schilling Sample (96-01)	
	Marginal Effect		Marginal Effect	
Constant	0.231	***	0.371	***
Frequency cond. on attr (F_i^{att})	-0.745	*	-0.130	
Frequency cond. on not attr (F_i^{natt})	0.649	*	-0.189	
Size of price changes$_i$	0.622	***	0.552	**
Av. Price$_i$ (Schilling)	0.000		0.000	
Av. Price$_i$ (Euro)	0.000			
Av. Inflation$_i$	-0.102	**	-0.132	***
Stdv. Inflation$_i$	0.001		0.006	
Group processed food	0.008		0.023	
Group energy	-0.528	***	-0.611	***
Group industrial goods	-0.284	***	-0.360	***
Group services	-0.315	***	-0.315	***
Share of sales prices$_i$	0.830	**	0.919	**
Number of observations	505		507	
Adjusted R^2	0.417		0.356	

*Notes: Estimation method is OLS on the log-odds ratio of the share of attractive prices; displayed coefficients are marginal effects of each variable on the share of attractive prices evaluated at the sample mean; standard errors are computed using White's correction for heteroskedasticity; inflation is calculated as monthly changes of the corresponding product category's sub-index; the number of products included is lower than the maximum 517 because some variables are not defined for all products; *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

The average (absolute) size of price changes in a market has a positive impact on the share of attractive prices in this market, as predicted by the model. The average price in the product category, which has been calculated and included in the regression for the Schilling period (1996–2001) and the euro period (2001–2003) separately, does not affect the incidence of attractive prices. This result is reassuring as it indicates that, if attractive prices in the data are equally distributed across the price spectrum, the definition of attractive prices has been chosen appropriately. Furthermore, average (monthly) inflation in a product category has a significant negative impact on the share of attractive prices in that category as predicted by the model, while the volatility of inflation (measured by the standard deviation over the sample period) has no significant impact. Finally, the practice of sales and temporary promotions turns out to be an important additional determinant

of attractive prices: the product categories with a higher share of sales and promotions are characterized by a higher share of attractive prices.

The dummy variables for product groups are included to account for product group fixed effects. The group dummies which are included in the regression are defined according to the five product groups used by the ECB to analyze inflation dynamics in the euro area: unprocessed food, processed food, energy, non-energy industrial goods and services. Unprocessed food is used as the reference group and is therefore not included in the regression. It is important to account for these fixed effects as there is extensive evidence that the frequency of price changes varies greatly across product groups (Baumgartner et al., 2005 provide the evidence for the data set we use; Dhyne et al., 2005 summarize these differences for ten euro area countries). The results indicate that the share of attractive prices is significantly lower for non-food items.

To check whether attractive price setting was not systematically different for Schilling and for euro prices, in column 2 we show the regression results obtained for the sample period covered by our dataset when the Schilling was the legal tender in Austria (1996–2001).[18] Overall, the results for the short sample are qualitatively similar to the long sample. The exception is that the frequency of a price change, conditional on the last price not being attractive price has a negative sign and neither conditional frequency is significant. The results for the longer sample are thus more in line with the theoretical model.

We now turn to the analysis of time-regular policies. We implement the model by looking at the determinants of the excess proportion of price changes taking place at the beginning of a year and, separately, at the beginning of a quarter; such behaviour will be called seasonal adjustment. Empirically, price changes in the Austrian data are, indeed, more frequent at the beginning of the year and, for some products, also at the beginning of a quarter (see Baumgartner et al., 2005).

According to the implications of the model, the same line of reasoning as for attractive prices applies to the share of price changes at the beginning of a period. Firms which have a flatter profit function will change their prices less frequently, by a larger amount and prefer a seasonal pattern of their price adjustment, i.e. have a larger proportion of price changes at the beginning of a period. Thus, in a large cross-sectional data set the share of price changes at the beginning of a period should be negatively related to the (conditional) frequency of price changes and positively to the average size of price changes. As in the regression for attractive prices, the average product-specific inflation and inflation volatility as well as the product group dummies and the share of sales prices have been included in the regression as additional control variables.

[18] The sample period form the introduction of the euro to the end of our sample (2002–2003) is too short to be analysed separately.

One important difference between the seasonal pattern and attractive prices is that, in some industries, firms tend to change prices together. For example, clothing stores hold simultaneous sales. This tendency to synchronize price changes needs to be controlled for so as to avoid spurious correlation between seasonal patterns and the conditional frequencies of adjustment. Therefore we include, on the right hand side of the regression, the synchronization index of price changes as defined by Fisher and Konieczny (2000). It summarizes, with a single number, the tendency of prices to be changed together. The index is defined as the ratio of sample standard deviation of the monthly proportion of price changes for a given product category to the standard deviation of the proportion under the assumption that price changes are perfectly synchronized.

The dependent variable in this regression is the ratio of the number of price changes taking place at the beginning of the period to the number of all price changes in that period, normalized to avoid it being bounded. Given that our data are monthly we adopt two definitions of a period: a year and a quarter. In yearly regressions we compute the ratio of the number of price changes in a January of any year to all price changes in the sample; in quarterly regressions we compute the ratio of the number of price changes in any January, April, July or September to the number of all changes in the sample. The (normalized) dependent variable is obtained by dividing the yearly (quarterly) statistics by the share of valid price observations at the beginning of the year (quarter). According to this definition, a number above 1 indicates that relatively more prices are changed at the beginning of the period than average. The resulting dependent variable is not bounded and OLS can be applied in the estimations. For a robustness check we also run equivalent regressions with the (log-odds ratio of the) non-normalized share of price changes at the beginning of a period as the dependent variable. The results are qualitatively very similar.

The regression results for seasonal price setting, shown in table 2 are also broadly consistent with model's implications. Table 2 shows the results for period defined as a year (column 1) and period defined as a quarter (column 2). Of the two specifications, price setting at the beginning of a year is empirically more relevant (the mean of the dependent variable is 2.01, indicating that price changes in January are 101% more frequent than in the other months of the year) than price adjustment at the beginning of a quarter (with a mean dependent variable of 1.16). Therefore, we regard the first column in the table as our standard specification and treat the results for price setting at the beginning of a quarter as an additional specification for a robustness check.

Table 2: Explaining the Share of Price Changes at the Beginning of a Period (Year, Quarter)

Variable	Period = Year Coefficient	Period = Quarter Coefficient
Constant	0.591 ***	0.904 ***
Frequency cond. on seas (F_i^{seas})	-2.926 ***	-1.771 ***
Frequency cond. on not seas (F_i^{nseas})	-0.650	1.367 ***
Size of price changes$_i$	1.635	1.020 ***
Av. Inflation$_i$	0.592 ***	0.023
Stdv. Inflation$_i$	-0.039	-0.007
Group processed food	-0.117	0.011
Group energy	-0.293	0.102
Group industrial goods	-0.116	0.062 ***
Group services	0.552 ***	0.038
Share of sales prices$_i$	-1.371	-0.741 *
Synchronization of price changes$_i$	5.643 ***	0.676 ***
Number of observations	491	480
Adjusted R^2	0.458	0.221

*Notes: Estimation method is OLS; standard errors are computed using White's correction for heteroskedasticity; inflation is calculated as monthly changes in the corresponding product category's sub-index; the number of products included is lower than the maximum 517 because some variables are not defined for all products; *** denotes significance at the 1%, ** at the 5% and * at the 10% level.*

The crucial result is that the sign on both conditional frequencies, i.e. if the last price change was at the beginning of a year (F_i^{seas}) or was not at the beginning of a year (F_i^{nseas}) is negative, as predicted by the model. The coefficient on F_i^{seas} which, as argued before, is more relevant in terms of the theoretical model, is significant at the 1% level. In other words, in markets where prices are changed infrequently, a large proportion of these changes take place in January. Note that in the regression we control for the synchronization of price setting. While the index is not a perfect control[19], the inclusion of the index in the regression reduces the likelihood that the negative sign is due to some markets being characterized by yearly price changes in January only.

[19] It leaves several degrees of freedom as it summarizes, with just a single number, the monthly pattern in the proportion of price changes.

The coefficient on the size of price changes has the expected positive sign (recall that, given the inflation rate, the size of price changes is inversely related to the frequency of adjustment) but the effect is only marginally significant (at the 11% level). An unexpected result is that the average product specific inflation has a positive effect on the share of price changes at the beginning of the year. This is at odds with the theoretical model, which implies that the higher is inflation, the more frequent are price adjustments and the less likely are firms to adjust prices at predefined dates. The coefficient on inflation volatility is negative, as expected, but the effect is not significant. Only services show a significantly higher share of price changes at the beginning of the year than the reference group (unprocessed food), which is related to the fact that many service prices in Austria are regularly changed in January (see Baumgartner et al. (2005)). The commercial practice of sales and temporary promotions is obviously not an important determinant of seasonal price setting in January: the coefficient on the sales variable is negative but not significant. Finally, the coefficient on the synchronization variable is positive and significant at the 1% level. This indicates that in markets where firms synchronize price changes, adjustment in January is frequent.

The regression results for the quarterly pattern of adjustment, shown in the second column of table 2, are similar. The results are qualitatively equivalent to those in the second column with a few exceptions. The frequency of price changes conditional on the last price change not at the beginning of a quarter (F_i^{nseas}) has a positive sign and group effects are somewhat different. Significance patterns are also a bit different. Although some results of this specification (e.g. for the size of price changes and average inflation) are more in line with the theoretical model, it is not our preferred specification as its fit measured by an adjusted R^2 of 0.22 is much lower than in the previous regression; this is not surprising given the quarterly seasonal pattern in price adjustment is much weaker than the yearly pattern.

To sum up, the regression results for both, the share of attractive prices and the share of price changes at the beginning of a period, support the cross-sectional implications of the model developed in the previous section: in markets which are characterized by a low adjustment frequency (independent of the adjustment to attractive prices), large price changes and lower average inflation, we find a high share of attractive prices as implied by the model. And in markets with low adjustment frequency (independent of the seasonal adjustment), large price changes and a higher synchronization of price changes, the share of price changes at the beginning of a year (and a quarter) is high. The only result that is not consistent with the model and cannot readily be explained with other common price-setting practices is the positive relation between average inflation and the share of price changes at the beginning of the year. But all other results are broadly consistent with the model and/or can be rationalized by the stylized facts of price setting in

Austria. Thus, we conclude that our theory is clearly supported by the cross-sectional relations in the Austrian micro CPI data.

4. Conclusions and Extensions

Regular adjustment is ubiquitous in many environments, yet the reasons for such behaviour have not received much attention. In this paper we make a small step towards explaining the incidence of regular adjustment. It is attributed to the heterogeneity in adjustment costs over time and/or levels and the heterogeneity in the shape of the benefit function across policymakers.

The empirical results obtained from a large Austrian data set are consistent with the model. As the benefit function heterogeneity is not observable, we show that the model implies a negative relationship between the average frequency of adjustment and the incidence of regular policies. We treat adjustment frequency as an instrument and find that firms which change prices infrequently often choose regular policies, by setting attractive prices or by adjusting at the beginning of a year or of a quarter.

An alternative source of differences is heterogeneity in price adjustment costs across policymakers as in Dotsey, King and Wolman (1999). In their model firms are otherwise identical but the costs of changing nominal prices differ across firms. These differences lead, in turn, to different frequencies of price changes. With adjustment costs heterogeneity across policymakers, the implied correlation between the frequency of adjustment and the incidence of regular policies is positive. The reason is that, whenever its adjustment cost is low and so the firm changes prices often, the profit function is flat over the variation of the real price and the firm is likely to choose a regular policy. Therefore our empirical results do not support the joint hypothesis that adjustment costs vary across time (or levels) and across firms.

Why are regular policies important? Policymakers who adopt regular adjustment reduce their flexibility. The understanding of the costs and benefits of flexibility is not only of intrinsic importance to these policymakers but is also important for more general considerations. For example, monetary policy is more effective when nominal price adjustments are regular.

One way of viewing state-contingent (as opposed to regular) adjustment is that it provides the option of flexibility, at the cost of higher adjustment costs. This may result in hysteresis. The value of the option is lower under low and more stable inflation. Imagine that there is a setup cost of switching to regular adjustment, for example the expense on the organization of the work flow. A period of monetary stability may lead firms to switch to regular policies and, once the sunk cost has been paid, even when monetary stability falls, some firms may not abandon regular policies.

Finally, the effect of low inflation on the effectiveness of monetary policy depends on the source of the stability. If the reason inflation has been low and stable in recent years is mostly due to monetary policy, then we can expect greater incidence of regular policies and increased monetary effectiveness. On the other hand, assume inflation is low because of increasing competition. This raises demand elasticity and, so, by increasing the concavity of profit functions, may lower the incidence of regular price adjustments and so reduce the effectiveness of monetary policy.

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Appendix

A.I Definition of Attractive Prices for the Schilling Period (1996–2001)

Attractive prices are defined for prices ranges in order to take account of different attractive prices at different price levels: from 0 to 10 Austrian Schillings (ATS) all prices ending at x.00, x.50 and x.90 ATS, from 10 to 100 ATS all prices ending at xx0.00, xx5.00 and xx.90 ATS, from 100 to 1,000 ATS prices ending at xx0.00, xx5.00 and xx9.00 and xxx.90 ATS and so on. An equivalent rule has been defined to identify attractive prices in euro after the cash changeover (2001–2003). Table A1 shows an excerpt of a list of attractive prices for the Schilling case. In order to give a complete list of attractive prices, the table would continue to the right and to the bottom. The extension to the right would show multiples of 10 and 100 of the last four columns.

Table A1: Attractive Prices for the Schilling Period

below 1	1-9.99	10-99.99		100-999.99			1000-9999.99			
					105.00	see col. P		1050.00	see col. Q	see col. R
0.50	1.00	10.00	10.90	100.00	109.00	100.90	1000.00	1090.00	1009.00	1009.90
					115.00	101.90		1150.00	1019.00	1019.90
0.90			11.90	110.00	119.00	102.90	1100.00	1190.00	1029.00	1029.90
					125.00	103.90		1250.00	1039.00	1039.90
			12.90	120.00	129.00	104.90	1200.00	1290.00	1049.00	1049.90
					135.00	105.90		1350.00	1059.00	1059.90
			13.90	130.00	139.00	106.90	1300.00	1390.00	1069.00	1069.90
					145.00	107.90		1450.00	1079.00	1079.90
			14.90	140.00	149.00	108.90	1400.00	1490.00	1089.00	1089.90
					155.00	109.90		1550.00	1099.00	1099.90
	1.50	15.00	15.90	150.00	159.00	110.90	1500.00	1590.00	1109.00	1109.90
					165.00	111.90		1650.00	1119.00	1119.90
			16.90	160.00	169.00	112.90	1600.00	1690.00	1129.00	1129.90
					175.00	113.90		1750.00	1139.00	1139.90
			17.90	170.00	179.00	114.90	1700.00	1790.00	1149.00	1149.90
					185.00	115.90		1850.00	1159.00	1159.90
			18.90	180.00	189.00	116.90	1800.00	1890.00	1169.00	1169.90
					195.00	117.90		1950.00	1179.00	1179.90
	1.90	19.00	19.90	190.00	199.00	118.90	1900.00	1990.00	1189.00	1189.90
					205.00	119.90		2050.00	1199.00	1199.90
	2.00	20.00	20.90	200.00	209.00	120.90	2000.00	2090.00	1209.00	1209.90
					215.00	121.90		2150.00	1219.00	1219.90
			21.90	210.00	219.00	122.90	2100.00	2190.00	1229.00	1229.90
					225.00	123.90		2250.00	1239.00	1239.90
			22.90	220.00	229.00	124.90	2200.00	2290.00	1249.00	1249.90
					235.00	125.90		2350.00	1259.00	1259.90
			23.90	230.00	239.00	126.90	2300.00	2390.00	1269.00	1269.90
					245.00	127.90		2450.00	1279.00	1279.90
			24.90	240.00	249.00	128.90	2400.00	2490.00	1289.00	1289.90
					255.00	129.90		2550.00	1299.00	1299.90
	2.50	25.00	25.90	250.00	259.00	130.90	2500.00	2590.00	1309.00	1309.90

The Price-Setting Behavior of Austrian Firms: Some Survey Evidence

Claudia Kwapil
Oesterreichische Nationalbank

Josef Baumgartner
Austrian Institute of Economic Research

Johann Scharler
Oesterreichische Nationalbank

Abstract

This paper explores the price-setting behavior of Austrian firms based on survey evidence. Our main result is that customer relationships are a major source of price stickiness in the Austrian economy. We also find that the majority of firms in our sample follows a time-dependent pricing strategy. However, a substantial fraction of firms deviates from time-dependent pricing in the case of large shocks and switches to a state-dependent pricing strategy. In addition, we present evidence suggesting that the price response to various shocks is subject to asymmetries.

Keywords: Price-setting behavior, price rigidity
JEL codes: C25, E30

Non-Technical Summary

Nominal rigidities play a key role in most macroeconomic models used for the analysis of monetary policy. The existence of sticky prices gives the central bank leverage over the real interest rate, which allows monetary policy to influence real economic activity. Although the importance of rigidities for the monetary transmission mechanism appears to be well accepted, a better understanding of the nature of the frictions seems to be crucial since the optimal macroeconomic policy depends on the sources and characteristics of these rigidities. Moreover, the analysis of nominal frictions is particularly relevant in the case of a monetary union since different degrees of price stickiness in the member countries might give rise to cross-country differences in the transmission mechanism.

The economic literature distinguishes between two different kinds of price setting policies. Firms following a time-dependent pricing rule can change their prices only at specific time intervals, while firms applying state-dependent pricing can change their prices whenever they like, especially if the economic environment changes. These two pricing policies have different consequences for price adjustments following an economic disturbance. Under a state-dependent rule, the firm changes its prices instantaneously after a shock (given that the shock is large enough), while with a time-dependent pricing policy it has to wait for the next opportunity. We find evidence that the firms in our sample follow time-dependent as well as state-dependent pricing strategies. Under normal circumstances around 70% of the firms apply time-dependent pricing. However, in the face of major shocks almost half of the firms deviate from this strategy and set their prices according to the state of the economy. Comparing this share with evidence from other countries suggests that the share of firms following state-dependent pricing rules in response to large shocks (56 percent) is relatively small in Austria, which suggests that real effects of monetary policy should (ceteris paribus) be stronger.

Furthermore, our results suggest that price setting takes place at two stages. First, firms review their prices to check whether they are at the optimal level or they need to be changed. Second, if firms find out that the price deviates from its optimal level, they need to decide whether to change the price or not. We find evidence that there are obstacles to price adjustments at both stages. However, the contest of the theories about price stickiness reveals that the main obstacles to price adjustment seem to lie at the second stage of price setting. Thus, informational costs, which are important at the reviewing (first) stage of price setting, do not seem to be among the most important obstacles to price changes. The fear that a price adjustment could jeopardize customer relationships (expressed in the theories on implicit and explicit contracts) seems to be a much more important explanation for sticky prices.

Finally, we investigate the reaction of prices to (cost and demand) shocks. The average time lag between a shock and the price adjustment is four to six months. Furthermore, we observe that firms react asymmetrically to cost and demand shocks. Prices are more sticky downwards than upwards in the face of cost shocks as more firms react more quickly to cost-push shocks than to decreasing cost shocks. In the case of large demand shocks, however, the opposite is true. Prices are more sticky upwards than downwards, because more firms react to receding demand than to increasing demand. If we interpret a monetary shock as a demand shock, it follows that monetary policy should have an asymmetric impact on the Austrian economy.

1. Introduction

Nominal rigidities play a key role in most macroeconomic models used for the analysis of monetary policy. In what appears to be the workhorse model for monetary policy evaluation, the fact that prices are sticky gives the central bank leverage over the real interest rate, which allows monetary policy to influence economic activity via aggregate demand.[1]

Although the importance of rigidities for the monetary transmission mechanism appears to be well accepted, a better understanding of the nature of the frictions that lead to monetary non-neutrality in the short run seems to be crucial for the conduct of monetary policy since the optimal macroeconomic policy depends on the sources and characteristics of these rigidities. Moreover, the analysis of nominal frictions is particularly relevant in the case of a monetary union since different degrees of price stickiness in the member countries might give rise to cross-country differences in the transmission mechanism.

In this paper we investigate price stickiness in Austria. We follow the seminal work of Blinder et al. (1998) and analyze survey evidence focusing on the price-setting behavior of Austrian firms.[2] Conducting a survey has the advantage that it allows to confront actual decision makers with the chain of reasoning that a specific theory of price stickiness describes. This appears to be an important advantage over assessing theories according to whether or not their testable implications are consistent with the data since most theories share virtually the same prediction, namely that prices are sticky.[3]

The purpose of this paper is threefold. First, we present some stylized facts on price setting in Austria. In particular, we study the question whether firms follow a time-dependent or state-dependent pricing policy. Second, we try to discriminate between different explanations of price stickiness advocated in the literature. This appears to be an interesting and important issue since the sources of price stickiness matter for the conduct of monetary policy. And finally, we analyze how firms react to shocks that hit the economy.

We find that time-dependent and state-dependent pricing strategies are prevalent among the firms in our sample. Approximately 70% of the firms follow a time-dependent pricing strategy under normal circumstances. However, around 50% of these firms deviate from time-dependent pricing in the case of large shocks. Moreover, firms tend to react asymmetrically to shocks. While more firms adjust their prices in reaction to increasing costs than to decreasing costs, the opposite is

[1] See for instance Clarida et al. (1999).
[2] For similar studies focusing on other countries see Apel et al. (2001), Aucremanne and Druant (2004), Fabiani et al. (2004b), Hall et al. (1997), Hoeberichts and Stokman (2004), Loupias and Ricart (2004), Martins (2004), Wied-Nebbeling (1985).
[3] See Blinder (1991).

true in the case of large demand shocks. More firms react to receding demand than to increasing demand. Overall, the average time lag between a shock to either demand or costs and the price adjustment lies in the range between four and six months. Finally, we find that the main explanation for sticky prices is the customer relationship. Firms shy away from price adjustments (especially in response to demand shocks) because they do not want to jeopardize their customer relationships. Firms that sell mostly to regular costumers are less likely to react to shocks by adjusting prices.

The remainder of the paper is organized as follows: Section 2 briefly discusses the conduct of our survey. Section 3 focuses on price reviews and price changes while section 4 investigates the explanatory content of various theories of price stickiness for our data set. Section 5 deals with time lags relevant for price adjustments after shocks and section 6 summarizes and concludes the paper.

2. The Survey

2.1 Implementation of the Survey

When compiling the questionnaire, we drew upon the experience of Blinder et al. (1998) for the U.S.A., Hall et al. (1997) for the U.K., Apel et al. (2001) for Sweden, Wied-Nebbeling (1985) for Germany and Fabian et al. (2004b) for Italy. However, the empirical designs of these studies show some differences. Blinder et al. 1998 used a sample of 200 private firms, which were surveyed in face-to-face interviews. The other studies used (much) larger samples with fill-in type of questionnaires. The Austrian survey was carried out as a fill-in questionnaire as well, and was sent as a supplement with the monthly WIFO Business Cycle Survey (BCS) in January 2004. In total, we contacted a sample of 2427 firms from the manufacturing and industry-related service (hereinafter referred to as services) sectors by mail, and 873 firms participated in the survey.[4] Thus, we obtained an overall response rate of 36%, which can be regarded as high given the complexity of the issue and the length of the questionnaire.[5]

As shown in chart 2 and table A1 in the Appendix, the response rates vary considerably across sectors and according to firm size. More manufacturing firms participated in the survey than service sector firms, and we recorded above-average participation of small firms (with less than 100 employees) whereas very large firms tended not to answer the questionnaire.

[4] We mailed the questionnaires to the decision makers of the firms (firm owners, CEOs or assistants of CEOs). In the first week of February 2004 a reminder letter was sent to approximately 1800 firms which had not responded by the end of January.

[5] The questionnaire consists of 13 sets of questions adding up to 79 detailed questions.

When asking about price setting, one has to deal with the issue that many firms sell several types of goods in different (domestic or foreign) markets. In order to operationalize this issue, we asked the respondents to refer to their main product or service (in terms of turnover) on their main market. This should avoid the problem that the respondents lose the focus and switch between different products when answering the questionnaire. We also decided to exclude some sectors a priori because the concept of a main product was less suitable for them (e.g. construction, retailing) as pointed out by Hall et al. (1997). In addition, some sectors had to be disregarded because they are not included in the WIFO BCS sample. Overall, the included sectors represent 42% of Austria's value added in 2001.[6]

The WIFO BCS sample was established as a stratified sample in the 1970s and has been re-stratified several times since then. As can be seen from chart 2 in the Appendix the sample and the response show a bias: industrial (intermediate goods-producing) and large (well-established and successful) firms are over-represented in terms of number of firms and employees, which is a common characteristic in longitudinal data sets of this kind.[7] To correct for these effects, we post-stratify the answers according to the sector of activity and the size class each firm belongs to (see table A1 in the Appendix for details on the post-stratification weights).

The questionnaire collects different types of information about the participating firms. In the first part, Questions A1 to A8 inquire several characteristics of the responding firms (e.g. main product, turnover shares, market and client structures). According to this information, 80% of the firms in our sample operate mainly in the domestic market[8]. Approximately three quarters of the respondents deal primarily with other firms. Just 7% deal directly with consumers and 5% report to have the government as their main customer. Moreover, 87% of the respondents achieve more than 60% of their turnover with regular customers.[9] These numbers indicate that our results focus on producer prices and that an environment of imperfect competition might be a good proxy for the market situation our firms operate in as they mainly deal with regular customers.

The price-setting process is the focus of Questions B1 to B7. To assess the importance of different theories about sticky prices, eleven theoretical concepts were translated into questions in everyday language (Questions B8 and B9). In Question B11 we ask about the reasons for price changes (e.g. labor costs, intermediate-good price changes). Finally, the issues of asymmetries of price

[6] The following sectors are covered in our survey: manufacturing (15, 17 to 36) and some industry-related services (60, 63, 70 to 74, 90). Codes in parentheses correspond to the NACE 2-digit classification.

[7] In the sample no newly founded firms are represented. In addition, firms which did not respond four times in a row (e.g. because of bankruptcy) are excluded form the BCS.

[8] The Austrian market is regarded as their main market, if they earn more than 60% of their turnover there.

[9] A selection of these results is reported in Appendix A, tables A2 to A5.

adjustments (increases vs. decreases), price reactions to different kinds of shocks (demand vs. cost shocks) and the influence of the size of a shock (small vs. large shocks) are addressed in Question B10.

According to the answers to Question B1, about 82% of the respondents are able to set prices by themselves. We restrict the analysis discussed in the following sections to these 715 firms.[10]

2.2 Economic Conditions

When filling in the questionnaire, the respondents were asked to answer either in a general way (i.e. how they usually react) or by indicating how they acted in the last years. Thus, their responses are a snapshot depending, among other things, on the economic situation in Austria at the time the survey was conducted.

In the following we briefly sketch the macroeconomic conditions at the time of the survey (for details see table A6 in the Appendix). Caused by an international business cycle downturn, economic growth in Austria lost its momentum after 2000. Following growth rates (in real terms) well above 3%, the economy slowed down markedly to rates below 1%. Inflation was on the rise until May 2001 (3.4%) and declined afterwards to 0.8% in 2003.

3. Price-Setting Behavior of Austrian Firms

3.1 Time-Dependent versus State-Dependent Pricing Rules

In this section we investigate the price-setting strategy of firms. The idea that economic agents cannot or do not want to change prices and wages instantaneously after shocks was introduced in the economic literature in different ways. Fischer (1979) as well as Taylor (1979, 1980) use the idea of nominal long-term labor contracts in order to inject an element of stickiness into the behavior of nominal wages. Blanchard (1983, 1986) for example applies the idea of monopolistic competition in the goods and labor markets, which creates an adjustment process of wages and prices that takes some time. This enables them to model nominal shocks having an effect on the short run behavior of output. Consequently, they argue that monetary policy can affect real output in the short run, rational expectations notwithstanding. Modeling the timing of wage and price changes is crucial to the real effects of nominal disturbances and is thus one of the cornerstones in New Keynesian macroeconomics.

The time interval of the nominal contracts modeled e.g. by Fischer (1977) and Taylor (1979, 1980) is fixed exogenously and the length is known in advance.

[10] The alternative answers were that e.g. the parent company, the main client or a regulatory authority determines prices.

Calvo (1983) introduces a stochastic element in the price-setting behavior by assuming that each price setter is allowed to change the price following a random signal. These models have in common that the agents cannot change their prices whenever they like, but have to hold prices constant for a (known or unknown) period of time. They are using a time-dependent pricing rule, where the time between successive price revisions cannot be chosen by the firm.

The second strand of literature follows a different line of argument on price adjustments. Firms use state-dependent pricing rules like the (s, S) price adjustment policy in the tradition of Barro (1972) developed further e.g. by Sheshinski and Weiss (1977). Whenever a price setter adjusts his or her price, he or she sets it such that the difference between the actual and the optimal price equals some target level S. The economic agent then keeps the nominal price at this level until the difference between the actual and the target level reaches the trigger level s, which induces an adjustment in the nominal price level. In these models the intervals between price adjustments depend on the nature, the direction as well as the frequency of shocks.

These two pricing policies have different consequences for price adjustments following an economic disturbance. Thus, they have different implications for the transmission of nominal shocks to the real economy. Under a state-dependent rule, the firm changes its prices instantaneously after a shock (given that the shock is large enough), while with a time-dependent pricing policy it has to wait for the next opportunity. If one economy faces a higher share of firms operating time-dependent pricing rules than another economy, then – all other things being equal – this could translate into a higher real effect of (large) nominal shocks in the short run. Consequently, the effect of monetary policy on the real economy is sensitive to the share of firms using time-dependent and state-dependent pricing policies.[11]

These concepts of pricing rules are difficult to explain in a questionnaire. Especially because it might be the case that firms are just able to adjust their prices at exogenous dates (as in the time-dependent rule described above) but because in the last years no shocks occurred that would have warranted a price change, the firms did not change their prices at these predefined time intervals. Thus, they might not agree to the statement that they change their prices regularly. That is why we did not ask whether they follow state-dependent and time-dependent pricing rules. Instead, we asked which strategy the firms follow when reviewing their prices (Question B6a). Following Apel et al. (2001), we allowed the respondents to choose from the following answers:

(1) the firm reviews the price regularly,

[11] In the case of shocks which are too small to guarantee that the difference between the actual price and the optimal price becomes large enough to trigger a price change for all firms following a state-dependent pricing strategy, it is not clear-cut whether a time-dependent or a state-dependent rule entails more flexible prices.

(2) the firm reviews the price on specific occasions,
(3) in general the firm reviews its price regularly and also on specific occasions,
(4) for other reasons and lastly
(5) the firm never checks prices without changing them.

We interpret the answer category (1) as a time-dependent rule, (2) as a state-dependent rule and (3) as normally time-dependent with a switch to a state-dependent regime if sufficiently significant changes occur.

Table 1: Price-Reviewing Strategies Followed by Austrian Firms

	Frequency	Percent
time-dependent	265.25	38.06%
state-dependent	178.73	25.64%
time- and state-dependent	210.24	30.16%
other reasons	28.45	4.08%
no review without change	14.33	2.06%
Total	697.00	100.00%

According to our results, which are presented in table 1, price reviews seem to be a common practice in the firms' pricing strategies. Nearly 98% of the respondents apply one of the above-mentioned reviewing strategies without necessarily changing their prices. Furthermore, our results suggest that both state-dependent and time-dependent strategies are pursued by Austrian firms.[12] Under normal conditions (in the absence of major shocks) approximately 68% of the firms carry out price reviews at constant time intervals, while approximately 26% conduct price reviews on specific occasions. This is in line with the results in Blinder et al. (1998) for the U.S.A., Apel et al. (2001) for Sweden and Aucremanne and Druant (2004) for Belgium, who find that approximately two thirds of the companies follow time-dependent and one third state-dependent reviewing strategies under normal circumstances.[13]

However, the picture changes considerably when we allow for shifts in the reviewing policies. Approximately 30% of the Austrian firms will alter their behavior in response to specific events and will change to state-dependent reviewing. When significant changes occur, 38% of the firms stick to their practice of checking their prices regularly, while nearly 56% apply state-dependent price reviews. Comparing this share with the results from other euro area countries, we

[12] There are no statistically significant differences in the share of firms following the pricing strategies as reported in table 1 across e.g. size classes, sectors, export share.

[13] The results in the literature mentioned above vary between 59% and 66% for firms following a time-dependent rule and between 30% and 34% for firms following a state-dependent reviewing strategy.

find country-specific differences. While the share of firms applying state-dependent reviewing in the face of exceptional circumstances is 54% in Italy (see Fabiani et al. (2004b)) and 56% in Austria, it amounts to 61% in France (see Louipas and Ricart (2004)), 64% in the Netherlands (see Hoeberichts and Stokman (2004)) and Portugal (see Martins (2004)) and 74% in Belgium (see Aucremanne and Druant (2004)). In the light of our above considerations, these results would suggest that in response to major shocks prices should respond more flexibly in Belgium, the Netherlands, Portugal and France than in Austria and Italy.

In Question B11 we asked the firms what factors actually drove price adjustments in recent years. One of the twelve answer categories the firms could choose from was "We raise prices at regular intervals". Combining the answers from this question with the information about whether the firms follow a time-dependent or a state-dependent reviewing policy results in the following picture: While 54% of the firms applying a time-dependent rule agree to the statement "We raise prices at regular intervals"[14], this is just true for 23% of the firms conducting state-dependent reviews. This statistically significant difference (at the 1% level) suggests that there is a connection between time-dependent reviews and time-dependent price changes, as we assumed above.

To conclude, we find evidence that the firms' reviewing strategies can indeed be used as proxies for time-dependent and state-dependent pricing rules. The results indicate that both types of price-setting strategies are prevalent among Austrian firms. Furthermore, we infer from the literature that the effect of monetary policy on the real economy is sensitive to the relative share of firms following time-dependent and state-dependent approaches. In Austria a comparatively smaller share of firms (56%) applies state-dependent pricing rules in response to major shocks, which suggests that the effect of significant monetary policy shocks on the real economy should be larger in Austria than in countries having a higher share of state-dependent price setters – all other things being equal.

3.2. How Often Do Firms Review Their Prices?

Those firms which indicated that they conduct periodic price reviews, applying a time-dependent pricing strategy, were asked at which intervals they review their prices (Question B6b). As shown in table 2, 25.5% of the firms carry out their price reviews at a yearly frequency, 17.5% half-yearly and 28.4% quarterly. Thus, the median firm reviews the price of its main product quarterly, which is also the mode meaning that a quarterly review is the most typical practice.

[14] The respondents could choose from four answers: (1) describes us very well, (2) applicable, (3) inapplicable and (4) completely inapplicable. We assume that firms ticking answer (1) or (2) agree to the statement, while the other firms are assumed to disagree.

Table 2: Frequency of Price Reviews

	Frequency	Percent
less frequently than yearly	2.74	0.9%
yearly	79.66	25.5%
half-yearly	54.48	17.5%
quarterly	88.52	28.4%
monthly	69.11	22.2%
weekly	12.36	3.9%
daily	5.13	1.6%
Total	312.00	100.0%

Given the observed differences in the reviewing behavior, we look for a pattern explaining the diverse frequencies of price reviews. However, a Chi-square test analyzing the equality of distribution over the frequency classes with respect to some firms' characteristics (e.g. market share, export share, share of explicit contracts) does not suggest any relationship at conventional significance levels. There is, however, one exception: the industrial grouping the firm belongs to.[15] Comparing the share of firms in different industries that review their prices more frequently than monthly (see table A8), we find that this share is 44% and 49% in the intermediate goods and capital goods sector, respectively, and below 25% in all the other sectors (consumer durables, consumer non-durables and services). A t-test analyzing the equality of proportions indicates a statistically significant difference in the reviewing behavior in these industries (at the 5% level), with firms in the intermediate goods and the capital goods sector reviewing their prices more frequently.

The majority of firms does not check prices continuously but at discrete time intervals. This could have several reasons. For one thing, this could be related to the (potentially sporadic) arrival of information. Thus, it might be possible that it does not make sense for firms to review their prices more often, as no additional information would be available.[16] For another, there are costs associated with price

[15] In distinguishing between the industrial groupings, we follow the European Commission that splits the manufacturing sector into four groups: firms producing consumer non-durables, consumer durables, intermediate goods and capital goods. Furthermore, our sample comprises manufacturing-related services, which we add as a fifth category to our definition of industrial groupings.

[16] Kashyap (1995) rejects this hypothesis. He observes differing reviewing behavior also with regard to products having similar cost and demand characteristics. However, if products are alike, then the arrival of the necessary information should be correlated as well.

reviews. If there are informational costs, then it might be optimal for firms to forego the most topical information instead of incurring these costs.

3.3 How Often Do Firms Change Their Prices?

The respondents were asked (Question B7) "How often do you change the price of your main product on average in a given year?" Table 3 reports that 22.1% of the firms answered that they do not change their prices at all, 54.2% change their prices once a year and 13.9% do it 2 to 3 times a year.[17] Thus, 90% of the firms adjust their prices less frequently than quarterly. The median firm changes its price yearly and also the mode of this distribution lies at the yearly frequency. Just around 10% of the firms change their prices more often than 3 times a year. These results are in line with Apel et al. (2001), Blinder et al. (1998) and Hall et al. (1997) as well as with the results of eight euro area countries described in Fabiani et al. (2004a), all of whom also find that the modal number of price changes per year lies at the yearly frequency.

Table 3: Frequency of Price Changes

	Frequency	Percent
0	69.03	22.1%
1	169.01	54.2%
2–3	43.44	13.9%
4–11	24.07	7.7%
12–49	3.72	1.2%
more than 50	2.73	0.9%
Total	312.00	100.0%

As in the case of price reviews, we are interested in finding a pattern explaining the difference in the behavior of adjusting prices. Again the sector the firms operate in explains some of the difference in the frequency of price changes. A Chi-square test analyzing the equality of distribution over the frequency classes rejects the null hypothesis at the 5% level. This result points into the same direction as the result on price reviews. Firms in the intermediate and capital goods-producing sectors change their prices more frequently (see table A7).

[17] The results shown in table 3 refer to a sample of firms that answered Question B6b and Question B7.

3.4 The Relation between Price Reviews and Changes

Price changes occur considerably less frequently than price reviews. As shown in table 4 nearly 30% of the firms review their prices monthly or more frequently, while just around 2% of the firms change their prices at that frequency. The median firm reviews its price quarterly and adjusts its price once a year.

Table 4: Cumulated Frequency Distribution of Price Reviews and Price Changes

	Review	Price change
weekly or more frequently	5.5%	0.9%
monthly or more frequently	27.7%	2.1%
quarterly or more frequently	56.1%	9.8%
half-yearly or more frequently	73.6%	23.7%
yearly or more frequently	99.1%	77.9%

Furthermore, we find a strong association between the frequency of price reviews and changes. A firm that reviews its price more often is also more likely to change its price at smaller time intervals. A test for association is significant at the 0.01% level.

The results suggest that price setting takes place at two stages. First, the firms review their prices to check whether they are at the optimal level or they need to be changed. They do that at discrete time intervals and not continuously. Thus, some kind of stickiness can already be observed at the first stage of price setting. Second, once the price review has taken place, firms might change their prices. However, they do so considerably less frequently than they review the prices. Prices are possibly left unchanged because there are no reasons to change them. But perhaps prices remain unchanged because, even once firms have decided to incur the informational costs of the review, they think that there are additional costs of changing the price, which prevents the price adjustment. We will discuss the possible sources of these costs in section 4.

4. Why Do Firms Prefer Not to Change Prices?

4.1 Theories Explaining Price Stickiness

In the economic literature we find manifold explanations for sticky prices. These range from physical menu costs to pricing points and implicit contracts, to name but a few. As Blinder (1991) points out, however, it is difficult to evaluate which of these theories come close to the real world's obstacles to changing prices (one

problem being observational equivalence). Thus, Blinder started to apply the interview method as a new way of finding out about the empirical relevance of different theories. He explained selected theories to managers in face-to-face interviews and assumed that they would recognize the line of reasoning when it came close to their way of thinking. We apply Blinder's methodology to Austrian firms.

We confronted managers with eleven theories, which we chose taking into account their relevance in the economic literature and their rankings in the surveys already conducted (Apel et al. (2001), Blinder et al. (1998), Fabiani et al. (2004b) and Hall et al. (1997)). In the following we will give a short description of all eleven theories.[18]

1. *Coordination failure:* It might not be attractive for a firm to change its price since a change would not only affect customers but also competing firms. After a shock a firm might want to change its price, but only if the other firms change their prices, too. If the firm is the only one to increase its price, it might stand to lose customers. At the same time, a single-handed price reduction might spark a price war, which could in the end be detrimental to the firm's profits.[19] Thus, it might be preferable to a firm to stick to its price as long as none of its competitors moves first. Blinder et al. (1998) call this "following the crowd". Without a coordinating mechanism which allows the firms to move together the prices might remain fixed.
2. *Explicit contracts:* Some of the theories explaining price stickiness were first applied to the labor market, which is for example true for explicit contracts fixing wages (e.g. see [14]). However, this idea can as well be applied to the product market. Firms have contractual arrangements with their customers, in which they guarantee to offer the product at a specific price. An explanation why firms might engage in such agreements is that they want to build up long-run customer relationships. This should discourage customers from shopping elsewhere, stabilizing the firm's future sales. Customers are attracted by a constant price because it helps to minimize transaction costs (e.g. shopping time). Thus, customers focus on the long-run average price rather than on the spot price. As will be described in section 2, explicit contracts are indeed widely used by Austrian firms.
3. *Pricing points:* Some firms set their prices at psychologically attractive thresholds. Especially in the retailing sector we observe prices of, for example, EUR 99.50 instead of EUR 100.00. This suggests that there are non-continuities in the demand curve. Firms choose such pricing points because increasing the price above these thresholds would decrease demand

[18] Here, we stick to the sequence with which they appear in the questionnaire.
[19] This outcome depends crucially on the assumptions of the non-cooperative game. One example of such a set-up is described in Stiglitz (1984).

disproportionately. Customer behavior of this kind can cause price stickiness. In the face of small shocks calling for small price changes firms might not want to react (at least not immediately); instead they rather postpone price adjustments until new events justify a large price change to the next pricing point.

4. *Price readjustments:* This explanation for sticky prices is based on the idea that firms regard the shock they are faced with as temporary. Thus, they assume that the optimal new price will be short-lived as well, and they will have to readjust the price in the opposite direction within a short time period. This theory shares characteristics with the idea of explicit contracts as both rely on the assumption that frequent price changes are detrimental to customer relationships.
5. *Menu costs*: The act of changing prices might be costly. Sheshinski and Weiss (1977) motivate this idea with companies selling through catalogs because printing and distributing new catalogs generates non-negligible costs. Thus, a company facing these costs will change its prices less frequently than an otherwise identical firm without such costs. Akerlof and Yellen (1985) and Mankiw (1985) show that even "small" costs of changing prices can lead to nominal rigidities having "large" macroeconomic effects. In the following we will use the term menu cost in the narrow sense of focusing on the physical cost of changing prices, and not in a broad sense as suggested by Ball and Mankiw (1994).
6. *Cost-based pricing*: It is assumed that costs are an important determinant in a firm's pricing decision and that if costs do not change, prices will not change either. Basically, this means that prices do not change because other prices (costs of inputs) do not change. However, the argument goes further. As products pass through different stages of production, a (demand or cost) shock somewhere in the production chain will take some time until it is propagated further up the chain and finally to the consumers. Thus, even small lags in the adjustment process of a single firm can add up to long lags, when we take into account the whole chain of production.
7. *Non-price competition:* Another possibility why prices are sticky is that firms prefer to react to shocks by changing features of the product other than the price. For example, instead of increasing the price, they could extend delivery times and/or reduce the level of service.
8. *Quality signal:* This question dealing with the quality of the product is related to the above question about non-price competition. However, it reverses the line of argument. It assumes that firms do not decrease the price of their product because customers might wrongly interpret the price decrease as a reduction in quality. Thus, they prefer to hold their nominal prices constant.
9. *Kinked demand curve:* The demand curve the firm faces has a break in the sense that the firm loses many customers when it increases the price. However,

it will not gain many customers if it reduces the price. This theory – like the idea of coordination failure – is based on interactions between firms. The firm assumes that if it raises the price, no other firm will follow and it will lose market share. Moreover, it assumes that if it decreases the price, all competitors will follow suit and it will not gain customers. Thus, it might prefer to hold its price constant.

10. *Implicit contracts:* This theory is based on a similar line of reasoning as the explicit contract theory but it goes one step further. Both theories assume that firms want to build up long-run customer relationships in order to make their future sales more predictable. In contrast to explicit contracts, however, implicit contracts try to win customer loyalty simply by changing prices as little as possible. Okun (1981, p.151) puts it like that: "Continuity and reliability are vital to all these arrangements. But because firms are subject to cost increases that they cannot control, they cannot maintain and realistically pledge constancy of price over an indefinite horizon." This is why Okun (1981) distinguishes between price increases due to cost shocks and those that are due to demand shocks. He argues that higher costs are an accepted rationale for rising prices, while increases in demand are viewed as unfair. Consequently, firms hold prices constant in the face of demand shocks, as they do not want to jeopardize customer relationships. They only adjust prices in response to cost shocks.
11. *Information costs:* As already mentioned above, Ball and Mankiw (1994) suggest a broader use of the term menu costs, in the sense that it includes more than just the physical costs of changing prices. In particular they argue that "the most important costs of price adjustment are the time and attention required of managers to gather the relevant information and to make and implement decisions" (Ball and Mankiw 1994, p. 142). In the following, we will call these costs information costs. The distinction between physical menu costs and information costs enables us to investigate their relative importance in pricing decisions.

4.2 How Relevant Are these Theories in Practice?

This section focuses on the insights we gain from confronting managers with the potential causes for sticky prices we described above. In Questions B8a and B9 we asked: "If there are reasons to increase the price of your main product, which of the following factors might prevent an immediate price adjustment?"[20] The list following this question contained the eleven theories mentioned above, explained as simple as possible in layman's language. For every theory the respondents could choose from four answer categories (4 if they agree very much and 1 if they

[20] In section 3 we deal with the question about price decreases.

disagree very much with the statement). Table 5 ranks the theories according to their mean scores (in column 1) and gives their standard errors (SE in column 2).

According to our results, implicit and explicit contracts are the explanations for sticky prices which were cited most frequently by the respondents. Both theories earned on average a grade of more than three and as their mean scores are very close, we should regard both theories as the winners of this contest. Column 3 and 4 give the results of testing the null hypothesis that the theory's mean score is equal to the score of the theory ranked just below it. This indicates that the mean scores of the two winners are too close to be – in a statistical sense – regarded as different from each other.

Taking a closer look at the mean scores of all theories, we can divide the participants of the contest into two groups. The first five theories earned average grades well above two, while the other six theories received a lower level of support with mean scores well below two. Column 5 contains an alternative way of ranking the theories, reporting a measure of how many respondents agree to the respective theory. It gives the fraction of respondents rating the theory as "applicable" or higher (grades 3 and 4). This way of ranking distinguishes between the two groups of theories even more clearly. While the first five theories are regarded as applicable by more than 50% of the respondents, the "tier two" group of theories received support from less than 15% of the firms.

This way of ranking the theories gives almost the same sequence of the theories' relevance as the ranking according to the mean scores.[21] Besides explicit and implicit contracts, the top group in the contest comprises cost-based pricing, kinked demand curve and coordination failure.

The results indicate that many firms refrain from changing their prices frequently because they have written contracts or implicit agreements to build up long-term customer relationships in order to safeguard tomorrow's sales. In line with this reasoning, we find an association (at the 10% level) between the firms agreeing to the implicit contract theory (rating it with 3 and 4) and those having a high share of regular customers (which was inquired in Question A8). 85% of all respondents have a high proportion of regular customers accounting for more than 70% of their sales.

[21] There is just one exception, namely menu costs would rank sixth under this criterion and information cost would rank seventh.

Table 5: Relevance of Theories Explaining Upward Price Stickiness

		(1) Mean	(2) SE	(3) t-Stat	(4) H_O	(5) Consent	(6) Blinder	(7) Fabiani	(8) Apel	(9) Hall
1	Implicit contracts	3.04	0.05	0.52		77.37%	4	1	1	5
2	Explicit contracts	3.02	0.06	4.05	***	73.42%	5	2	3	1
3	Cost-based pricing	2.72	0.06	0.77		67.56%	2	3	2	2
4	Kinked demand curve	2.69	0.05	3.47	***	62.77%	-	-	4	-
5	Coordination failure	2.47	0.06	12.86	***	52.86%	1	4	-	3
6	Information costs	1.61	0.04	2.00	**	12.21%	-	9	13	-
7	Menu costs	1.52	0.06	0.25		13.39%	6	8	11	11
8	Non-price competition	1.49	0.05	0.73		11.19%	3	7	-	8
9	Price readjustments	1.42	0.04	2.34	**	8.42%	-	5	-	-
10	Pricing points	1.32	0.04	-		7.98%	8	10	7	4
11	Quality signal	-	-	-						

Notes to Table 5: ***(**)[*] stands for significant at the 1% (5%) [10%] level. The null hypothesis referred to in column 4 is that the theory's mean score (given in column 1) is equal to the score of the theory ranked just below it.

Just 4 firms out of 703 having answered this question say that they do not have regular customers at all. It seems that regular customers are a common phenomenon preventing frequent price changes.

In Question B2 we asked the firms whether they have explicit contracts in place. We observe a very clear association between the firms with such arrangements and those agreeing to the explicit contract theory as an explanation for price stickiness (the test being significant at the 1% level). This indicates that the responses throughout the questionnaire seem indeed to be consistent. Approximately 75% of all respondents have written arrangements with their customers and the most typical practice is a contract length of one year: 21% of the firms have price agreements valid for less than one year, 68% for one year and 11% for more than one year.

Columns 6 to 9 in table 5 show the ranking of the eleven theories in other surveys. (Column 6 refers to the results in Blinder et al. (1998) for the U.S.A., column 7 to Fabiani et al. (2004a) for an average of the results from nine euro area countries, column 8 to Apel et al. (2001) for Sweden and column 9 to Hall et al. (1997) for the U.K.) There are, however, some difficulties in comparing these rankings. The questionnaires cover different theories, and moreover the number of theories varies. Furthermore, the other surveys contain theories which are not covered by the Austrian questionnaire. However, we tried to deal with this problem by including the four best performing theories of all other surveys in our questionnaire. Nonetheless, this comparison points out that all the theories ranking first and second in the other surveys are within our top group of theories.[22]

The theories ranking in our "tier two" group include prominent candidates like physical menu costs. Although they are a favorite explanation for price stickiness in the theoretical literature, they seem to be less important in practice. It should be kept in mind, however, that this survey only covers firms operating in the manufacturing industry and in the industry-related service sector. Thus, it includes mostly firms dealing with other firms. Less than 10% of the respondents have final consumers as their main customers. This might be an explanation why theories like pricing points and non-price competition are not regarded as good explanations for price stickiness.[23]

To conclude, we want to go back to section 4. There we discuss the possibility that price setting might take place at two stages. At the first stage, the firms review their prices to find out whether they are still optimal, and at the second stage, they decide whether the circumstances allow for a price change. In section 4 we infer from our results that there seem to be impediments to price adjustments at both

[22] There is one additional explanation among our best performers, namely the kinked demand curve, which was just considered by Apel et al. (2001).

[23] A test for association clearly points out (at the 5% significance level) that firms dealing mainly with consumers and retailers prefer the theory of pricing points much more than the other firms.

stages. However, we were not able to pinpoint which obstacles are regarded as more relevant by the respondents. The explanation for price stickiness ranking sixth in Table 5 and labeled information costs might help answer this question. This theory focuses on the costs associated with gathering information relevant for pricing decisions. In short, this theory deals with the reviewing (first) stage of our two-stage approach. Obviously, these costs exist as more than 12% of the firms regard these costs as relevant (see table 5, column 5). However, as information costs just rank in the "tier two" group of theories, the majority of the firms regard other impediments as more important.[24] Thus, our results indicate that the main obstacles to adjusting prices to their optimal level (implicit and explicit contracts) are associated with the second stage of price setting and are related to the wariness of the firms to change prices in order not to jeopardize the relationships with their regular customers.

4.3 More about Price Stickiness

In addition to the questions about theories explaining price stickiness in the upward direction, we also investigate the reasons for downward price stickiness. We posed two separate questions (B8a and B8b) according to the direction of the price change for all but four theories. One exception is the implicit contract theory, which is just related to price increases (B9b). Furthermore, we explained the idea of the kinked demand curve in one question (B9a) as it is related to price increases and decreases at the same time. The question on information costs is related to price reviews in general rather than changes, thus we packed it into one question as well (B9c). Finally, the theory of quality signals is only relevant for price decreases (B8b).[25] The other seven theories were dealt with in two separate questions.

The ranking of the theories is surprisingly similar regardless of the direction of the price change. Also in the case of downward rigidity, we find implicit contracts ahead of explicit contracts ranking first and second, respectively. The top group comprises exactly the same theories, all receiving mean scores well above two. Within the "tier two" group the rankings changed only slightly. The similarity of the ranking is also confirmed by the rank correlation coefficient, which is 0.88. (For detailed results about the theories' ranking in the case of downward rigidity see table A9 in Appendix A.)

[24] The theory of information costs was also considered by Apel et al. (2001), Aucremanne and Druant (2004) and Martins (2004). There, the degree of recognition was very low as well, and it ranked last in the Swedish and the Portuguese case and took the penultimate rank in the Belgian results.

[25] This explains why table 5 does not contain results about quality signals.

Table 6: Rank Correlations of Motives for Upward Price Stickiness by Sector

	Consumer durables	Intermediate goods	Capital goods	Services
Consumer non-durables	0.82	0.79	0.76	0.79
Consumer durables	–	0.93	0.94	0.96
Intermediate goods	–	–	0.87	0.90
Capital goods	–	–	–	0.94

Apart from the direction of the price change, we want to investigate whether the rankings of the eleven theories vary across industrial sectors (see table A10).[26] In all sectors the theory about implicit contracts ranks first or second and that about explicit contracts ranks first, second or third. Furthermore, the top group (top five theories) comprises the same theories in all sectors. In short, the main message is the same for all industrial groupings. Table 6, which displays the rank correlation coefficients between the five main industrial groupings, supports the above conclusion that the rankings are indeed very similar. The correlation coefficients vary between 0.76 and 0.96 and are generally at a high level.

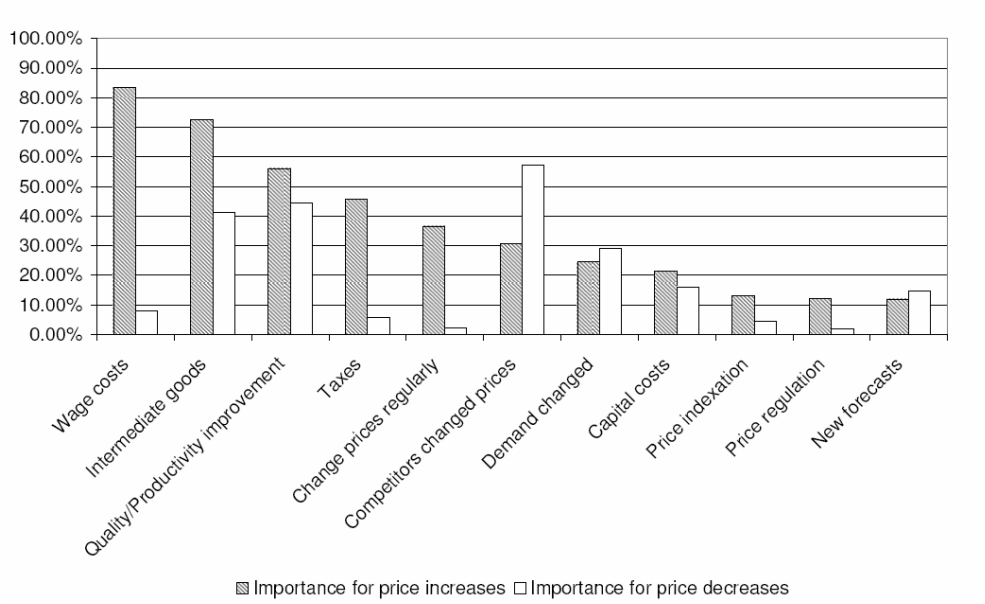
5. Price Adjustments

5.1 What Is Driving Price Changes?

This section deals with price adjustments, shedding light on the questions about what drives prices, how prices respond to different kinds of shocks and the length of these time lags. Regarding the first question about the driving forces of price changes, the respondents were given a list of potential factors and were asked "Which of the factors were relevant for price increases/decreases of your main product in recent years?" (Question B11a for increases and B11b for decreases). As with other questions, the respondents could indicate the importance ((4) very important, (3) important, (2) not important and (1) completely unimportant) of a single factor. Chart 1 summarizes the results and gives the percentage of respondents indicating that a factor was important (4 and 3) in their pricing decision.

[26] As the results are very similar for upward and downward price rigidity, we report just the findings with regard to impediments to price increases.

Chart 1: Importance of Factors Driving Prices Upwards and Downwards



83% and 70% of the respondents report that wage costs and costs of intermediate goods, respectively, were important driving forces to raise prices. By contrast, the two most important reasons for price decreases were changes in competitors' prices (57%) and the improvement in productivity (44%). As shown in chart 1, for most of the factors the proportion of respondents indicating that this factor is important for their pricing decision is higher for price increases than for price decreases. However, there are three exceptions that are more relevant for price decreases than for increases: A change in the competitor's price is far more important for a decision to decrease prices than to increase them, whereas a change in the demand conditions and in forecasts are slightly more important for downward than for upward revisions. Thus, the results suggest that price increases and decreases are driven by different factors. While mainly cost factors drive prices up, mainly market factors are responsible for price reductions. We share this finding with Fabiani et al. (2004a), who find the same pattern of asymmetries for nearly all euro area countries covered by their work.

5.2 Time Lag of Price Reactions

In order to investigate the issue of price stickiness further, we analyze the time lag of price adjustments. Thus, we included Question B10 "If the demand for your main product rises slightly, how much time passes before you change prices?" We

asked eight questions along these lines in order to distinguish between large and small, positive and negative as well as cost and demand shocks.[27] First, the firms were asked to indicate whether they change prices in reaction to shocks or not. If they change prices in reaction to a specific shock, they were then requested to give us the number of months elapsing before the price change is executed.

The results are summarized in table 7, which shows in the first column the fraction of firms holding their prices constant in response to a shock. Furthermore, the second column gives the mean of the number of months that elapse between the occurrence of the shock and the price reaction.

Table 7: Price Reactions after Shocks

Type of shock	(1) Fraction of firms holding the price constant	(2) Mean lag of price reaction	(3) Blinder's mean lag
Small positive demand shock	82%	6.1	
Large positive demand shock	63%	4.6	2.9
Small negative demand shock	82%	4.6	
Large negative demand shock	52%	3.6	2.9
Small cost-push shock	38%	4.8	
Large cost-push shock	8%	3.8	2.8
Small decreasing cost shock	71%	4.8	
Large decreasing cost shock	38%	4.2	3.3

The average time lag of price reactions after shocks is four to six months. The answers range from a price adjustment within the same month to a time span of 24 months. The distribution is thus skewed to the right and the median firm waits for three to four months until it changes its price.[28] An adjustment process of one to two periods in macro models for Austria using quarterly data seems to be justified on the ground of our results. A comparison with the results from Blinder et al. (1998) – which are shown in column three in Table 7 – indicates that the mean lag with which Austrian firms react to shocks seems to be slightly longer than that of U.S. firms. Blinder's survey reveals that the average time lag is approximately three months.

[27] We did not, however, distinguish between temporary and permanent shocks.

[28] In reaction to a small positive demand shock the median firm's response time is four months. For all other shocks the time lag is three months.

We draw the following conclusions, which are all statistically significant at the 5% level (the results of all the tests are shown in the tables A11 to A16 in Appendix A):

- Comparing small and large shocks (pair wise according to the direction and the source of the shock), table 7 reveals that more firms change their prices in reaction to large shocks than to small shocks. Moreover, the firms react more quickly to large than to small shocks.
- In the case of large demand shocks, we find evidence that more firms adjust their prices in response to a drop in demand than to an increase in demand. We did not ask explicitly whether firms adjust their prices upwards or downwards. However, we assume that firms reduce their prices in response to shrinking demand and increase the prices in response to boosted demand. The answers to question B13, where we investigate how firms react to demand shocks (e.g. with price or with output changes), justify this assumption as not one single firm indicated that it would increase prices in the face of falling demand. Thus, we conclude that prices are on average more flexible downwards than upwards in the face of large demand shocks.
- With regard to cost shocks, the opposite is true. In the case of cost shocks (regardless of the size), more firms react to a cost-push shock than to decreasing costs. Moreover, these firms react more quickly to an upward cost shock than to a downward shock. Thus, the results indicate that prices seem to be more flexible upwards than downwards in the face of cost shocks. We share this conclusion with Blinder et al. (1998), who find that price decreases come at a half-month longer lag than price increases.
- Finally, we observe that significantly more firms react to cost shocks than to demand shocks (regardless of the size and the sign of the shock).

To conclude, our results partly contradict the commonly held belief that prices adjust more rapidly upward than downward. In fact, the degree and direction of price rigidity seems to depend on the source of the shock. In the face of significant demand shocks, prices are more sticky upwards, while they are more sticky downwards in the face of significant cost shocks. Moreover, prices are on average more rigid in response to shifts in demand than to cost shocks.

5.3 Factors Explaining Price Reactions after Shocks

In this section probit regressions are estimated to gain some additional insights on how firms react to shocks and thus on the sources of price stickiness in Austria. In particular, we try to link the reaction of firms to demand and cost shocks to various firm characteristics and answers from the questionnaire.

The dependent variable in our regressions records whether a firm has indicated in the survey that it reacts to shocks by adjusting prices or not (as described in section 2). We analyze the reaction of firms in our sample to positive and negative

demand as well as cost shocks. Moreover, we also distinguish between small and large shocks. The different types of shocks will be dealt with separately in our analysis.

For all the estimations carried out in this section, the dependent variable y_i can take on two values. Let y_i be equal to unity if a firm has indicated that it changes its price in response to a given shock, and zero otherwise. For this type of dependent variable, a probit model represents an appropriate framework. In general, the model can be written as

$$P(y_i = 1) = \Phi(x_i \beta) \tag{1}$$

where β is a vector of coefficients, x_i is a vector of explanatory variables and $\Phi(\cdot)$ denotes the cumulative normal distribution function.

Following Small and Yates (1999), we start by including proxies for the overall degree of competitiveness, such as the market share of the firm and the number of competitors, as explanatory variables. We also include a variable that indicates the shape of the marginal cost curve since a flat marginal cost curve can be an explanation for constant prices in response to demand shocks if we assume constant mark-ups. Since the relationship between firms and customers might be important, we include the percentages of sales to regular customers and to consumers. Customers may incur search and information costs to make optimal purchases, and these costs might in turn influence the price-setting behavior of producers. Moreover, costumer relationships may be more important when dealing with consumers as opposed to other firms (or the government).

Pricing to market has also been emphasized as a potential source of price stickiness. If firms are active in foreign markets, they may price to market, that is, set a price that reflects foreign market conditions.

The variables are constructed as follows: For market share we construct a dummy variable ($market$) that takes on the value unity if the market share of the main product is above 30%, and zero otherwise.

The number of competitors ($comp$) is also a dummy that takes on the value unity if a firm has at least five competitors, and zero otherwise. The slope of the marginal cost curve is captured by the dummy mc that takes on the value unity if the firm has indicated that it faces constant marginal costs in question B5 of the questionnaire, and zero otherwise.

Furthermore, we include the fraction of sales achieved through regular customers ($regular$) and the percentage of sales that is generated by selling directly to consumers (con).

We also explore whether the probability of a price change is influenced by explicit contracts and menu costs. For this purpose, we create the dummy variable

explicit that takes on the value unity if firms make arrangements that guarantee a specific price for a certain period of time. Similarly, *menu* is a dummy that indicates whether respondents rated menu costs as applicable or higher (grades three or four) for preventing price increases and price reductions. In addition, we include the variable *export*, which is the share of turnover of the main product generated outside of Austria.

Finally, we include a set of dummies to capture industry and firm size effects. Firm size is continuous and measured by the number of employees, *emp*. The dummy variable *service* takes on the value unity for firms in the service sector, and zero otherwise.

Table 8 shows the results for large demand shocks. From the included proxies for the overall degree of competitiveness, only the number of competitors turns out to be significantly different from zero. It appears that firms having at least five competitors are more likely to adjust prices in reaction to large demand shocks regardless of the sign of the shock. We also find that firms with a large fraction of regular customers are less likely to adjust their prices, whereas firms with a large export share are characterized by a higher probability of reacting to large demand shocks.

In the case of small shocks to demand, the picture is somewhat different as can be seen in table 9. The fraction of regular customers is still highly significant and negative for both decreases and increases in demand. However, for small negative demand shocks, sales to consumers and the shape of the marginal cost curve are also significantly and negatively related to the probability of a price adjustment. Hence, we find some evidence in favor of asymmetries in the reaction to positive and negative demand shocks.

Table 8: Results from Probit Regressions with the Price Reaction to Large Demand Shocks as Dependent Variable

	y = 1 if firms react to a large increase in demand				y = 1 if firms react to a large decrease in demand			
Variable	Coef.		St. Err.	p-val	Coef.		St. Err.	p-val
market	-0.3396		0.2151	0.12	-0.0027		0.2179	0.99
comp	0.4472	**	0.2025	0.03	0.5658	***	0.2076	0.01
mc	0.0028		0.1687	0.99	0.0921		0.1725	0.59
con	-0.0017		0.0035	0.64	0.0017		0.0043	0.69
regular	-0.0120	***	0.0043	0.01	-0.0196	***	0.0051	0.00
export	0.0066	***	0.0027	0.01	0.0052	*	0.0028	0.06
explicit	0.2216		0.2024	0.27	0.0660		0.2085	0.75
menu	-0.1871		0.3046	0.54	-0.1246		0.2876	0.67
service	0.0123		0.1670	0.94	-0.1867		0.1726	0.28
emp	-0.0001		0.0004	0.73	0.0001		0.0004	0.77
constant	0.1675		0.4498	0.71	1.0596	**	0.4974	0.03
Obs	476				434			
F (10,466)	2.95				3.05			
Prob > F	0.0013				0.0009			

Notes to Table 8: ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Table 9: Results from Probit Regressions with the Price Reaction to Small Demand Shocks as Dependent Variable

	y = 1 if firms react to a small increase in demand				y = 1 if firms react to a small decrease in demand			
Variable	Coef.		St. Err.	p-val	Coef.		St. Err.	p-val
market	0.0787		0.2514	0.75	0.0331		0.2417	0.89
comp	0.4117		0.2541	0.11	0.1616		0.2174	0.46
mc	–0.1534		0.1870	0.41	–0.4064	**	0.1857	0.03
con	–0.0061		0.0042	0.14	–0.0080	**	0.0036	0.03
regular	–0.0144	***	0.0046	0.00	–0.0168	***	0.0042	0.00
export	0.0029		0.0031	0.35	–0.0016		0.0028	0.55
explicit	–0.1224		0.2181	0.58	0.1284		0.2151	0.55
menu	–0.1832		0.2959	0.54	0.0317		0.3199	0.92
service	–0.0373		0.1882	0.84	–0.0853		0.1807	0.64
emp	–0.0001		0.0004	0.69	–0.0001		0.0004	0.86
constant	0.0120		0.4945	0.98	0.5999		0.4330	0.17
Obs	490				498			
F (10,466)	1.75				2.50			
Prob > F	0.0679				0.0061			

Notes to table 9: $^{***(**)[*]}$ *stands for significant at the 1% (5%) [10%] level.*

Next, Tables 10 and 11 show the results for cost shocks. For increases in costs, none of our explanatory variables turns out to be different from zero at conventional significance levels. For decreases in costs, however, we find that firms in the service sector are more likely to react by changing prices. Moreover, in case of large decreases in costs, firms with a high share of sales to consumers are more likely to adjust their prices.

As a robustness check we have repeated all our calculations with an alternative definition of the dependent variable. In particular, we have defined $y_i = 1$ if the firm has indicated that it changes its price within a period of three months after the shock, and $y_i = 0$ otherwise. Moreover, we have estimated different versions of our regressions, which include only one indicator of the overall degree of competitiveness, that is, either *market* or *comp*. However, our results are robust to these modifications.[29]

[29]Detailed results are available upon request.

Table 10: Results from Probit Regressions with the Price Reaction to Small Cost Shocks as Dependent Variable

	y = 1 if firms react to a slight increase in costs				y = 1 if firms react to a slight decrease in costs			
Variable	Coef.		St. Err.	p-val	Coef.		St. Err.	p-val
market	–0.0151		0.2050	0.94	–0.1395		0.2238	0.53
comp	–0.0792		0.1979	0.69	0.0892		0.2278	0.70
mc	–0.1921		0.1681	0.25	0.2597		0.1767	0.14
con	–0.0034		0.0037	0.37	0.0022		0.0045	0.63
regular	–0.0045		0.0041	0.27	0.0048		0.0048	0.32
export	0.0013		0.0025	0.62	0.0007		0.0028	0.80
explicit	0.2213		0.1968	0.26	0.0433		0.1903	0.82
menu	–0.3542		0.2718	0.19	–0.0125		0.2651	0.96
service	0.1155		0.1670	0.49	1.3304	***	0.1785	0.00
emp	–0.0004		0.0003	0.29	–0.0005		0.0004	0.20
constant	0.7798	*	0.4265	0.07	–1.0175	**	0.4878	0.04
Obs	487				502			
F (10,466)	0.76				7.80			
Prob > F	0.6721				0.0000			

Notes to table 10: ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Table 11: Results from Probit Regressions with the Price Reaction to Large Cost Shocks as Dependent Variable

	y = 1 if firms react to a marked increase in costs				y = 1 if firms react to a marked decrease in costs			
Variable	Coef.		St. Err.	p-val	Coef.		St. Err.	p-val
market	–0.0525		0.2100	0.80	–0.3566		0.2228	0.11
comp	0.3405		0.2261	0.13	0.1586		0.2096	0.45
mc	–0.2853		0.2913	0.33	–0.0518		0.1879	0.78
con	0.0055		0.0048	0.25	0.0114	**	0.0037	0.00
regular	0.0044		0.0039	0.26	0.0098		0.0047	0.03
export	–0.0020		0.0036	0.58	–0.0023		0.0027	0.40
explicit	–0.3227		0.3113	0.30	0.1654		0.2339	0.48
menu	–0.4677		0.3420	0.17	–0.3212		0.3173	0.31
service	0.3175		0.2935	0.28	0.7369	***	0.1952	0.00
emp	0.0001		0.0004	0.84	0.0001		0.0003	0.65
constant	1.2206	**	0.3934	0.00	–0.4474		0.4611	0.33
Obs	491				476			
F (10,466)	3.07				4.74			
Prob > F	0.0009				0.0000			

Notes to table 11: $^{***(**)[*]}$ *stands for significant at the 1% (5%) [10%] level.*

In short, we find that in case of demand shocks, a high share of regular customers decreases the probability of a price change. This is true regardless of the size and the sign of the shocks, which makes it the most robust finding of our analysis. Since implicit contracts are likely to play an important role when firms deal with regular customers, this outcome is also consistent with the findings reported in section 4 indicating that implicit contracts are a key explanation for price stickiness in our sample. In case of large demand shocks, a higher number of competitors increases the probability of a price adjustment. Furthermore, firms with a higher share of exports are more likely to change their price in response to big demand shocks. In the case of cost-push shocks, there is no statistical evidence for any difference in the pricing behavior across the firms in our sample. This suggests that a rise in costs triggers a similar response by all firms in the economy. Note that this is in line with the result that 92% of all firms adjust their prices in response to a large cost-push shock as reported in table 7. For a decrease in costs, we find that the service sector is more likely to react with a price adjustment.

Note, however, that our results should be interpreted with some caution since the fit of our equations and the statistical levels of significance are not always satisfactory. This is particularly true for cost shocks.

6. Summary

We find evidence that the firms in our sample follow time-dependent as well as state-dependent pricing strategies. Under normal circumstances around 70% of the firms apply time-dependent pricing. However, in the face of major shocks almost half of the firms deviate from this strategy and set their prices according to the state of the economy. Comparing this share with evidence from other countries suggests that the share of firms following state-dependent pricing rules in response to large shocks (56%) is relatively small in Austria, which suggests that real effects of monetary policy should (ceteris paribus) be stronger.

Furthermore, our results suggest that price setting takes place at two stages. First, firms review their prices to check whether they are at the optimal level or they need to be changed. Second, if firms find out that the price deviates from its optimal level, they need to decide whether to change the price or not. We find evidence that there are obstacles to price adjustments at both stages. However, the contest of the theories about price stickiness reveals that the main obstacles to price adjustment seem to lie at the second stage of price setting. In contrast to the suggestion of Ball (1994), informational costs, which are important at the reviewing stage of price setting, do not seem to be among the most important obstacles to price changes. The fear that a price adjustment could jeopardize customer relationships (expressed in the theories on implicit and explicit contracts) seems to be a much more important explanation for sticky prices. The implicit contract theory, which was heavily recognized by our respondents, suggests that customers regard price adjustments in response to cost shocks as fairer than price adjustments in response to demand shocks. This finding ties in with Rotemberg (2002), who also argues that fairness is an important driving force in customers' decisions.

Finally, we investigate the reaction of prices to (cost and demand) shocks. The average time lag between a shock and the price adjustment is four to six months. Furthermore, we observe that firms react asymmetrically to cost and demand shocks. Prices are more sticky downwards than upwards in the face of cost shocks as more firms react more quickly to cost-push shocks than to decreasing cost shocks. In the case of large demand shocks, however, the opposite is true. Prices are more sticky upwards than downwards, because more firms react to receding demand than to increasing demand. If we interpret a monetary shock as a demand shock, it follows that monetary policy has an asymmetric impact on the Austrian economy. The price reaction after a significant contractive monetary policy shock should thus be more pronounced than after a significant expansionary monetary

policy shock. Note, however, that although the number of firms reacting to a demand shock with a price adjustment differs significantly with respect to the direction of the shock, this does not necessarily mean that this translates into a meaningful difference in economic terms as well. It could be that the differences we observe in our sample are too small in order to matter economically.

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Appendix: Tables and Charts

Table A1: Post-Stratification Weights and Response Rates

Strata			Population		Respondents		Weights	Response rate
h	Sector	Size	Z_h	$(Z_h/Z)*100$	z_h^r	$(z_h^r/z_r)*100$	w_h	$(n_h^r/n_h^g)*100$
1	Food and beverages (15)	1	41,749	5.01	1,711	1.29	1.149	45.9
2		2	28,346	3.40	6,583	4.96	0.203	33.9
3	Textiles, leather (17-19)	1	13,391	1.61	1,019	0.77	0.619	29.9
4		2	19,403	2.33	5,619	4.23	0.163	33.3
5	Wood products (20)	1	18,632	2.24	1,656	1.25	0.530	47.9
6		2	13,863	1.66	2,506	1.89	0.261	23.3
7	Paper products (21-22)	1	18,978	2.28	678	0.51	1.318	21.3
8		2	20,433	2.45	8,758	6.60	0.110	39.3
9	Coke, chemicals (23-25)	1	16,544	1.99	966	0.73	0.807	33.7
10		2	35,425	4.25	10,034	7.56	0.166	34.0
11	Mineral products (26)	1	11,655	1.40	1,352	1.02	0.406	46.6
12		2	15,144	1.82	4,938	3.72	0.144	33.3
13	Metal products (27)	1	3,543	0.43	358	0.27	0.466	42.1
14		2	27,358	3.28	9,957	7.50	0.129	47.8
15	Fabricated metal (28)	1	36,982	4.44	1,819	1.37	0.958	35.4
16		2	29,644	3.56	9,894	7.45	0.141	34.1
17	Machinery (29)	1	21,810	2.62	1,369	1.03	0.750	30.7
18		2	36,578	4.39	20,063	15.11	0.086	39.8
19	Machinery equipment (30-33)	1	16,683	2.00	1,151	0.87	0.683	41.2
20		2	41,550	4.99	8,727	6.57	0.224	36.2
21	Vehicles (34-35)	1	4,001	0.48	75	0.06	2.513	18.8
22		2	14,868	1.78	18,874	14.22	0.037	48.5
23	Manufacturing (36)	1	25,090	3.01	1,085	0.82	1.089	44.4
24		2	13,372	1.60	5,696	4.29	0.111	50.0

Notes to Table A1 see next page.

Table A1 continued: Post-Stratification Weights and Response Rates

Strata			Population		Respondents		Weights	Response rate
h	Sector	Size	Z_h	$(Z_h/Z)*100$	z_h^r	$(z_h^r/z_r)*100$	w_h	$(n_h^r/n_h^g)*100$
25	Transport (60,63)	1	63,696	7.64	906	0.68	3.311	32.9
26		2	24,370	2.92	695	0.52	1.651	35.7
27	Real estate, renting, etc (70-73)	1	30,682	3.68	739	0.56	1.955	27.4
28		2	11,515	1.38	1,337	1.01	0.406	38.1
29	Business activities (74)	1	117,488	14.10	2,185	1.65	2.532	36.8
30		2	54,767	6.57	1,751	1.32	1.473	14.8
31	Sewage and refuse (90)	1	4,345	0.52	149	0.11	1.373	18.9
32		2	1,307	0.16	110	0.08	0.560	33.3
			Z		z_r			
	Total		833,210	100.00	132,760	100.00	26.3	*36.0*

Notes to Table A1: Source: Social security accounts, WIFO BCS and PSB Survey. Sectors: NACE 2-digit sectors (or the sum of them). Size 1: Firms with less than 100 employees. Size 2: Firms with 100 or more employees.

Z_h number of employees in the population in stratum h, Z number of employees in the population, z_h^r number of employees of the responding firms in stratum h, z^r number of employees of the responding firms.

$w_h = \frac{Z_h/Z}{z_h^r/z_h}\rho$ is the post-stratification weight for stratum h, with $\rho = 3.38$ being a constant re-scaling factor to assure that the total number of firms after post-stratification equals $N = 873$, the total number of respondents.

n_h^r number of firms that responded in stratum h, n_g^h number of firms in the gross sample in stratum h.

Table A2: Question A3: What Share of Your Turnover Is Generated in Austria?

	Frequency	%
0%	9.93	1.44
1% – 19%	33.96	4.91
20% – 39%	38.23	5.53
40% – 59%	55.19	7.99
60% – 79%	66.73	9.66
80% – 99%	232.94	33.71
100 %	254.02	36.76
	691.00	100.00

Table A3: Question A4: What Percentage of Sales Do You Generate by Selling Your Main Product to...?

	Frequency	Percent
wholesalers	67.77	9.74
retailers	29.19	4.19
within group	32.80	4.71
other companies	381.09	54.75
government	35.05	5.04
consumers	51.89	7.46
no main customer	77.30	11.11
others	20.91	3.00
	696.00	100.00

Notes to table A3: The main customer is defined as generating more than 50% of the sales of the company.

Table A4: Question A6: How Many Competitors Do You Have for Your Main Product on Its Most Important Market?

	Frequency	Percent
none	10.46	1.47
fewer than 5	114.14	16.03
between 5 and 20	286.39	40.22
more than 20	301.01	42.28
	712.00	100.00

Table A5: Question A8: What Percentage of Sales Do You Achieve through Regular Customers?

	Frequency	Percent
0% – 20%	14.98	2.13
21% – 40%	24.99	3.56
41% – 60%	52.38	7.45
61% – 80%	254.57	36.21
81% – 100%	356.08	50.65
	703.00	100.00

Table A6: Macroeconomic Indicators for Austria 1999 to 2003

	1999	2000	2001	2002	2003
	Annual changes in%				
Gross domestic product	3.3	3.4	0.7	1.2	0.8
Consumer price index	0.6	2.3	2.7	1.8	1.3
Real wages per capita	1.0	1.0	–0.8	1.0	0.5
Unemployment rate (in %)	4.0	3.7	3.6	4.2	4.3
Fiscal balance (in % of GDP)	–2.2	–1.5	0.3	–0.2	–1.1

Notes to table A6: Source: WIFO Database.

Table A7: Frequency of Price Changes in Different Sectors (in %)

Number of price changes per year	0	1	2–3	4–11	12–49	50–
Total	22.1	54.2	13.9	7.7	1.2	0.9
Consumer non-durables	5.9	71.7	17.4	1.8	0.0	3.2
Consumer durables	0.6	75.5	23.9	0.0	0.0	0.0
Intermediate goods	4.1	55.1	24.9	14.1	0.4	1.4
Capital goods	6.4	53.8	25.3	8.7	2.9	2.9
Services	35.3	48.3	7.3	7.6	1.5	0.0

Table A8: Frequency of Price Reviews in Different Sectors (in %)

Frequency of price reviews	daily	weekly	monthly	quarterly	half-yearly	yearly	less frequently
Total	1.6	3.9	22.2	28.4	17.5	25.5	0.9
Consumer non-durables	0.6	7.9	14.9	27.7	18.5	30.4	0.0
Consumer durables	0.0	0.0	0.8	73.0	1.6	24.6	0.0
Intermediate goods	2.8	3.7	37.5	21.0	15.7	19.3	0.0
Capital goods	6.1	3.9	39.0	33.4	6.6	11.0	0.0
Services	1.0	3.6	18.4	26.3	20.7	28.5	1.5

Table A9: Relevance of the Theories Explaining Downward Price Stickiness

Table A9: Relevance of the theories explaining downward price stickiness

		(1) Mean	(2) SE	(3) t-Stat	(4) H_O	(5) Consent	(6) Blinder	(7) Fabiani	(8) Apel	(9) Hall
1	Implicit contracts	3.04	0.05	1.78	*	77.37%	4	1	1	5
2	Explicit contracts	2.94	0.06	2.92	***	70.53%	5	2	3	1
3	Kinked demand curve	2.69	0.05	2.60	***	62.77%	-	-	4	-
4	Cost-based pricing	2.49	0.06	4.60	***	57.27%	2	3	2	2
5	Coordination failure	2.13	0.06	1.68	*	35.68%	1	4	-	3
6	Non-price competition	1.98	0.07	0.87		33.50%	3	7	-	8
7	Quality signal	1.88	0.06	2.94	***	23.42%	12	6	-	10
8	Price readjustments	1.70	0.06	1.15		21.33%	-	5	-	-
9	Information costs	1.61	0.04	2.04	**	12.21%	-	9	13	-
10	Menu costs	1.52	0.06	4.91	***	13.32%	6	8	11	11
11	Pricing points	1.24	0.03	-		5.27%	8	10	7	4

Notes to Table A9: ***(**)[*] stands for significant at the 1% (5%) [10%] level. The null hypothesis referred to in column 4 is that the theory's mean score (given in column 1) is equal to the score of the theory ranked just below it.

Table A10: Differences in the Theories' Ranking According to the Sectors the Firms Operate in

	Total	Consumer non-durables	Consumer durables	Intermediate goods	Capital goods	Services
Implicit contracts	1	1	2	2	2	1
Explicit contracts	2	2	1	1	3	2
Cost-based pricing	3	4	3	3	1	4
Kinked demand curve	4	5	4	4	4	3
Coordination failure	5	3	5	5	5	5
Information costs	6	7	6	7	6	6
Menu costs	7	8	7	8	8	8
Non-price competition	8	10	8	9	7	7
Price readjustments	9	9	9	6	9	9
Pricing points	10	6	10	10	10	10
Quality signal	–	–	–	–	–	–

Table A11: Comparison between Small and Large Shocks with Respect to the Fraction of Firms Holding the Price Constant

Type of shock	Fraction of firms holding the price constant	t-statistics	
Small positive demand shock	82%	7.52	***
Large positive demand shock	63%		
Small negative demand shock	82%	11.05	***
Large negative demand shock	52%		
Small cost-push shock	38%	10.09	***
Large cost-push shock	8%		
Small decreasing cost shock	71%	8.77	***
Large decreasing cost shock	38%		

Notes to Table A11: Ho = No difference between the fractions with respect to large and small shocks. ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Table A12: Comparison between Small and Large Shocks with Respect to the Mean Lag

Type of shock	Mean lag	t-statistics	
Small positive demand shock	6.1	5.22	***
Large positive demand shock	4.6		
Small negative demand shock	4.6	4.50	***
Large negative demand shock	3.6		
Small cost-push shock	4.8	5.86	***
Large cost-push shock	3.8		
Small decreasing cost shock	4.8	4.15	***
Large decreasing cost shock	4.2		

Notes to Table A12: Ho = No difference between the means with respect to large and small shocks. ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Table A13: Comparison between Positive and Negative Shocks with Respect to the Fraction of Firms Holding the Price Constant

Type of shock	Fraction of firms holding the price constant	t-statistics	
Small positive demand shock	82%		
Small negative demand shock	82%	0.00	
Large positive demand shock	63%		
Large negative demand shock	52%	3.79	***
Small cost-push shock	38%		
Small decreasing cost shock	71%	–9.98	***
Large cost-push shock	8%		
Large decreasing cost shock	38%	–9.39	***

Notes to Table A13: Ho = No difference between the fractions with respect to positive and negative shocks. ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Table A14: Comparison between Positive and Negative Shocks with Respect to the Mean Lag

Type of shock	Mean lag	t-statistics	
Small positive demand shock	6.1		
Small negative demand shock	4.6	–1.48	
Large positive demand shock	4.6		
Large negative demand shock	3.6	0.61	
Small cost-push shock	4.8		
Small decreasing cost shock	4.8	–2.40	**(1)
Large cost-push shock	3.8		
Large decreasing cost shock	4.2	–5.05	***

Notes to Table A14: Ho = No difference between the means with respect to positive and negative shocks. ***(**)[*] *stands for significant at the 1% (5%) [10%] level. (1) The mean lags reported in this table are averages over the whole sample. The t-tests, however, only take those firms into account that have answered both questions. Thus, the means used for the t-test can deviate from the means reported in the table.*

Table A15: Comparison between Cost and Demand Shocks with Respect to the Fraction of Firms Holding the Price Constant

Type of shock	Fraction of firms holding the price constant	t-statistics	
Small positive demand shock	82%	15.93	***
Small cost-push shock	38%		
Small negative demand shock	82%	4.03	***
Small decreasing cost shock	71%		
Large positive demand shock	63%	16.58	***
Large cost-push shock	8%		
Large negative demand shock	52%	4.06	***
Large decreasing cost shock	38%		

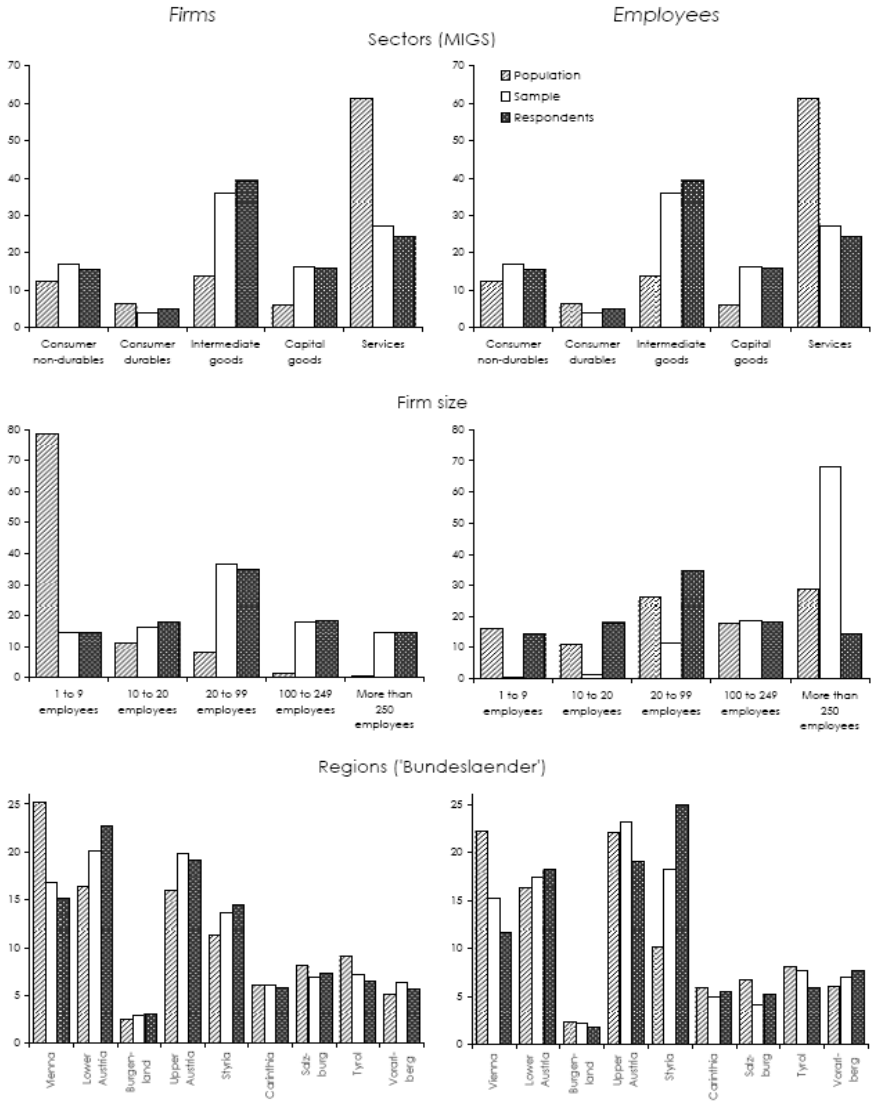
Notes to Table A15: Ho = No difference between the fractions with respect to cost and demand shocks. ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Table A16: Comparison between Cost and Demand Shocks with Respect to the Mean Lag

Type of shock	Mean lag	t-statistics	
Small positive demand shock	6.1	1.25	
Small cost-push shock	4.8		
Small negative demand shock	4.6	–0.67	
Small decreasing cost shock	4.8		
Large positive demand shock	4.6	4.39	***
Large cost-push shock	3.8		
Large negative demand shock	3.6	–2.08	**
Large decreasing cost shock	4.2		

Notes to Table A16: Ho = No difference between the means with respect to cost and demand shocks. ***(**)[*] *stands for significant at the 1% (5%) [10%] level.*

Chart A: Comparison of Population, Sample and Respondent Characteristics



Comment on "Price-Setting Behavior of Austrian Firms: Some Survey Evidence"

Thomas Y. Mathä[1]

Banque centrale du Luxembourg

1. Introduction

This paper reports the findings of a survey on the price-setting behavior of Austrian firms, which was conducted at the beginning of 2004 among over 2,400 Austrian firms. It is part of a wider initiative that aims to analyze the price rigidities and the degree of inflation persistence in the Eurosystem. In this respect, surveys constitute a research methodology only recently exploited for the analysis of price rigidities. Blinder et al. (1998) pioneered using surveys to obtain information of firms' price setting practices and the reasons for price stickiness in particular. Surveys have been conducted for firms in Canada, Japan, Sweden and the U.K. since – now also including Austria and several other Eurosystem countries. Surveys help to improve our understanding of the underlying sources and characteristics of the frictions firms encounter when setting prices. Importantly, surveys go beyond the simple quantification of existing price rigidities and provide new important insights at the much desired micro or firm level, thereby helping to improve our understanding of the wider monetary transmission process, an area of key interest for central banks.

However, surveys do not come without problems. There is always a sampling issue. Furthermore, the answers may be sensitive to the way questions are posed. The sincerity of the respondent's answers is unknown, or worse, the answers may not make sense as contradicting answers are given. Firms are normally given a list of predefined answers to choose from. However, these lists may neglect the most important answer for individual firms. Hence, scrutiny needs to be applied at every stage of the survey.

[1] Banque centrale du Luxembourg, Monetary, Economics & Statistics Department, 2, Bd Royal, L-2983 Luxembourg, Luxembourg, E-mail: Thomas.Mathae@bcl.lu. The views expressed in this paper are personal views of the authors and do not necessarily reflect those of the Banque centrale du Luxembourg or the Eurosystem.

2. The Austrian Survey

The survey by Kwapil, Baumgartner and Scharler discloses hitherto unknown and hidden characteristics of Austrian firms in general and their price-setting practices in particular. We learn about price review and price change frequencies, the reasons why firms do not change prices, the factors of relevance for price in/decreases, as well as the speed at which prices are adjusted depending on the direction and sources of shocks. The general survey design, its overall structure, as well as the type of questions asked in the survey are, due to the collaborative effort within the Eurosystem Inflation Persistence Network (IPN), similar to those of other participating NCBs.

However, each participating NCB deliberately designed the survey, such that national characteristics and idiosyncrasies are reflected. Compared to the surveys of other Eurosystem NCBs, the Austrian survey is very detailed in some particular areas of interest. Unlike other surveys, it distinguishes for example between price increases and decreases, small and large economic shocks, and it specifically requests information on price guarantees with clients and the duration thereof. Unfortunately, it only covers industry and industry related services. A broader economic coverage including, construction, services and trade would have been very welcome. The IPN network results show that sizeable sectoral differences in price rigidities exist. For example one of the most robust findings of the IPN network relates to services being different. Services' prices change rarely and even more rarely downwards (e.g. Dhyne et al., 2005).

Overall, the results presented in this paper are comparable with the results reported for other euro area countries (see Fabiani et al., 2005 for a cross-country comparison). Yet explicit comparisons of country results are, while very tempting, a difficult undertaking, as the sectoral composition of the firms surveyed differs substantially from country to country. Without going into quantitative details, the similarities include:

1. that the price setting takes place in two stages – the price reviewing stage and the price-setting stage,
2. that firms use both time- and state-dependent price reviewing practices,
3. that explicit and implicit contracts rank among the most important reasons for price rigidities, and
4. that the adjustment speed of prices depends both on the direction and the source of the shock.

2.1 The Price Setting Takes Place in Two Phases

The prices are first reviewed and then eventually changed. As Kwapil, Baumgartner and Scharler show, Austrian firms tend to review prices more often than they change them. The modal frequency of price reviews is quarterly, while

the modal price change frequency is annual – both results square well with those from other Eurosystem surveys.

One point of interest, extending beyond the actual frequencies, is to what extent these frequencies are governed by existing price frictions and to what extent firms review and change prices at the same frequencies. Put differently under what circumstances would we expect this not to be the case? In addition, what do different price review and price change frequencies imply for the size of price adjustment costs? For example, those firms that review and change prices at different frequencies, do they face higher adjustment costs at the second stage of the price setting than firms that review and change their price at the same frequencies? What would we expect to be the equilibrium outcome? These are intriguing questions waiting to be explored.

2.2 Firms Make Use of Both Time-Dependent and State-Dependent Price-Setting Rules

Kwapil, Baumgartner and Scharler report that 38% of the firms use purely time-dependent pricing rules, 30% use both time- and state-dependent pricing rules while 25% use purely state-dependent pricing rules. In comparison to other euro area countries (see Fabiani et al., 2005), the share of firms using state-dependent rules is lower. The authors conclude from this that the effect of a nominal monetary policy shock on the real economy could be larger in the short run than would be the case if the share of state-dependent firms was higher. This is intuitive as a higher share of state-dependent firms raises the share of firms that can react immediately to economic shocks, unlike time-dependent firms which have to wait their turn.

Nonetheless, I wonder whether this result per se suffices for this conclusion. Firstly, the paper does not compare the price review and price change frequencies of state- and time-dependent firms, which would give an indication of whether there were indeed differences between time- and state-dependent firms. For example, the survey results for Canadian firms show that state-dependent firms changes prices five times more often than time-dependent firms (Amirault et al. (2004). Using a non-negative binominal specification, the price change frequency could be regressed on firm-specific characteristics, such as time- vs. state-dependent price reviewing behavior, some competition measures as well as other firm- and sector-specific controls. As state-dependent firms are not requested to disclose how often they undertook a price review, the price review frequency could only be incorporated as regressor when interacted with a dummy variable indicating that the firm is of the time-dependent type. Such a regression would certainly return results that could be interpreted and would strengthen or weaken the above made argument.

However, even a regression analysis, as is suggested, would not be able to deliver entirely conclusive evidence. State-dependent firms may review and change

their prices infrequently simply because there is/was no economic shock. Not knowing whether or not firms were hit by an economic shock renders the comparison between state-and time dependent firms very difficult. Thus, state-dependent firms may appear very sticky in a very stable business environment, yet very flexible in a volatile environment – difficult to know what the maximum enticed flexibility would be. Lastly, we always assume that the price reviewing process is exogenous to the firm, but this need not be the case. The price review cost may be specific to the firm and may depend on whether the firm adopts a backward- or forward-looking price reviewing behavior. A firm with a high cost price review may find it optimal to review prices only if the economic conditions change, while a firm with a low cost price review may find it optimal to review prices on a regular basis. Moreover, firms may alter their behavior, as the Austrian and other euro area country results show. The Austrian survey results show, 30% of firms demonstrate flexibility in the way they conduct price reviews. They switch from time-dependent behavior to state-dependent behavior in the case of economic shocks.

In a nutshell, I believe that surveys, as they have been undertaken so far, are not well suited to answer the question whether state-dependent or time-dependent firms are more flexible.

3. Reasons for Price Stickiness

A central question in most surveys of the euro area wide research network (including the Austrian survey) is the request of firms to disclose, in a list of various theories, to what extent a particular theory is recognized as important for not changing prices (typically a choice is given ranging from (1) "unimportant" to (4) "very important"). The answers are ranked according to the average score they receive. Implicit and explicit contracts most often figure among the top four theories. However, with an average score of 2.7 and 2.6 for the euro area (see Fabiani et al. 2005), their scores are barely higher than the theoretically expected value of 2.5 of a uniform distribution between (1 and 4). Nevertheless, the existence of im/explicit contracts are judged to highly relevant a reason for price rigidities.

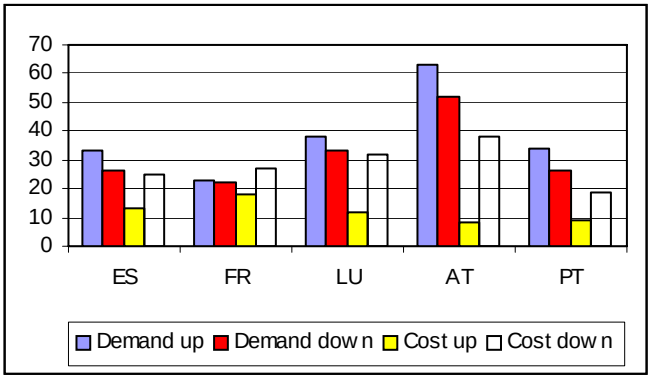
Similarly, the Austrian survey provides a list of reasons for price rigidity and asks firms whether and to what extent they recognize the listed theories as reasons for not changing their prices. In line with the high proportion of regular customers (85%) implicit and explicit contracts are recognized most strongly by firms as reasons for not changing their prices, followed by cost-based pricing, kinked demand curve and coordination failure. Other theories often cited in the academic literature such as menu costs and information costs are in contrast not very well recognized.

Now, it would have been interesting to learn whether these "revealed" impediments can also explain price change frequencies and differences therein. As reported in the paper, the overall price change frequency figures disguise important sectoral variations. Firms in the sectors "consumer durables", "consumer non-durables" and "services" have lower price review and price change frequencies than the firms in the sectors "intermediate goods" and "capital goods". Can these differences, at least in part, be explained by differences in the importance attached to the respective theories? Theoretically, all theories should have a negative influence on the price change frequency. Similarly, the indication whether the firms' clientele is mostly comprised of long-term or short term customers should matter.

4. Double Asymmetry in Price-Setting Behavior

An important finding is what I would refer to as a double asymmetry in the price-setting behavior of firms. The response depends on both the source and the direction of the shock. A result common to some Eurosystem surveys, including the Austrian survey, is that prices react faster to rising costs than to strengthening demand, while the opposite is the case for reverse shocks. Furthermore, prices react faster to rising costs than to weakening demand. Noteworthy from an Austrian perspective is that the share of firms not responding (i.e. not changing prices) to demand shocks is seemingly larger than in the other euro area countries depicted in Figure 1. A possible explanation may be the high or relatively higher importance attached to implicit and explicit contracts and cost based pricing in particular in explaining the price stickiness of Austrian firms than in other euro area countries (see Fabiani et al., (2005)).

Chart : Percentage of Firms Not Changing Prices after Specific Shocks



Source: Fabiani et al. 2005.

Furthermore, asking Austrian firms to disclose the relevance of specific factors for price increases and decreases reveals that wage costs, intermediate goods prices followed by quality improvement and taxes are most important for price increases, while changes in competitors' prices followed by intermediate goods, productivity improvements and weakened demand are most important for price reductions. Noteworthy from the Austrian perspective is the high size of the asymmetry in case of labor costs.

As the authors argue, these results point to an asymmetric monetary policy response – an important contribution of surveys to our understanding of monetary policy.

5. Summing up

As stated in the introduction, surveys are very good means to obtain information that would otherwise not be available. Surveys should been seen as a good complement to the use of quantitative micro data sets in order to get to the roots of price rigidities. The price-setting survey by Kwapil, Baumgartner and Scharler is the first survey of this kind undertaken for Austrian firms.

The survey provides plenty of new material and insights. Too plenty for everything to be exploited in one single research paper. In the follow up papers we might learn more about the competitive environment and the backward versus forward looking behavior of firms. One answer to the observed degree of inflation inertia in the Eurosystem and its member countries may rest in the extent to which firms' price reviewing behavior is backward looking or depends on the usage of rules of thumb or the like – a question the Austrian survey posed, but that hitherto has not exploited. Questions, such as this are relevant, as the popular New Keynesian Phillips Curve model, which emphasizes rational expectations and in its pure form is entirely forward-looking, has difficulties to generate the sluggishness of the price movements observed empirically. In contrast, hybrid versions of the New Keynesian Phillips Curve in include both backward- and forward-looking behavior of firms and do much better in this respect.

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Inflation Persistence in Austria: First Results for Aggregate and Sectoral Price Series

Josef Baumgartner[1]

Austrian Institute of Economic Research

Abstract

Based on univariate AR models, the sum of the AR-parameters is defined as a measure of persistence. As for other OECD countries estimates for a long sample period (almost 40 years) show a very high degree of inflation persistence and the presence of a unit root in the inflation process could not be rejected. We find evidence that 3 structural breaks occurred in the inflation process: in the mid seventies, eighties and nineties. If these structural breaks are taken into account, the persistence measures are dramatically smaller. We further investigate the influence of the data frequency, treatment of seasonality, the estimation methods, and the aggregation level of the CPI on both the evidence of structural breaks and the degree of inflation persistence.

Keywords: Structural breaks, inflation persistence
JEL classification: E31, C22, C11

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1. Introduction and Motivation

Inflation persistence refers to the (possibly sluggish) return of the rate of inflation to its long-run mean after a shock occurred. For central banks this is import to know in order to assess the short-run impact of monetary policy decisions. Given that inflation is a monetary phenomenon in the long-run and a central banks main target is to achieve price stability, the degree of persistence has a strong influence for the conduct of monetary policy: The higher inflation persistence the earlier and the stronger a central bank will react to disturbances to inflation in order to maintain price stability.

Mainly based on evidence for the U.S.A. and some other OECD countries a high degree of inflation persistence has been viewed as a key stylized macroeconomic fact, which micro-founded macroeconomic models should replicate.[2] An alternative view is that the degree of inflation persistence is not an inherent structural property of the inflation process, but depends on structural changes in economic processes and the institutional environment, as e. g. the monetary policy regime changes.[3] Hence, it is not only the level of persistence that is of interest but also whether persistence has changed over time.

Levin and Piger (2004) show that in their sample of 12 OECD countries the apparent high degrees of inflation persistence declined considerably if structural breaks in the mean of inflation are taken into account. Benati (2004) provides evidence for 20 OECD countries and the euro area and concludes that for some countries and/or sample periods inflation persistence is characterized by a significant amount of uncertainty and high inflation persistence is not a robust feature of the data.

For the euro area recently several studies were conducted to investigate the Euro area wide, as well as the individual country properties of inflation persistence.[4] As pointed out in Altissimo et al. (2005), there is a considerable degree of heterogeneity across countries, but also in the results of the different studies for the same country. In table 1 we report these estimates for Austria. As can be seen, the persistence estimates for CPI inflation vary considerably from 0.33 to 1.03, the last number implies that inflation is a unit root process.

This paper addresses the issue of the wide range of the inflation persistence estimates for Austria, and tries to shed some light on the reasons driving this

[2] See e.g. Nelson and Plosser (1982), Fuhrer and Moore (1995), Stock (2001), Pivetta and Reis (2004).

[3] See e.g. Bordo and Schwartz (1999), Sargent (1999), Cogley and Sargent (2001), Erceg and Levin (2003).

[4] See O'Reilly and Whelan (2004), Gadzinski and Orlandi (2004), Lünneman and Mathä (2004), Corvoisier and Mojon (2005), Cecchetti and Debelle (2005).

heterogeneity in the results. In doing so, we apply the common empirical strategy of the studies mentioned in table 1. Thus the dynamic process of inflation is characterized in a time series framework of univariate autoregressive (AR) models and the degree of persistence is measured in terms of the sum of the AR coefficients (φ).[5] In estimating inflation persistence measures we take into account the influence of structural breaks in the mean of inflation on the level of persistence. We emphasize also the treatment of seasonality which is very pronounced in our data set. The application of standard seasonal adjustment procedures may have undesirable properties, which could introduce an upward bias in the persistence estimates (see Ghysels, 1990). Finally, we investigate the influence of the sample length and the frequency at which the data are observed on results of the structural break tests and the persistence estimates.

The remainder of the paper is organized as follows. In section 2 the data set used for the empirical analysis is described. The econometric methods for estimating the structural breaks and persistence measures are the focus of section 3. In sections 4 and 5 we present the estimates for the number and location of structural breaks and the degree of persistence in the inflation series, respectively. In this discussion we highlight the influence of (i) the treatment of seasonality, (ii) the length of the sample, (iii) the data frequency, (iv) the price variables used and (v) the level of aggregation.

2. Data

As the Governing Council of the ECB holds its monetary policy decision meetings every month it would be appropriate to analyze also the dynamic properties of the inflation process at the monthly frequency. However, most of the empirical evidence in the related literature uses quarterly data and monthly inflation observations are extremely volatile, possibly because of measurement errors or temporary factors unrelated to the underlying inflation trends (see charts 1 and, 2 and table 2). Thus, we present most of the results for quarterly and monthly data and highlight differences in the empirical results due to the frequency of the observations.

2.1 Data Sets and Sources

To analyze the (possibly time varying) properties of inflation persistence in Austria, we use inflation data for different observational frequencies and different levels of aggregation for the period 1966 to 2004. As aggregate price series, which are available on a quarterly frequency, we use four series for the sample period

[5] See Rumler (2005) for estimates of New Keynesian Phillips Curve type equations for Austria.

1966:Q1 to 2004:Q4: GDP deflator (PGDP), private consumption deflator (PCP), wholesales price index (WPI) and consumer price index (CPI).

For the sectoral analysis, two different definitions of CPI subaggregate time series are used at the quarterly and monthly frequency. The first classification is based on the 'use'-classification employed by the Statistics Austria before the COICOP system was introduced in 1996. We slightly deviate from this 10-sector classification as we aggregate food and beverages with tobacco to a single category.[6] The CPI data based on the 'use'-classification are available from 1966:M01 to 2004:M12.

Second, for the period 1977:M01 to 2004:M12 as another sectoral breakdown a data set based on a 'main groups' definition is applied. This definition comes as close as possible to the harmonized index of consumer prices (HICP) subaggregates employed by the ECB, but is built on CPI data instead.[7] Monthly price series for the HICP and its 5 main groups are used for the period 1987:M01 to 2004:M12.

Finally, a data set with monthly time series for 234 individual CPI items (the lowest aggregation level of data – i. e. products – published by Statistics Austria) for the sample period 1977:M01 to 2004:M12 was created.[8] As some of this series show either a very erratic or to the contrary very infrequent discrete price changes (as e.g. postal services) we excluded these 'weird series' which left us with 181 time series of individual CPI items.

With the individual item data factitious subaggregates (main groups and use categories) were created for a comparison with the official subaggregates to get an impression of the representativity of the 181-items subsample for the CPI and its subaggregates (see table 3). The representation based the CPI weights represented by the 181 items is at the highest 50% and declining to 32% for the most recent CPI basket. But based on correlations of year-on-year rates of changes of factitious CPI aggregate with the official aggregate CPI the 181-items subsample matches the official data reasonably well, especially for the period before 2001. However, as shown in table 3, based on the main group definition, services products are underrepresented. One has to keep in mind that constructing long enough time

[6] The 9 use-categories are: food, beverages and tobacco (FB), housing (rent and maintenance; HO), electricity and heating (EH), furniture and household equipment (FH), clothing and personnel equipment (CE), cleaning (apartment, linen and clothes; CL) body and health care (BH), leisure and education (LE) and transport (TT).

[7] The 5 main groups are: unprocessed food (UF), processed food (PF), energy (EN), non-energy industrial goods (NI) and services (SE).
Both data sets were compiled by the Austrian Institute of Economic Research (WIFO) based on published data by Statistics Austria.

[8] The main effort in this task was set by Ernst Glatzer from the Statistics Unit of the Economic Analysis Department of the OeNB, in collaboration with Statistics Austria. This data set was available till April 2003 and was updated by WIFO till December 2004.

series to employ structural break tests comes with the cost that 'modern' products, such as e. g. computers or CD players – which are today a standard in many households – are not included in the 181-items CPI basket. Therefore the expansions of products included in the CPI baskets 1986 and 1996 are necessarily not reflected in the list of the 181 items, and as a consequence the representativity of the subsampleof products has to deteriorate with time.

2.2 Seasonality

As shown in charts 1 and 2 a strong seasonal variation and changes in the seasonal patterns are important time series features visible in (Austrian) CPI data. A closer look at these seasonal properties reveals that changes in the seasonal patterns coincide with changes in the base years and/or changes in statistical concepts and definitions for national accounts based price series (PGDP and PCP). Also for the CPI and its subaggregates changes in the seasonal patterns coincide with changes in the goods baskets (reweighting plus inclusion of new products or exclusion of outdated products) in the years 1976, 1986, 1996 and 2000.[9] Additionally, in 1995 Statistics Austria started to account for price changes due to sales and promotions. As expected the product subcategories clothes and personnel equipment (CE) and non-energy industrial good (NI) were most strongly affected by this change in the CPI concept.

A careful treatment of seasonality is extremely important in estimating the degree of persistence, as very volatile unadjusted series show considerably lower persistence. The previous literature tackled this issue by using seasonally adjusted data, without a further investigation of the possible consequences of seasonal adjustment on the results. As Ghysels (1990) and Ghysels and Perron (1993) point out, the application of seasonal adjustment procedures as X11 has a smoothing effect on the time series with the undesirable consequence of (most likely) inducing an upward bias in persistence, the parameter we want to estimate.

We address the issue of seasonality by applying 5 different treatments of seasonal adjustment for the quarterly data to analyze the effect of seasonal adjustment on the estimated structural breaks and persistence measures. As a benchmark seasonal model we applied Tramo/Seats (Gómez and Maravall, (1994A, B, 2001A, B)) for outlier detection and correction and seasonal adjustment to 4 subperiods to address the issue of changing seasonal pattern (we refer to this adjustment procedure as Tramo/Seats_I later in teh text). The four subsamples are the periods for which the various SNA/ESA base years or definitions (for national accounts based data) and the various CPI baskets were in use. For both sets of

[9] A change in the goods basket becomes visible in the rate of inflation with a lag of one year. So the changes in the seasonal patterns in charts 1 and 2 if they occurred are visible from 1977, 1987, 1997 and 2001 onwards.

series these periods highly overlap and we estimated seasonal models for the following subsamples: 1966:Q1 – 1976:Q4, 1977:Q1 – 1986:Q4, 1987:Q1 – 1996:Q4 and 1997:Q1 – 2004:Q4.[10] With respect to outliers, all spikes according to VAT changes (1973, 1976, 1978, 1981, 1984, 1992) and changes in energy taxes (1980, 1981, 1984, 1992, 1994, 1996, 2000) in the sample periods has been removed by Tramo. Therefore, the identified structural breaks in section 4 should not be due to changes in main excise taxes.

As a second seasonal adjustment procedure we use an autoregressive model of order 4 with seasonal dummy variables applying a different set of dummies for each of the four subsamples described above and also period specific constant and persistence terms. The influences of deterministic seasonality represented by the seasonal dummies effects were then removed from the series. A formal representation of this approach for quarterly data is given by the following equations:

$$Y_t = \alpha_0 + \sum_{j=1}^{k-1} \alpha_j I_{jt} + \varphi Y_{t-1} + \sum_{j=1}^{k-1} \varphi_j I_{jt} Y_{t-1} + \sum_{h=1}^{3} \gamma_h \Delta Y_{t-h} + \sum_{j=1}^{k} \sum_{i=1}^{3} \beta_{ij} I_{jt} S_{ijt} + u_t$$

$$y_t = Y_t - \sum_{j=1}^{k} \sum_{i=1}^{3} \hat{\beta}_{ij} I_{jt} S_{ijt} = \hat{\alpha}_0 + \sum_{j=1}^{k-1} \hat{\alpha}_j I_{jt} + \hat{\varphi} Y_{t-1} + \sum_{j=1}^{k-1} \hat{\varphi}_j I_{jt} Y_{t-1} + \sum_{h=1}^{3} \hat{\gamma}_h \Delta Y_{t-h} + \hat{u}_t$$

where I_{jt} (j=1,...,k) are indicator variables for specific subsamples with I_{jt} = 1 within subsample j and 0 otherwise. $S_{it} = D_{it} - D_{4t}$, $(i = 1,\ldots,3)$ are rescaled seasonal dummies, which sum up to zero (see Osborne and Sensier, 2004). y_t (Y_t) is defined as the seasonal (un)adjusted series.[11]

[10] For the subcategories clothing and personnel equipment and non-energy industrial goods the inclusion of sales prices changed the seasonal pattern starting in 1995. As a consequence for these subindices the last two subsamples are1987:Q1 – 1994:Q4 and 1995:Q1 – 2004:Q4.
The last change in the CPI goods basket occurred in 2000. We considered the two 5-year periods as too short to estimate separate models. Fortunately for these periods the seasonal patterns look quite similar (see chart 2). For the CPI main group categories and the HICP series after taking into account the later start of the sample the subsamples definitions are the same.

[11] In principle, we could include all seasonal dummies in the linear model (1) discussed below. But the approximate critical values for the Andrews and Ploberger (1994) tests are tabled in Hansen (1997) for up to 20 variables. For the monthly series (not reported here) the number of estimated parameters would be too large to apply Hansen p-values, so we followed the approach described above.

As other seasonal adjustment procedures we applied: fourth seasonal difference to outlier adjusted series (D4); X12-Arima (Findley et al., (1998)) to the total sample as the seasonal filter uses moving averages which are in principle able to account for the changing seasonal pattern; Tramo/Seats to the total sample (Tramo/Seats_II).[12] In charts 1 and 2 for the 4 aggregate series and 9 CPI use categories the original, Tramo/Seats_I and Tramo/Seats_II adjusted series are are shown. The last procedure creates the smoothest series and therefore we expect higher persistence estimates for these series.

In the discussion of the results in sections 4 and 5 we use the estimates for quarterly data adjusted with Tramo/Seats_I as a benchmark to which the results based on monthly data and other seasonal adjustment procedures are compared.

3. Methodology

3.1 Persistence Measure

We define inflation πt as the first differences of price series in logarithmic terms

$$\pi_t = \log(P_t) - \log(P_{t-1}),$$

on which the seasonal adjustment procedures described in the previous section are applied. As much of the related literature, we characterize the dynamics of each inflation time series by an univariate autoregressive (AR) model of order p, selected by the Hannan-Quinn (HQ) information criterion with a maximum order of 4 quarters (12 months). Following the discussion in Andrews and Chen (1994) persistence is measured as the sum of the AR coefficients (φ), estimated by the reformulated AR model

$$\begin{aligned}\pi_t &= \alpha_0 + \alpha_1\pi_{t-1} + \cdots + \alpha_p\pi_{t-p} + \varepsilon_t \\ &= \alpha_0 + \varphi\pi_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\pi_{t-i} + \varepsilon_t \quad .\end{aligned}$$

The persistence parameter (φ) is estimated for the total sample and for subsamples conditional on the occurrence of structural breaks in the mean of the inflation process. We apply (multiple) structural breaks tests introduced by Andrews and Ploberger (1994) and Bai and Perron (1998, 2003A) and estimate the number and dates of the break points. In the following we give a brief sketch of these tests.

[12] Tramo/Seats_I stands for the seasonal adjustment applied to 4 subsamples, whereas Tramo/Seats_II indicates the use of all observations.

3.2 Andrews-Ploberger Structural Break Tests

Consider a univariate time series yt, (t = 1,...*T*), which under the null hypothesis is i.i.d. with a constant mean μ and finite variance. Under the alternative, y_t is subject to a single change in mean at some unknown break date T_b,

$$y_t = \mu_1 + \mu_2 1(t > T_b) + e_t \tag{1}$$

with et~i.i.d.(0,σ2e) and 1(•) is an indicator function for the break [i.e.,1(•) = 1 for $t>T_b$, and T_b= 0 otherwise]. Letting $F_T(T_b)$ be the Wald (or LM or LR) test statistic of the equality of the coefficients $\mu_1 = \mu_2$ under the null hypothesis, that there is no break, Quandt (1958, 1960) introduced what is now known as supF test, that the most probable break date is T_b where $F_T(T_b)$ takes the highest value. However, as T_b is a nuisance parameter, that appears only under the alternative hypothesis the limiting distribution is non-standard and was unknown until Andrews (1993) generalized the solution to this problem and proposed the test statistic

$$SupF_T = \sup_{T_1 \le T_b \le T_2} F_T(T_b),$$

now known as Andrews-Quandt test, derived its asymptotic properties and asymptotic critical values. T_1 and T_2 are the lower and upper bound defining the range within the possible break point is located. Andrews and Ploberger (1994) proposed an analogous class of tests that a single structural change occurs at an unknown date, but with stronger optimality properties and introduced

$$ExpF_T = \ln\left(\frac{1}{T_2 - T_1 + 1}\sum_{T_b=T_1}^{T_2}\exp\left(\tfrac{1}{2}F_T(T_b)\right)\right),$$

which is an exponentially weighted average of the test statistics $F_T(T_b)$. Hansen (1997) presented an approximation of the asymptotic p-value function for $ExpF_T$ (and $AveF_T$).[13]

In our application to test for single breaks in the unconditional mean of inflation, we apply Andrews-Ploberger's $ExpF_T$ test with Hansen's approximate p-values, use the LM statistic for F_T and follow the usual convention and exclude the first and last 15% of the observations from the consideration as potential structural change dates (T_1=0.15T, T_2=0.85*T*).

Based on simulation results discussed in Vogelsang (1997, 1999), Perron (2005) conjectures that most test will suffer from important power problems if the number of breaks under the alternative hypothesis is higher than the number of breaks

[13] Andrews and Ploberger (1994) also proposed an $AveF_T$ test, which is not presented here, as the authors express a mild recommendation for $ExpF_T$ (p. 1398). However, based on simulation results Andrews et al. (1996) recommend $AveF_T$ for small shifts and $ExpF_T$ for moderate to large shifts.

explicitly accounted for in the construction of the tests. Hence, substantial power gains may result from applying multiple structural change tests. Therefore we also applied Bai and Perron's (1998, 2003A) test to account for multiple break points in the sample period.

3.3 Bai – Perron Multiple Structural Break Test

Bai and Perron (1998, 2003A) discuss the issue of estimating and testing break dates in a linear regression model with m unknown breaks (or m+1 regimes) of the form

$$y_t = x_t'\beta + z_t'\delta_j + u_t \qquad t = T_{j-1}+1,...,T_j \tag{2}$$

for j = 1,...,m+1, with y_t is the dependent variable, x_t (p x 1) and z_t (q x 1) are vectors of possible covariates with the corresponding parameter vectors β and δ_j, respectively, and u_t represents the error term at time t. The unknown break points (T_1,...,T_m) and the unknown regression parameters β and δ_j are jointly estimated.[14] Equation (2) represents a partial structural change model since the vector β is not subject to shifts. When p = 0 the pure structural change model is obtained.
In matrix notation the model has the form

$$Y = X\beta + \overline{Z}\delta + U ,$$

where $Y = [y_1,...,y_T]'$, $X = [x_1,...,x_T]'$, $U = [u_1,...,u_T]'$, $\delta = [\delta_1',\delta_2',...,\delta_{m+1}']'$ and $\overline{Z}$ is the matrix which diagonally partitions Z at (T_1,...,T_m), i.e. $\overline{Z} = \text{diag}[Z_1', Z_2',..., Z_{m+1}']$ with $Z_i = [z_{T_{i-1}+1},..., z_{T_i}]'$.

The estimation method is based on the least-squares principle. For each m-partition (T_1,...,T_m), the associated least-squares estimates of β and δj are obtained by minimizing the sum of squared residuals

$$U'U = (Y - X\beta + \overline{Z}\delta)'(Y - X\beta + \overline{Z}\delta) = \sum_{i=1}^{m+1}\sum_{t=T_{i-1}+1}^{T_i}(y_t - x_t'\beta - z_t'\delta)^2 .$$

Let $\hat{\beta}(\{T_j\})$ and $\hat{\delta}(\{T_j\})$ be the estimates for a given partition (T_1,...,T_m) denoted $\{T_j\}$ and substituting these in the objective function and denoting the resulting sum of squared residuals as $S_T(T_1,...,T_m)$, then the estimated break points are such that

$$(\hat{T}_1,...,\hat{T}_m) = \arg\min_{(T_1,...,T_m)} S_T(T_1,...,T_m) ,$$

where the minimization is taken over some set of admissible partitions (see section 3.1 and chart 1 in Bai and Perron, 2003A). The regression estimates are those with the associated m-partition $\{T_j\}$. A method based on a dynamic programming

[14] By convention T_0 = 0 and T_{m+1} = T.

algorithm to efficiently compute these estimates is presented in Bai and Perron (2003A).

They considered the *supF* type test of no structural break *i*. e., $m = 0$ vs. $m = k$ breaks. Let $(T_1,...,T_k)$ be a partition such that $T_i = T\lambda_i$ $(i = 1,...,k)$ and R be a matrix such that $R\delta = (\delta_1' - \delta_2', ..., \delta_k' - \delta_{k+1}')$ and define

$$F_T(\lambda_1,...,\lambda_k;q) = \frac{1}{T}\left(\frac{T-(k+1)q-p}{kq}\right)\hat{\delta}' R'(RV(\hat{\delta})R')^{-1} R\hat{\delta}$$

with $V(\hat{\delta})$ is an estimate of the variance-covariance matrix of $\hat{\delta}$ that is robust to serial correlation and heteroscedasticity, the proposed test is the type $SubF_T = F_T(\hat{\lambda}_1,...,\hat{\lambda}_k;q)$, where $(\hat{\lambda}_1,...,\hat{\lambda}_k)$ minimize the global sum of squared residuals. The asymptotic distribution of this test is non-standard and tabulated in Bai and Perron (1998, 2003B) and depends on the trimming parameter $\varepsilon = h/T$, where h is the minimum length of a segment.

In addition Bai – Perron propose a test of ℓ vs. $\ell+1$ breaks, $SupF_T(\ell \mid \ell+1)$ to perform a sequential testing procedure, i. e. applying of $\ell+1$ tests of the null hypothesis of no structural change vs. the alternative of a single change. The test is applied to each segment containing the observations $\hat{T}_i - 1$ to $\hat{T}_i$, $(i = 1,...,\ell+1)$. Bai – Perron conclude for a rejection in favor of a model with $\ell+1$ breaks if the overall minimal value of the sum of squared residuals is sufficiently smaller than the RSS from the ℓ breaks model.

Bai – Perron discuss also the application of a BIC and a modified Schwartz information criteria (LWZ, as it was introduced by Lui et al., 1997). They conclude from simulation studies that the BIC and LWZ works well under some conditions, while performs less so in the presence of serial correlation in the errors, as the chosen number of breaks is too high.

Next, the most important assumptions imposed on the regressors and errors in the Bai – Perron framework are briefly mentioned.15 It is allowed for the distribution of the regressors to vary across regimes but it is required that they are weakly stationary stochastic processes. Hence, integrated variables are precluded as regressors. A wide class of potential correlation and heterogeneity (also conditional heteroscedasticity) and lagged dependent variables are allowed, but error terms with a unit root are ruled out.

In the empirical implication to test for multiple breaks in the unconditional mean of inflation we selected a pure change model with an intercept only. We have chosen a minimum span of 24 quarters (72 months) which lead to a trimming parameter for the total sample of around 15%. In the testing procedure we allowed

[15] See Bai and Perron (1998, 2003A, B) for details and Perron (2005) for possible relaxations of these assumptions.

a maximum number of 4 breaks, and have chosen the BIC as a selection criterion for the number of breaks. Although the properties of this selection criterion is in some occasions less favorable to the sequential subF test, for the estimates of the 181 individual CPI items and the many variants of the model we estimated, the last procedure is computationally too burdensome.

For shorter sample periods (1977 – 2004) [1987 - 2004] we also reduced the parameters for the minimum span (20 quarters) [16 quarters] and the maximum number of breaks (2) [3].

4. Results of the Structural Break Tests[16]

In this section we discuss the results on the estimated number and the dates of structural breaks for the inflation series described in section 2. We applied break tests according to Andrews and Ploberger (1994) and Bai and Perron (1998, 2003A) discussed in section 3.

The overall evidence based on the aggregate, sectoral and item level structural change analysis is consistent, in the way that in the mid eighties and early/mid nineties structural breaks in the unconditional mean of the rate of inflation series are detected. For all aggregate series and CPI subaggregate series break points are shown in the time intervals 1982:Q2 – 1986:Q3 (except body and health care) and 1993:Q3 – 1995:Q4 (except for transport; see table 4A). In addition, for the GDP deflator and the CPI-total and some CPI subaggregates also in the mid/late seventies a structural break is detected (1974:Q1 – 1977:Q3).

According to the evidence based on the 181 individual CPI items an accumulation of break points is also found in the mid eighties and nineties (see chart 3).

For monetary policy analysis and inflation forecasting especially the last break date is the most important one, as forecasts based on data before the break occurred, could give misleading signals about the future dynamics of inflation.

Next we discuss the stability of this evidence with respect to the estimation method, data frequency, the sample period and the various treatments of seasonality.

As most series exhibit more than one break according to the Bai – Perron test, hence the results of these two tests are not totally comparable. However, the single

[16] The estimation results are presented in tables 4 to 13. Panels A contain the results of the structural break tests. In panels B the OLS estimates for the intercept and the persistence parameters for the total sample as well as for various subsample according to the structural breaks detected for this series are shown To safe space we refer to table x – panel A and table x - panel B as table xA and. table xB, respectively (with x = 4 to 13). Tables 4 to 9 present the results for quarterly data, whereas for monthly data the results are in tables 10 to 13. The results of different treatments of seasonality could be found in tables 6 to 9.

break dates detected by the Andrews-Ploberger test are in almost any case also detected by the Bai - Perron procedure. For all of the aggregate series and most of the CPI subindices the Andrews-Ploberger test detects the break in the mid eighties. Therefore for these series, although there are possibly additional breaks, this evidence suggests that the most dominant break in the inflation process occurred in the mid eighties.

A comparison of quarterly and monthly CPI series shows, that the frequency of the data does not have an important influence on the number and dates of structural breaks, if the trimming parameter, which means the minimum time span between to possible breaks, is equivalent (table 4A and table 10A). The break point in the mid seventies is not detected for the monthly CPI-total and for some CPI-subaggregates. But more important, for the last break, when it is detected using quarterly series it is also detected in the monthly series (except transport).

When analyzing the consequences of a shorter sample, one has to decide either holding the minimum time span between two consecutive breaks constant and therefore increasing the trimming parameter for the shorter sample or doing it the other way round i.e. a constant trimming parameter and thus a shorter minimum span for the shorter sample. We decided for the first option (see table 4 A vs. table 5A and table 10A vs. table 11A).

The comparison of the estimates for the total sample (1966 - 2004) with shorter subsamples for both quarterly data (see table 4 A vs. table 5A) as well as for the monthly data (see table 10A vs. table 11A and table 12A) for a medium (1997 – 2004) and a short (1987 – 2004) sample period shows a good correspondence of the estimated break points.

For the sample 1987 – 2004 we can compare the CPI results with the HICP inflation series (see table 12A vs. table 13A). There is a high accordance in the timing of the break dates between this two price concepts. The Bai-Perron test also depicts not more than one break point and the estimated dates show in almost all cases a perfect correspondence with the Andrews-Ploberger findings.

With respect to the various seasonal adjustment procedures, we found that for the seasonal dummy variable approach (table 6A) a lower number of breaks is estimated for the CPI subindices: in 4 out of 8 cases where a break in the benchmark case (table 4A) is found for the mid nineties no breaks are detected if data based on a seasonal dummy variable adjustment are applied. For the seasonal fourth differences adjustment (table 7A) overall the accordance for the aggregate and subaggregate series is reasonably consistent. The X12-adjusted series show for the aggregated as well as for the subindices a lower number of breaks (table 8A). The accordance with the benchmark is very good for the break in the eighties, whereas there is less evidence for the CPI subaggregates for breaks in the seventies and nineties. For the smoother Tramo/Seats_II series (table 9A) the pattern in the number of the detected break point and the overall location is very similar, but in some cases the difference to the same break point in table 4A is as large as 4 years.

5. Results of the Inflation Persistence Estimates

In this section we present OLS estimates of the persistence measures. As seasonal adjustment tends to induce an upward bias in the persistence estimates and as OLS point estimates have a downward bias for highly persistent series (for φ>0.7 or so) these effects balance to some (unknown) extent. Especially for subsamples the OLS estimates are quite low, thus OLSestimates should be appropriate (see Cecchetti and Debelle, (2005)).

For the estimates of the total sample over 4 decades we can confirm the international evidence of high inflation persistence also for Austria (see table 4B). For the aggregate as well as for the subaggregates series persistence estimates in many cases are well above 0.8 and a unit root could probably not be rejected for many series. However, if the occurrence of structural breaks is taken into account, the persistence estimates for the subsample are much lower and in several cases they became negative and insignificant.

Overall these results hold also for monthly data (table 10B), but for some subindices the estimates based on monthly series are considerably smaller, reflecting the higher volatility of this series.

As the sample size is reduced to a sample of medium size (1977 – 2004; table 4B vs. table 5B and table 10B vs. table 11B) and to a short one (1987 – 2004; table 10B vs. table 12B and table 13B) in general also the estimated persistence measures decrease.

With respect to the seasonal adjustment procedures we find that for series adjusted with seasonal dummy variables, the estimates for the CPI and its subaggregates with the total sample are (slightly) lower (table 6B). The opposite is true in the case of a seasonal differences treatment of seasonality: the estimates for (φ) are larger (table 7B). X12 (table 8B) and Tramo/Seats_II (table 9B) adjusted series show roughly the same persistence estimates, in some cases even smaller values. This is surprising as X12 and Tramo/Seats_II adjusted series look smoother then Tramo/Seats_I adjusted series. Overall, in our case study we found only a minor effect of the seasonal adjustment procedure for the persistence estimates.

6. Summary

In this study we present empirical results for the occurrence of structural breaks and the level of persistence for aggregate inflation indicators as well as for and CPI subaggregate time series. We find strong evidence for a structural break in the inflation process in the mid eighties for the aggregate, subaggregate and individual CPI items. For the mid seventies as well as for the mid nineties we find significant breaks at the aggregate CPI level but to a lesser extent for the more disaggregated inflation data. A comparison of the results for the CPI total with its subaggregates reveals that the timing of the detected shifts in the mean tends to be consistent,

although some series, as housing and body and health care (and to a lesser extent) transport, tend to follow their own dynamic processes. There is good accordance of the estimated break points for different data frequencies, and sample periods. No difference in the results occurs if CPI data are used instead of HICP data.

The differences with respect to methods of seasonal adjustment indicate some uncertainty with respect to the estimated break points: there is an overwhelming and highly consistent evidence for the occurrence of structural break in the mid of the eighties. For the occurrence of additional breaks in the mid seventies and in the mid nineties the evidence for the CPI-total is also strong, but less so for the CPI subindices.

Persistence in the inflation series is very high when the models are estimated for the total sample of 40 years. But as for other OECD countries this finding is not robust. Once one controls for breaks in the mean of inflation, estimates for persistence are considerably lower, in several cases they become even insignificant. This suggests that the weight of the backward looking part in the formation of inflations expectations decreased over time.

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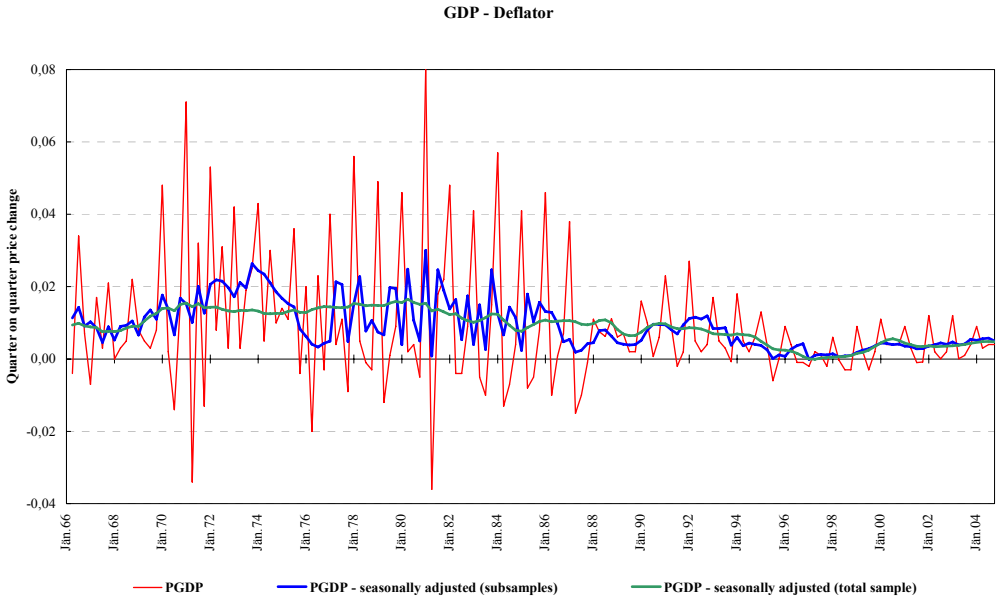
Appendix A: Charts

Chart 1: Aggregate Inflation Series



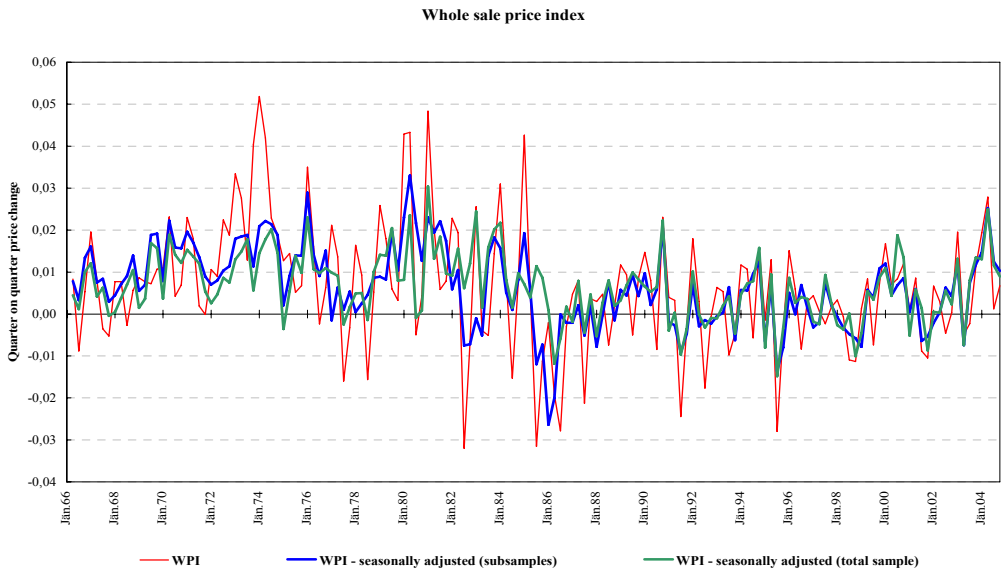


Chart 1 continued: Aggregate Inflation Series

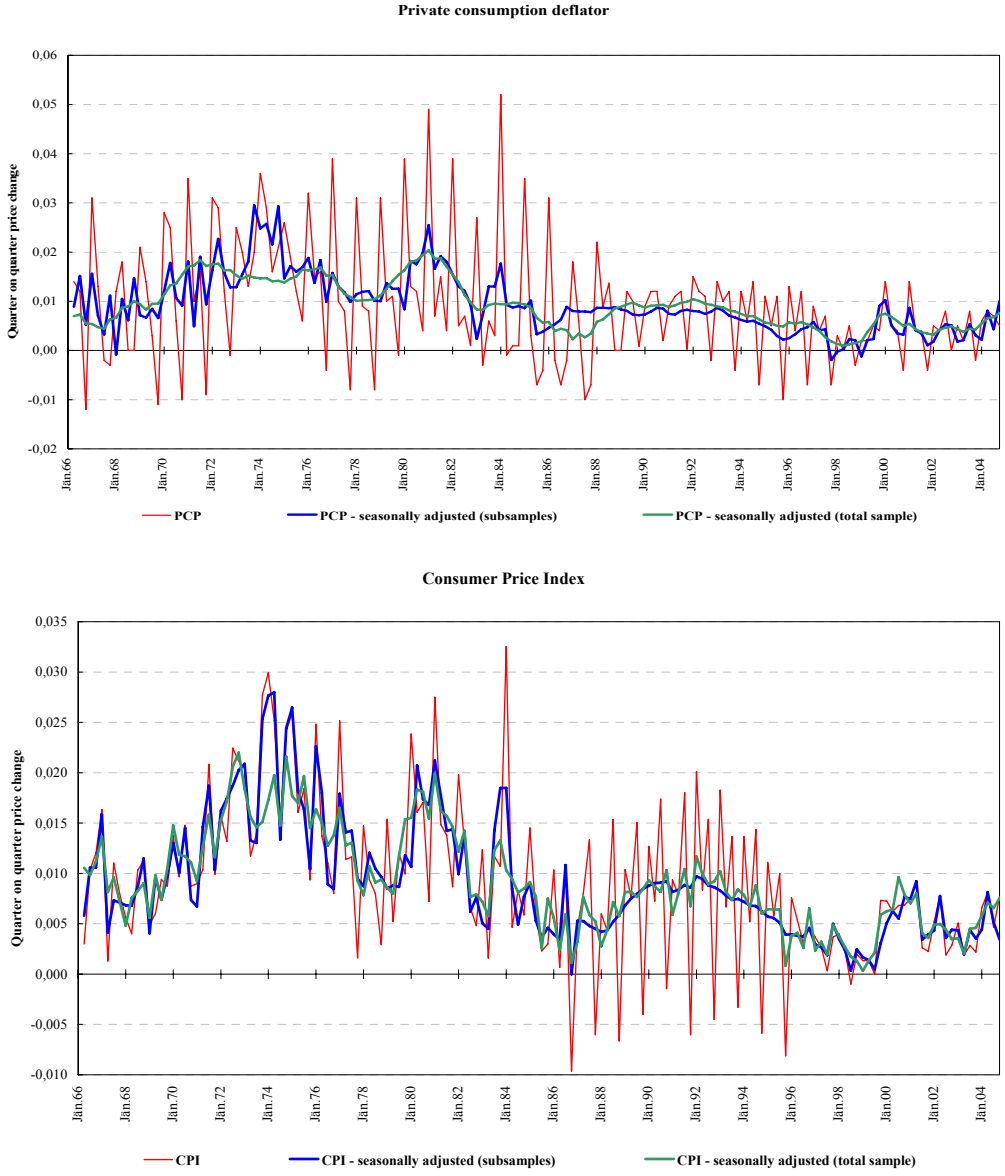


Chart 2: CPI Subaggregate Indices

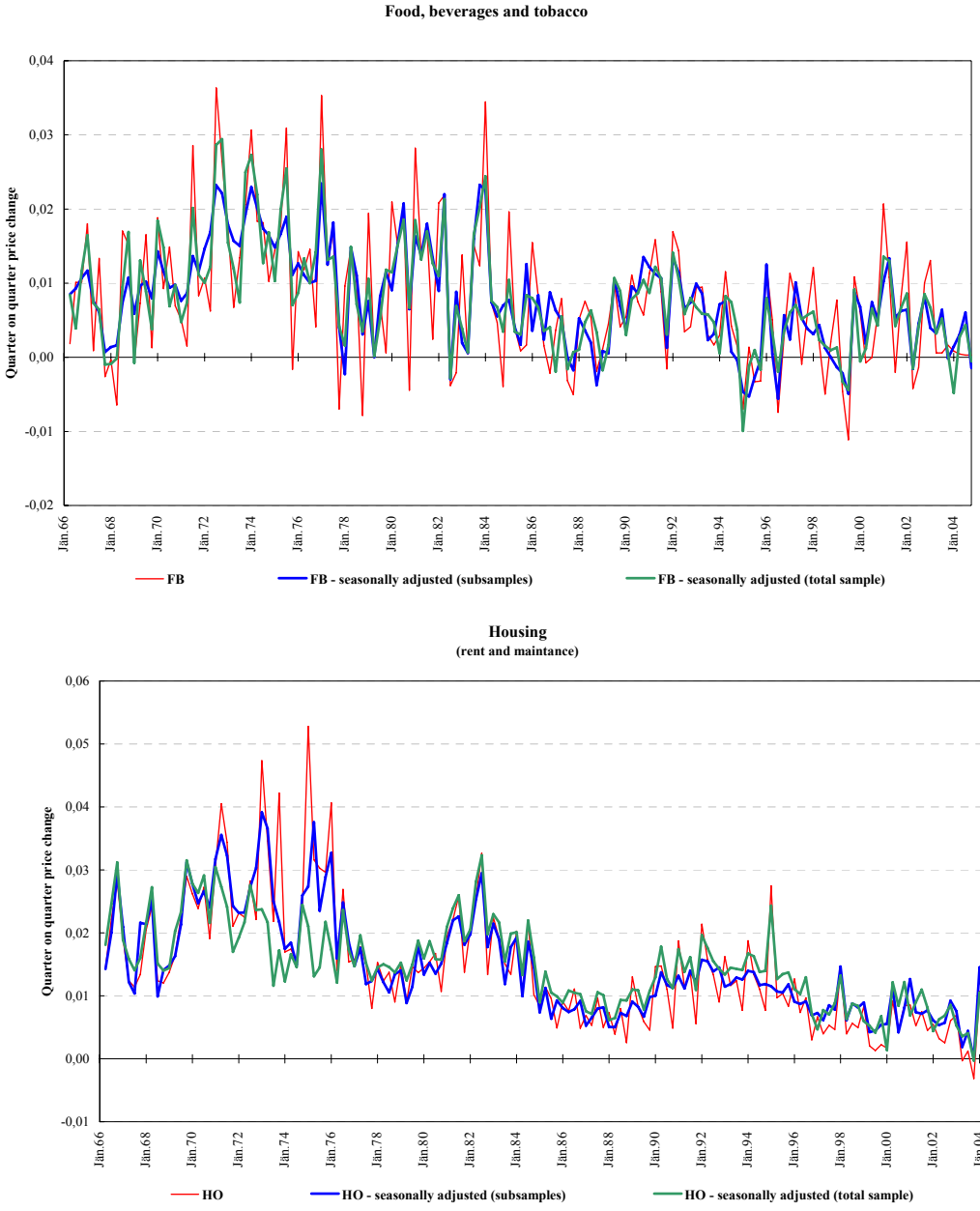
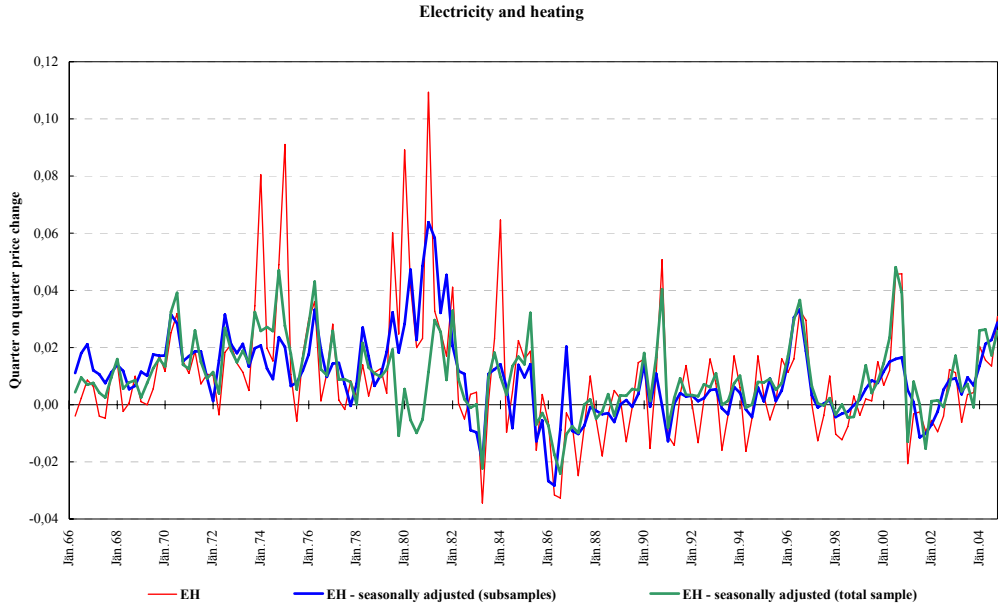


Chart 2 continued: CPI Subaggregate Indices



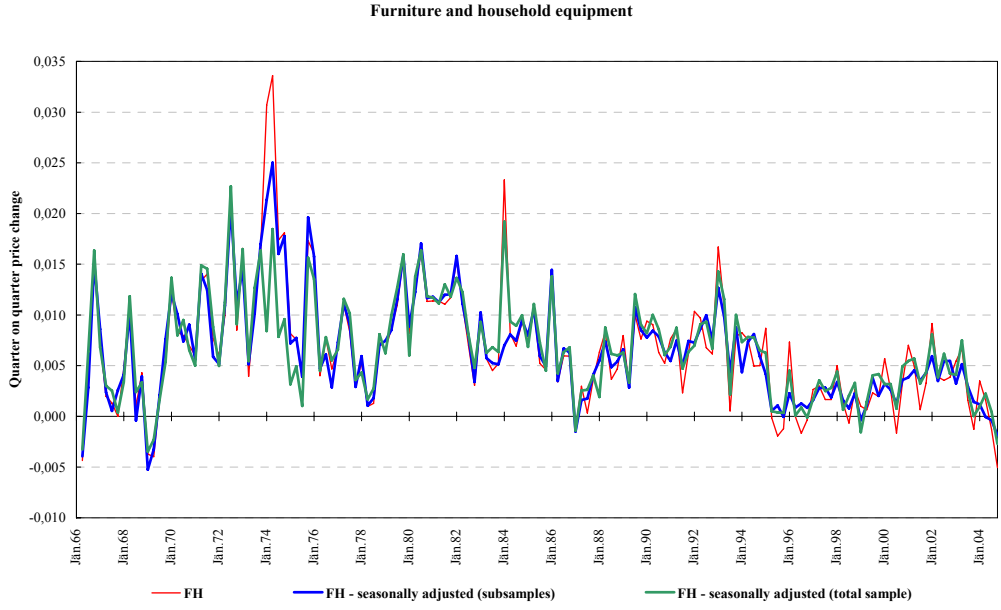


Chart 2 continued: CPI Subaggregate Indices

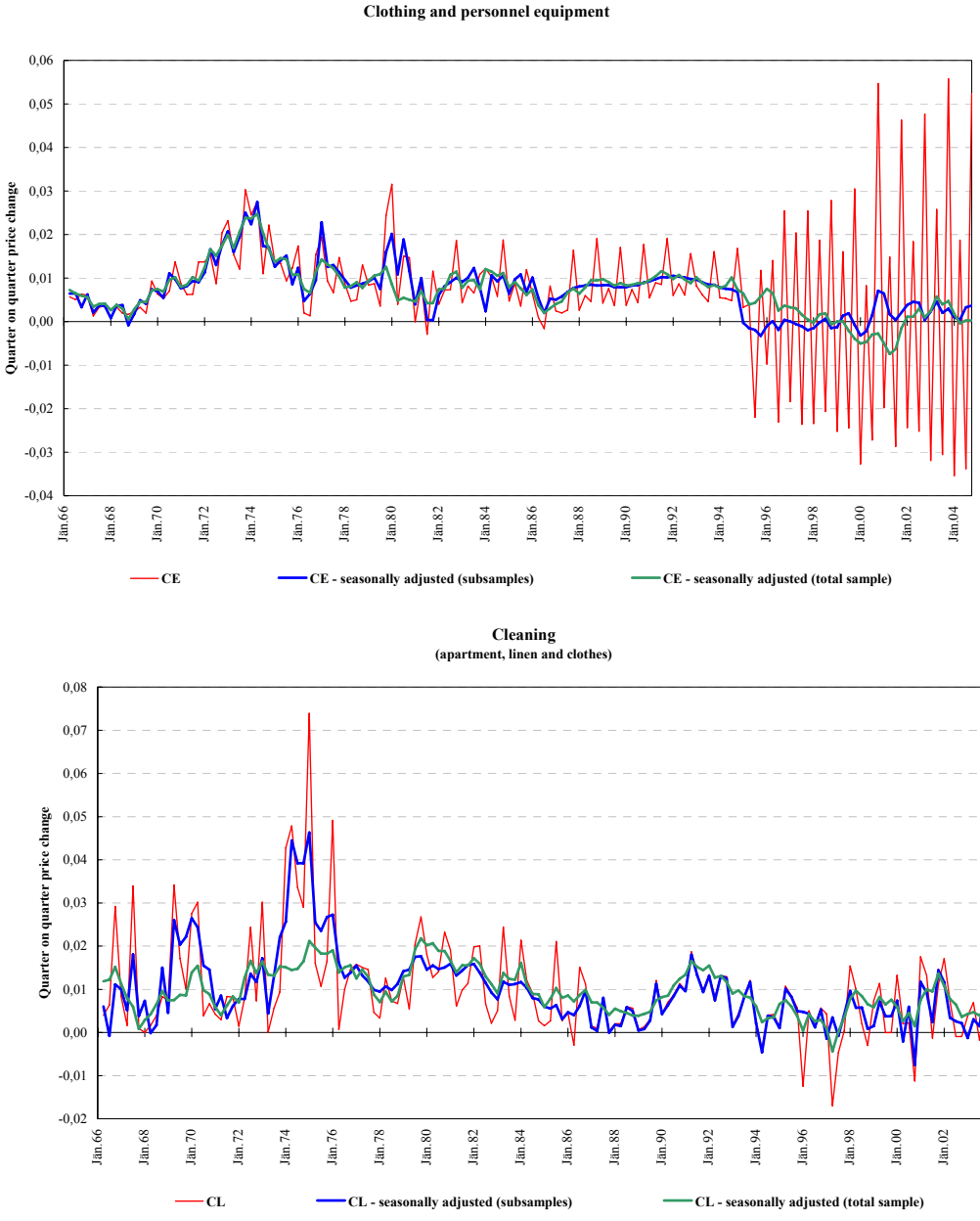
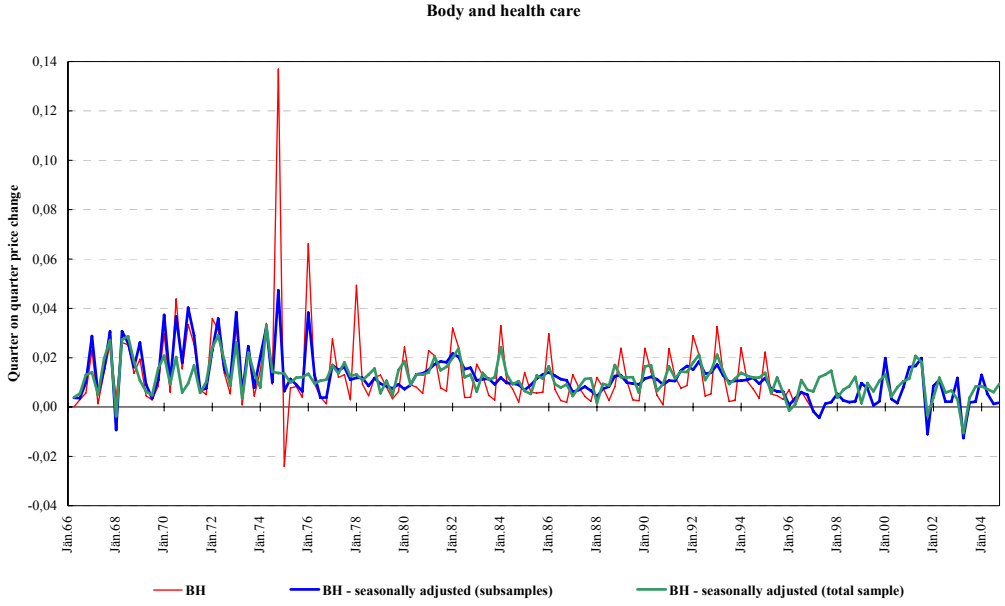


Chart 2 continued: CPI Subaggregate Indices



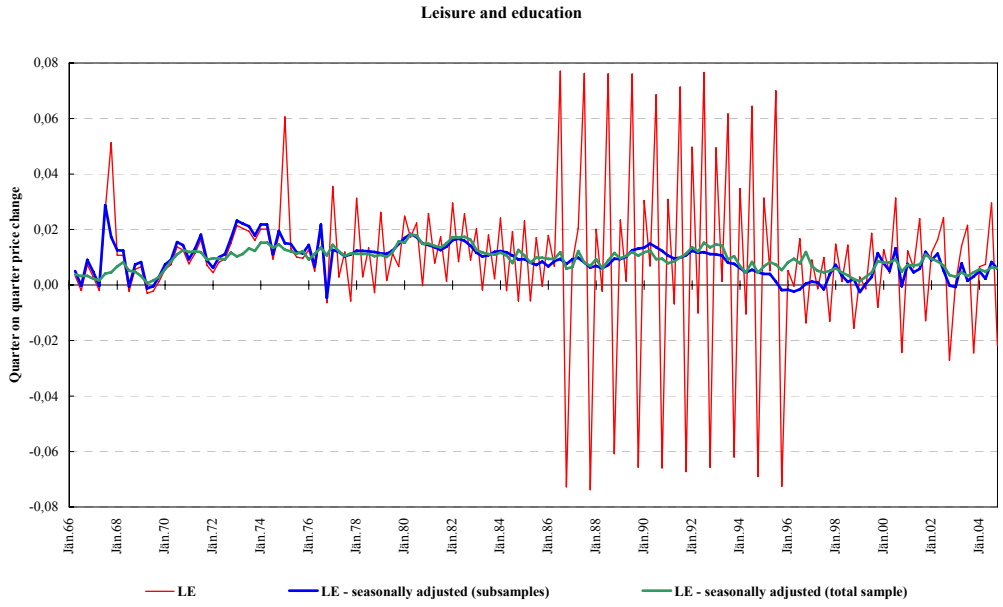


Chart 2 continued: CPI Subaggregate Indices

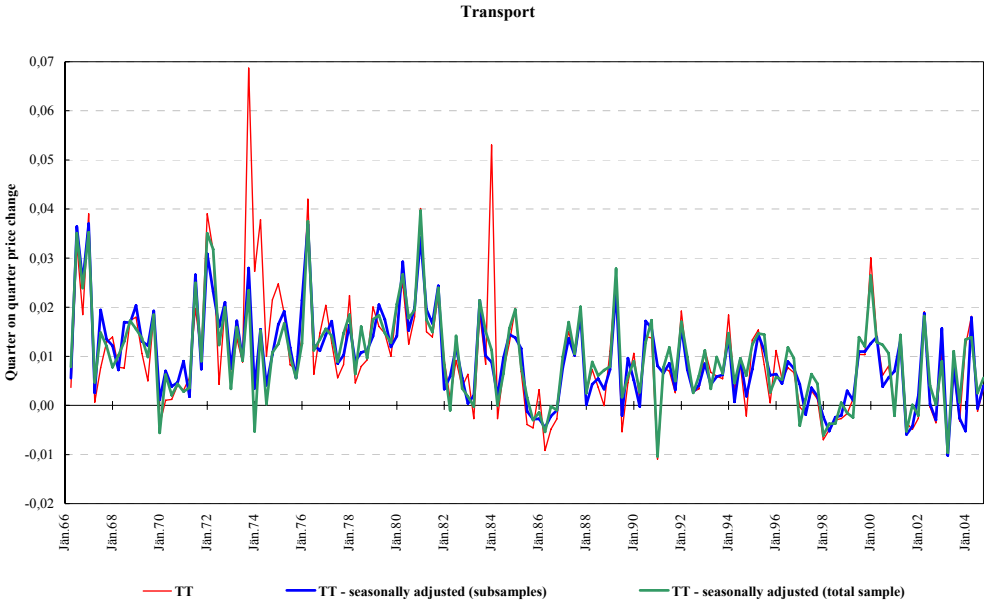
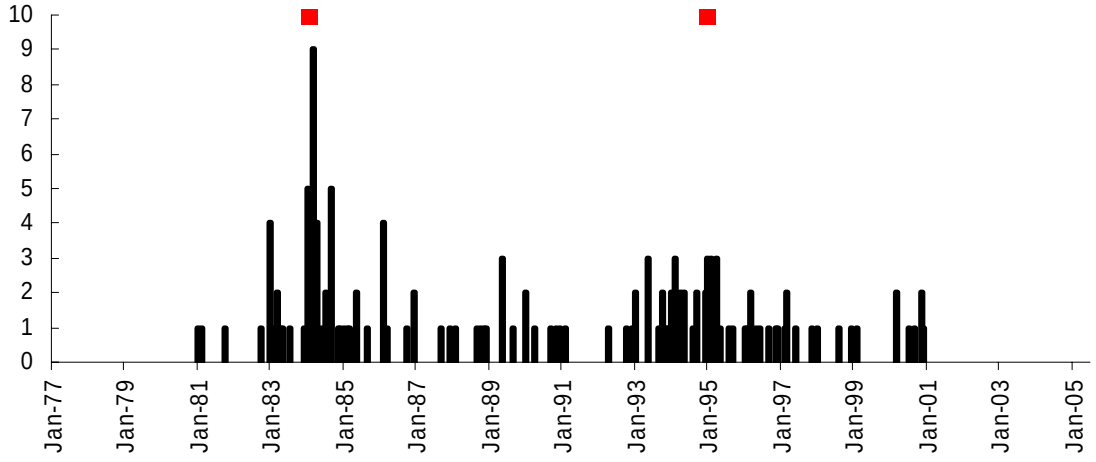


Chart 3: Distribution of Structural Breaks for the 181 Individual CPI items



Note: The squares indicate break points detected for the aggregate CPI for the sample period 1979:M02 to 2004:M12 (table 11 – Panel A).

Appendix B: Tables

Table 1: Evidence on Inflation Persistence for Austria

	Variable	Sample	Frequency	Structural break date	Persistence Method	Persistence φ
Gazinski - Orlandi (2005)	PGDP	1988:Q3 - 2003:Q2	Quarterly	1995:Q3	Hansen (1999)	-0.14
	PCP	1984:Q1 - 2003:Q1	Quarterly	–	Hansen (1999)	0.77
	CPI	1984:Q1 - 2003:Q1	Quarterly	–	Hansen (1999)	1.03
Lünnemann - Mathä (2004)	HICP	1995:Q1-2003:Q4	Quarterly	–	OLS	0.43
Ceccetti - Debelle (2005)	HICP	1987:1 - 2003:M1	Montly	1994:M10	OLS	0.33
Benati (2004)	PGDP	1964:Q2 - 2003:Q4	Quarterly	1971:Q2	Hansen (1999)	0.94
	CPI	1950:Q1 - 2002:Q2	Quarterly	1957:Q4	Hansen (1999)	0.44

Table 2: Descriptive Statsitics for Annualized Quarterly Rates of Inflation)*

Series	Obs	Mean	SE	Min	Max	Obs	Mean	SE	Min	Max
		1966:2 1976:4					1977:1 1986:4			
PGDP	43	5.29	8.00	-13.84	27.44	40	4.77	9.76	-14.67	30.78
PCPR	43	5.36	5.19	-4.83	14.15	40	4.60	6.46	-3.21	20.28
WPI	43	5.22	5.13	-3.53	20.22	40	2.62	7.95	-13.00	18.87
CPI	43	5.42	2.77	0.52	11.79	40	4.23	3.13	-3.88	12.81
FB	43	4.76	3.81	-2.58	14.28	40	3.91	4.30	-3.15	13.88
HO	43	9.65	3.84	4.52	20.58	40	5.84	2.36	1.93	12.85
EH	43	6.04	7.64	-2.31	34.86	40	5.73	11.23	-13.99	41.49
FH	43	3.58	3.19	-1.74	13.22	40	3.45	1.78	0.39	9.22
CE	43	4.01	3.00	0.53	11.93	40	3.64	2.70	-1.16	12.43
CL	43	6.32	6.39	0.00	28.52	40	4.46	2.95	-1.18	10.57
BH	43	6.92	9.17	-9.74	51.34	40	4.89	4.18	0.77	19.24
LE	43	4.63	4.90	-2.55	23.52	40	4.51	8.21	-30.19	29.69
TT	43	6.23	5.52	-1.56	26.58	40	4.43	4.72	-3.69	20.68
		1987:1 1996:4					1997:1 2004:4			
PGDP	40	2.43	3.76	-6.05	14.92	32	1.18	1.72	-1.20	4.77
PCPR	40	2.71	3.17	-4.02	8.70	32	1.54	1.86	-2.81	5.56
WPI	40	0.64	4.56	-11.35	9.10	32	1.39	3.70	-4.55	10.98
CPI	40	2.72	3.11	-3.26	7.96	32	1.66	1.09	-0.39	3.65
FB	40	1.86	2.37	-2.98	6.72	32	1.55	2.74	-4.47	8.19
HO	40	4.19	2.08	1.03	10.84	32	2.52	2.56	-1.26	12.06
EH	40	1.17	6.11	-10.06	19.80	32	1.73	6.10	-8.31	17.93
FH	40	2.16	1.67	-0.78	6.63	32	1.01	1.13	-2.02	3.65
CE	40	2.68	3.77	-9.32	10.03	32	0.52	12.34	-14.43	21.72
CL	40	2.31	2.25	-5.03	7.39	32	1.27	3.20	-6.84	6.94
BH	40	4.00	3.36	0.27	12.84	32	1.89	2.98	-5.06	7.86
LE	40	2.81	19.75	-30.63	29.52	32	1.75	6.39	-10.99	12.33
TT	40	3.06	2.78	-4.40	10.44	32	1.46	3.54	-3.99	11.85

*Note: *) $\pi(t)$) = 400*[P(t)/P(t-1)]. For labels see section 2 in the paper.*

Table 3: Representativness of 181 CPI-Items for the Austrian CPI

Main groups	No. of series	CPI Weighting structure				Sample of 181 Products Weighting Structure			
		1976	1986	1996	2000	1976	1986	1996	2000
Unprocessed food	24	8.6	6.2	5.2	5.7	12.3	9.4	7.2	8.8
Processed food	43	19.2	14.2	12.0	11.1	16.7	14.2	13.2	14.8
Energy	7	7.6	9.1	7.9	7.4	9.3	10.4	8.2	8.7
Non-energy industrial goods	82	26.8	31.0	33.4	34.0	44.5	39.4	40.4	41.7
Services	25	37.8	39.5	41.5	41.9	17.2	26.6	31.0	25.9
Total CPI	181								
Correlation of year-on-year changes of CPI with a 181-items CPI						0.82	0.74	0.77	0.81
Coverage of the 181 Products in terms of the CPI weights included:						54.3	48.5	42.3	32.5

Table 4 – Panel A: Structural Breaks for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4)
Minimum Span 24 Quarters

	Andrews - Ploberger Test		Bai-Perron Test for Mutiple Breaks *)				
	No. of Break	Break date	No. of Breaks	Break dates			
				1	2	3	4
Aggregate series							
GDP deflator	1	86:Q3	3	75:Q3	86:Q3	93:Q3	
Private consumption deflator	1	84:Q1	2	82:Q3	94:Q3		
Whole sale price index	1	82:Q2	2	82:Q2	99:Q4		
Consumer price index	1	84:Q1	3	76:Q2	84:Q1	95:Q2	
Use categories							
Food, beverages and tobacco	1	84:Q1	3	77:Q3	84:Q1	94:Q2	
Housing (rent and maintainance)	1	77:Q4	4	76:Q1	84:Q3	90:Q3	96:Q3
Electricity and heating	1	82:Q2	3	76:Q1	82:Q1	95:Q1	
Furniture and household equipment	1	95:Q4	2	82:Q2	95:Q4		
Clothing and personnel equipment	1	95:Q4	2	81:Q4	95:Q4		
Cleaning (apartment, linen and clothes)	1	82:Q3	3	74:Q1	82:Q2	94:Q4	
Body and health care	1	75:Q4	2	74:Q2	95:Q1		
Leisure and education	1	93:Q3	2	84:Q2	94:Q4		
Transport	1	82:Q4	1	82:Q4			

Note: Seasonal adjustment with TRAMO/SEATS applied to 4 subsamples: 1966:Q2–1976:Q4, 1977:Q1–1986:Q4, 1987:Q1–1996:Q4, 1997:Q1–2004:Q4
**) For the Bai-Perron Test a minimum span of 24 quarters and a maximum of 4 breaks are assumed.*

Table 4 – Panel B: Intercept and Persistence Parameters for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (24 Quarters) *)*

	NB	Total Sample		Regime 1		Regime 2		Regime 3		Regime 4		Regime 5	
		α	ρ	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series													
GDP deflator	3	0.34 **	0.63 ***	0.51 **	0.71 ***	2.10 ***	-0.79	0.20 ***	0.72 ***	0.10 **	0.68		
Private consumption deflator	2	0.13 **	0.87 ***	0.52 ***	0.66 ***	0.45 ***	0.42 **	0.22 ***	0.43 ***				
Whole sale price index	2	0.21 ***	0.66 ***	0.68 **	0.50 **	0.08	0.18	0.35 ***	0.22 **				
Consumer price index	3	0.08 *	0.91 ***	0.53 **	0.72 ***	0.90 ***	0.29 *	0.34 ***	0.46 ***	0.19 **	0.54		
Use categories													
Food, beverages and tobacco	3	0.26 ***	0.67 ***	0.52 ***	0.65 ***	0.89 ***	0.15	0.43 ***	0.29 *	0.21 **	0.28		
Housing (rent and maintainance)	4	0.20 **	0.86 ***	1.19 ***	0.57 ***	1.02 ***	0.36 **	0.47 ***	0.42 ***	0.20	0.82 ***	0.98 ***	-0.38
Electricity and heating	3	0.26 ***	0.75 ***	1.43 ***	0.07	0.86 **	0.69 ***	-0.01	0.30 **	0.24 **	0.72 ***		
Furniture and household equipment	2	0.10 *	0.85 ***	0.47 **	0.60 ***	0.51 ***	0.24	0.13 ***	0.47 ***				
Clothing and personnel equipment	2	0.10 **	0.87 ***	0.30 **	0.77 ***	0.54 ***	0.32 *	0.05	0.42 ***				
Cleaning (apartment, linen and clothes)	3	0.14 **	0.84 ***	0.75 ***	0.45 ***	0.36 **	0.78 ***	0.21 **	0.69 ***	0.48 **	-0.32		
Body and health care	2	0.23 *	0.76 ***	6.65 ***	-1.05 **	1.10 ***	0.07	0.43 ***	0.16				
Leisure and education	2	0.17 **	0.81 ***	0.49 ***	0.62 ***	0.19 **	0.80 ***	0.18 **	0.53 ***				
Transport	1	0.44 ***	0.51 ***	1.13 ***	0.26 *	0.50 ***	0.13						

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
Seasonal adjustment with TRAMO/SEATS applied to 4 subsamples: 1966:Q2–1976:Q4, 1977:Q1–1986:Q4, 1987:Q1–1996:Q4, 1997:Q1–2004:Q4.
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 24 quarters and a maximum of 4 breaks.*

Table 5: Structural Breaks, Intercept and Persistence Parameters for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1978:Q2 – 2004:Q4)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (20 Quarters) *)*

	Panel A: Structural Break Tests						**Panel B: Intercept and Persistence Parameters**									
	A-P Test		BP - Test for Mutiple Breaks				Total Sample		Regime 1		Regime 2		Regime 3		Regime 4	
	NB	BD	NB	Break dates 1	2	3	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series																
GDP deflator	1	86:Q3	2	86:Q2	93:Q3		0.07 *	0.83 ***	1.30	-0.06	0.23	0.69 ***	0.11 **	0.65 ***		
Private consumption deflator	1	84:Q1	2	85:Q1	94:Q3		0.14 **	0.77 ***	0.88 **	0.31	0.74	0.03	0.31 **	0.21		
Whole sale price index	1	85:Q1	2	85:Q1	99:Q4		0.11 *	0.62 ***	0.39 **	0.59 ***	-0.02	0.23	0.29 ***	0.46 **		
Consumer price index	1	84:Q1	2	85:Q1	95:Q2		0.11 **	0.82 ***	0.54 **	0.54 ***	0.15	0.77 ***	0.19 **	0.54 ***		
Use categories																
Food, beverages and tobacco	1	84:Q1	2	85:Q1	94:Q2		0.27 ***	0.54 ***	1.00 ***	0.12	0.34	0.44 **	0.21 **	0.28		
Housing (rent and maintainance)	1	85:Q4	3	85:Q1	91:Q1	97:Q1	0.22 **	0.80 ***	1.02 ***	0.41 **	0.18	0.81 ***	-0.05	1.01 ***	0.99 ***	-0.38
Electricity and heating	1	83:Q1	2	85:Q2	94:Q3		0.19 **	0.58 ***	0.70 **	0.43 ***	-0.16	-0.02	0.40 ***	0.39 **		
Furniture and household equipment	1	95:Q4	2	86:Q1	95:Q4		0.05	0.87 ***	0.35 **	0.61 ***	0.28	0.55 ***	0.07	0.66 ***		
Clothing and personnel equipment	1	95:Q4	1	95:Q4			0.05 *	0.89 ***	0.71 **	0.13	0.05	0.47 **				
Cleaning (apartment, linen and clothes)	1	84:Q2	2	85:Q1	94:Q4		0.21 ***	0.64 ***	0.09	0.89 ***	0.32	0.52 ***	0.36 ***	-0.05		
Body and health care	1	95:Q1	1	95:Q1			0.23 **	0.74 ***	0.39 ***	0.66 ***	0.43	0.16				
Leisure and education	1	94:Q4	2	85:Q1	94:Q4		0.11 **	0.84 ***	0.16	0.87 ***	0.28	0.71 ***	0.21 **	0.46 **		
Transport	1	85:Q2	1	85:Q2			0.39 ***	0.44 **	0.80 ***	0.39 ***	0.44	0.15				

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
Seasonal adjustment with TRAMO/SEATS applied to 3 subsamples: 1977:Q1–1986:Q4, 1987:Q1–1996:Q4, 1997:Q1–2004:Q4.
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 24 quarters and a maximum of 4 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Table 6 – Panel A: Structural Breaks for Inflation in Austria
Aggregate and Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4; Minimum Span 24 Quarters)
Seasonal Adjustment: Seasonal Dummy Variables

	Andrews - Ploberger Test		Bai-Perron Test for Mutiple Breaks *)				
	No. of Break	Break date	No. of Breaks	Break dates			
				1	2	3	4
Aggregate series							
GDP deflator	1	84:Q1	2	75:Q3	87:Q1		
Private consumption deflator	1	84:Q1	2	84:Q1	94:Q3		
Whole sale price index	1	82:Q4	1	82:Q4			
Consumer price index	1	84:Q2	3	76:Q2	84:Q2	95:Q2	
Use categories							
Food, beverages and tobacco	1	84:Q2	2	77:Q2	84:Q2		
Housing (rent and maintainance)	1	77:Q4	4	76:Q1	85:Q4	91:Q4	97:Q4
Electricity and heating	1	82:Q2	1	82:Q2			
Furniture and household equipment	1	94:Q3	2	76:Q1	95:Q1		
Clothing and personnel equipment	1	95:Q2	2	80:Q3	95:Q2		
Cleaning (apartment, linen and clothes)	1	82:Q2	2	76:Q1	84:Q2		
Body and health care	1	75:Q4	2	75:Q4	95:Q3		
Leisure and education	1	86:Q3	1	86:Q3			
Transport	1	82:Q4	1	82:Q4			

*Note: *) For the Bai-Perron Test a minimum span of 24 quarters and a maximum of 4 breaks are assumed.*

Table 6 – Panel B: Intercept and Persistence Parameters for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (24 Quarters) *)*
Seasonal Adjustment: Seasonal Dummy Variables

	NB	Total Sample		Regime 1		Regime 2		Regime 3		Regime 4		Regime 5	
		α	ρ	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series													
GDP deflator	2	0.11	0.72 ***	1.70	-0.09	2.02 ***	-1.40 **	0.07	0.44 *				
Private consumption deflator	2	0.15 *	0.82 ***	0.75 **	0.46 **	0.54 **	0.05	0.19 *	0.26				
Whole sale price index	1	0.15 *	0.57 ***	0.70 **	0.41 *	-0.08	0.28 *						
Consumer price index	3	0.15 ***	0.80 ***	0.79 **	0.50 ***	0.81 ***	0.23	0.40 ***	0.22	0.20 ***	0.26		
Use categories													
Food, beverages and tobacco	2	0.25 ***	0.52 ***	1.21 ***	0.00	0.68 ***	0.10	0.11 **	0.33 ***				
Housing (rent and maintainance)	4	0.22 ***	0.82 ***	2.54 ***	0.01	0.89 ***	0.34 **	0.62 ***	-0.16	0.80 **	0.17	0.14	0.80 *
Electricity and heating	1	0.38 **	0.56 ***	1.48 ***	0.29 ***	0.09	0.45 ***						
Furniture and household equipment	2	0.21 ***	0.67 ***	0.67 ***	0.45 ***	0.45 ***	0.34 **	0.11 **	0.25				
Clothing and personnel equipment	2	0.17 **	0.68 ***	0.42 **	0.65 ***	0.45 **	0.21	-0.20	-0.93 ***				
Cleaning (apartment, linen and clothes)	2	0.21 **	0.65 ***	0.79 **	0.55 ***	1.18 ***	-0.20	0.15 **	0.27 *				
Body and health care		0.18	0.41 **	3.39 **	-0.92 *	0.45 ***	-0.30 **	-0.27 *	0.25				
Leisure and education	1	0.56 ***	-0.36	0.64 ***	0.25 *	0.18	-1.65 ***						
Transport	1	0.27 **	0.48 ***	0.78 **	0.34 **	0.13	0.21						

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 24 quarters and a maximum of 4 breaks.*

Table 7: Structural Breaks, Intercept and Persistence Parameters for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (24 Quarters) *)*
Seasonal Adjustment: Fourth Seasonal Differences (D4)

	Panel A: Structural Break Tests						**Panel B: Intercept and Persistence Parameters**									
	A-P Test		B-P Test for Mutiple Breaks *)				Total Sample		Regime 1		Regime 2		Regime 3		Regime 4	
	NB	BD	NB	Break dates 1	2	3	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series																
GDP deflator	1	85:Q4	3	76:Q1	85:Q4	95:Q2	0.37 **	0.90 ***	1.39 **	0.79 ***	4.74 ***	0.03	1.37 ***	0.53 ***	0.24 **	0.78 ***
Private consumption deflator	1	85:Q4	3	74:Q2	83:Q4	95:Q2	0.21 **	0.94 ***	-0.03	1.07 ***	1.09 ***	0.81 ***	0.78 **	0.73 ***	0.41 **	0.74 ***
Whole sale price index	1	82:Q2	1	82:Q2			0.22 **	0.92 ***	0.73 ***	0.87 ***	0.21 **	0.75 ***				
Consumer price index	1	85:Q4	3	77:Q2	85:Q4	95:Q2	0.14 *	0.96 ***	0.50 **	0.92 ***	1.21 ***	0.75 ***	0.56 ***	0.79 ***	0.47 **	0.72 ***
Use categories																
Food, beverages and tobacco	1	85:Q4	2	85:Q4	95:Q4		0.21 *	0.93 ***	1.07 ***	0.79 ***	0.43 **	0.81 ***	0.82 ***	0.41 **		
Housing (rent and maintainance)	1	85:Q4	3	77:Q4	85:Q4	97:Q4	0.25 *	0.96 ***	2.19 **	0.81 ***	1.69 ***	0.75 ***	0.57 ***	0.86 ***	0.92 ***	0.62 ***
Electricity and heating	1	82:Q3	2	74:Q2	82:Q2		0.41 **	0.90 ***	0.56	0.96 ***	1.81 *	0.80 ***	0.27	0.81 ***		
Furniture and household equipment	1	95:Q1	3	74:Q2	85:Q4	95:Q2	0.20 **	0.92 ***	0.10	1.08 ***	1.10 ***	0.72 ***	0.86 ***	0.67 ***	0.25 **	0.76 ***
Clothing and personnel equipment	1	95:Q2	3	74:Q2	82:Q4	95:Q2	0.18 *	0.93 ***	0.06	1.05 ***	1.45 **	0.68 ***	0.82 ***	0.75 ***	0.08	0.57 ***
Cleaning (apartment, linen and clothes)	1	85:Q4	3	74:Q2	82:Q3	94:Q1	0.41 ***	0.89 ***	2.30 ***	0.54 ***	1.36 ***	0.79 ***	0.56 **	0.80 ***	0.51 **	0.60 ***
Body and health care	1	79:Q4	2	79:Q4	96:Q4		1.08 **	0.77 ***	6.46 ***	0.12	1.57 **	0.64 ***	0.64 ***	0.68 ***		
Leisure and education	1	86:Q3	3	74:Q2	83:Q2	94:Q1	0.56 **	0.83 ***	0.66 **	0.84 ***	0.97 *	0.82 ***	2.59 **	0.26	0.71 ***	0.52 ***
Transport	1	85:Q2	1	85:Q2			0.46 **	0.88 ***	1.52 **	0.75 ***	1.12 ***	0.50 ***				

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix. ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 24 quarters and a maximum of 4 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Table 8: Structural Breaks, Intercept and Persistence Parameters for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (24 Quarters) *)*
Seasonal Adjustment: X12-Arima

	Panel A: Structural Break Tests						**Panel B: Intercept and Persistence Parameters**									
	A-P Test		B-P Test for Mutiple Breaks *)				Total Sample		Regime 1		Regime 2		Regime 3		Regime 4	
	NB	BD	NB	Break dates 1	2	3	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series																
GDP deflator	1	84:Q1	1	84:Q1			0.32 **	0.64 ***	1.52 ***	-0.08	0.27 **	0.44 **				
Private consumption deflator	1	84:Q1	2	84:Q1	94:Q3		0.14 *	0.85 ***	0.64 ***	0.57 ***	0.44 *	0.33	0.25 *	0.36		
Whole sale price index	1	82:Q2	1	82:Q2			0.21 ***	0.70 ***	0.54 **	0.63 ***	0.13	0.30 **				
Consumer price index	1	84:Q1	2	82:Q2	94:Q3		0.11 **	0.88 ***	0.31 **	0.79 ***	0.45 ***	0.38 **	0.23 **	0.45 **		
Use categories																
Food, beverages and tobacco	1	84:Q2	1	84:Q2			0.29 ***	0.64 ***	0.91 ***	0.25 *	0.24 ***	0.43 ***				
Housing (rent and maintainance)	1	84:Q1	3	76:Q3	85:Q4	96:Q3	0.13 *	0.90 ***	1.47 *	0.43	0.68 ***	0.57 ***	0.24 **	0.75 ***	0.58 ***	-0.08
Electricity and heating	1	82:Q2	2	74:Q2	82:Q2		0.37 **	0.63 ***	0.83 **	0.41 **	1.46 **	0.41 ***	0.16	0.51 ***		
Furniture and household equipment	1	95:Q4	2	82:Q2	95:Q1		0.09 *	0.85 ***	0.30 **	0.72 ***	0.45 **	0.33 *	0.14 **	0.37 *		
Clothing and personnel equipment	1	95:Q1	2	80:Q3	95:Q1		0.16 **	0.78 ***	0.26 **	0.79 ***	0.50 **	0.35	0.07	0.07		
Cleaning (apartment, linen and clothes)	1	84:Q2	1	84:Q2			0.29 ***	0.66 ***	0.66 ***	0.54 ***	0.34 ***	0.28 *				
Body and health care	1	79:Q4	2	79:Q4	95:Q1		0.27 **	0.73 ***	3.68 **	-1.12	0.76 **	0.31	0.46			
Leisure and education	1	95:Q3	1	95:Q3			0.56 ***	0.37 **	1.00 ***	0.10	0.58 ***	-0.67				
Transport	1	82:Q4	1	82:Q4			0.42 ***	0.55 ***	0.89 ***	0.42 **	0.44 **	0.24				

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 24 quarters and a maximum of 4 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Table 9: Structural breaks, Intercept and Persistence Parameters for Inflation in Austria
Aggregate and CPI Subaggregate Indices (Quarterly Data, 1967:Q2 – 2004:Q4)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (24 Quarters) *)*
Seasonal Adjustment: Tramo/Seats (Total Sample)

	Panel A: Structural Break Tests						**Panel B: Intercept and Persistence Parameters**									
	A-P Test		B-P Test for Mutiple Breaks *)				Total Sample		Regime 1		Regime 2		Regime 3		Regime 4	
	NB	BD	NB	Break dates 1	2	3	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series																
GDP deflator	1	84:Q1	2	84:Q1	95:Q4		0.20 **	0.78 ***	1.04 ***	0.28	0.82 ***	-0.10	0.11	0.62 ***		
Private consumption deflator	1	82:Q3	2	82:Q2	95:Q4		0.03	0.96 ***	0.41 ***	0.71 ***	0.20 ***	0.75 ***	0.13 **	0.68 ***		
Whole sale price index	1	86:Q4	1	86:Q4			0.39 ***	0.40 ***	0.80 ***	0.15	0.26 ***	0.32 **				
Consumer price index	1	82:Q2	2	82:Q2	94:Q3		0.10 **	0.90 ***	0.37 ***	0.74 ***	0.33 ***	0.56 ***	0.25 **	0.48 ***		
Use categories																
Food, beverages and tobacco	1	84:Q2	2	84:Q1	94:Q3		0.37 ***	0.53 ***	1.10 ***	-0.01	0.37 ***	0.40 ***	0.30 ***	0.25 *		
Housing (rent and maintainance)	1	85:Q4	3	74:Q2	85:Q4	96:Q3	0.08	0.93 ***	0.98 **	0.58 ***	0.64 **	0.64 ***	0.44 **	0.63 ***	0.57 **	0.15
Electricity and heating	1	77:Q1	3	79:Q3	88:Q2	96:Q4	0.22 **	0.78 ***	0.77 ***	0.57 ***	-0.09	0.52 **	0.58 ***	0.03	0.41 **	0.69 ***
Furniture and household equipment	1	95:Q1	3	78:Q3	86:Q1	95:Q1	0.27 ***	0.60 ***	0.40 ***	0.47 ***	0.53 ***	0.46 ***	0.64 **	0.10	0.30 ***	-0.03
Clothing and personnel equipment	1	95:Q1	2	80:Q4	96:Q2		0.04	0.95 ***	0.12 **	0.91 ***	0.16 **	0.78 ***	0.02	0.73 ***		
Cleaning (apartment, linen and clothes)	1	84:Q3	2	84:Q3	94:Q4		0.47 ***	0.48 ***	1.19 ***	0.05	0.60 **	0.29	0.58 ***	-0.19		
Body and health care	1	95:Q1	2	77:Q4	95:Q1		0.65 ***	0.45 **	1.65 **	-0.50	0.89 ***	0.34 *	1.25 ***	-0.35		
Leisure and education	1	94:Q4	3	79:Q3	88:Q1	97:Q4	0.11 ***	0.89 ***	0.16 ***	0.87 ***	0.74 ***	0.45 ***	0.26 **	0.71 ***	0.28 ***	0.42 **
Transport	1	82:Q4	1	82:Q4			0.51 ***	0.47 ***	1.04 ***	0.32 **	0.52 ***	0.14				

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 24 quarters and a maximum of 4 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Table 10 – Panel A: Structural Breaks for Inflation in Austria
CPI Subaggregate Indices (Monthly Data, 1967:M02 – 2004:M12)
Minimum Span 72 Months

		Andrews - Ploberger Test		Bai - Perron Test for Mutiple Breaks*)				
		No. of Break	Break date	No. of Breaks	Break dates			
					1	2	3	4
	Aggregate series							
1	Consumer price index	1	82:M05	2	82:M05	95:M12		
	Use categories							
7	Food, beverages and tobacco	1	84:M06	1	84:M06			
8	Housing (rent and maintainance)	1	76:M09	4	76:M09	84:M09	90:M09	96:M09
9	Electricity and heating	1	85:M04	1	85:M04			
10	Furniture and household equipment	1	95:M02	2	82:M04	95:M02		
11	Clothing and personnel equipment	1	95:M01	2	75:M08	95:M01		
12	Cleaning (apartment, linen and clothes)	1	82:M06	3	77:M02	84:M07	93:M11	
13	Body and health care	1	74:M11	2	74:M11	95:M01		
14	Leisure and education	1	95:M04	2	83:M12	95:M04		
15	Transport	1	81:M10	1	81:M10			

Note: Seasonal adjustment with TRAMO/SEATS applied to 4 subsamples: 1966:M02–1976:M12, 1977:M01–1986:M12, 1987:M01–1996:M12, 1997:M01–2004:M12
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 72 Months and a maximum of 4 breaks.*

Table 10 – Panel B: Intercept and Persistence Parameters for Inflation in Austria
CPI Subaggregate Indices (Montly Data, 1967:M2 – 2004:M12)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (72 Months) *)*

	NB	Total Sample		Regime 1		Regime 2		Regime 3		Regime 4		Regime 5	
		α	ρ	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series													
Consumer price index	2	0.03 *	0.90 ***	0.13 **	0.75 ***	0.13 **	0.49 **	0.07 **	0.49 **				
Use categories													
Food, beverages and tobacco	1	0.10 ***	0.62 ***	0.34 ***	0.20	0.10 **	0.34 *						
Housing	4	0.04 **	0.90 ***	0.40 ***	0.52 ***	0.24 ***	0.53 ***	0.15 ***	0.49 ***	0.15 **	0.60 ***	0.16 **	0.31
Electricity and heating	1	0.19 ***	0.37 ***	0.55 ***	-0.01	0.06 *	0.24 *						
Furniture and household	2	0.05 **	0.76 ***	0.16 ***	0.56 ***	0.17 ***	0.21	0.07 *	0.06				
Clothing and personnel equipment	2	0.03	0.90 ***	0.08 **	0.86 ***	0.40 ***	-0.38 *	0.01	0.47 **				
Cleaning (apartment, linen and clothes)	3	0.13 ***	0.57 ***	0.16 **	0.75 ***	0.19 ***	0.49 ***	0.18 ***	0.22 **	0.14 **	-0.27		
Body and health care	2	0.06 *	0.82 ***	1.65 **	-1.42	0.38 ***	-0.01	0.10 ***	0.45 ***				
Leisure and education	2	0.08 **	0.73 ***	0.14 *	0.68 ***	0.30 **	0.04	0.10 ***	0.18				
Transport	1	0.25 ***	0.18 **	0.59 ***	-0.17	0.18 ***	0.05						

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
Seasonal adjustment with TRAMO/SEATS applied to 4 subsamples: 1966:M02 - 1976:M12, 1977:M01 - 1986:M12, 1987:M01 - 1996:M12, 1997:M01 - 2004:M12.
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 72 months and a maximum of 4 breaks.*

Table 11: Structural Breaks, Intercept and Persistence Parameters for Inflation in Austria
CPI Subaggregate Indices (Montly Data, 1978:M02 – 2004:M12)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (60 Months) *)*

	Panel A: Structural Break Tests						Panel B: Intercept and Persistence Parameters									
	A-P Test		Bai - Perron Test for Mutiple Breaks *)				Total Sample		Regime 1		Regime 2		Regime 3		Regime 4	
	NB	BD	NB	Break dates 1	2	3	α	ρ	α	ρ	α	ρ	α	ρ	α	ρ
Aggregate series																
Consumer price index	1	85:M04	2	84:M02	95:M12		0.03 *	0.87 ***	0.16 *	0.64 ***	0.09 *	0.59 **	0.06 **	0.55 **		
Main groups																
Unprocessed food	0		0				0.25 ***	-0.24 **								
Processed food	1	86:M07	1	86:M07			0.14 ***	0.25 ***	0.21 ***	0.29 **	0.14 ***	-0.08				
Energy	1	85:M05	1	85:M05			0.13 **	0.36 ***	0.29 ***	0.46 ***	0.06	0.24 **				
Non-energy industrial goods	1	94:M08	2	85:M12	94:M08		0.01	0.93 ***	0.35 **	-0.16	0.16 **	0.28	0.03 **	0.20		
Services	1	85:M05	2	84:M02	95:M07		0.04 *	0.87 ***	0.23 *	0.55 **	0.13 **	0.63 ***	0.15 ***	0.26		
Use categories																
Food, beverages and tobacco	1	84:M06	1	84:M06			0.09 **	0.56 ***	0.27 **	0.32	0.10 **	0.36 *				
Housing (rent and maintainance)	1	84:M09	3	84:M09	90:M09	96:M09	0.04 *	0.88 ***	0.15 **	0.71 ***	0.15 ***	0.49 ***	0.15 **	0.60 ***	0.16 **	0.31
Electricity and heating	1	85:M04	2	85:M04	91:M04		0.11 ***	0.51 ***	0.54 ***	0.01	-0.05	0.22	0.11 **	0.27		
Furniture and household	1	95:M02	2	85:M06	95:M02		0.06 ***	0.69 ***	0.12 **	0.59 ***	0.20 ***	0.03	0.08 **	-0.05		
Clothing and personnel equipment	1	95:M01	1	95:M01			0.02	0.89 ***	0.35 ***	-0.20	0.01	0.47 **				
Cleaning (apartment, linen and clothes)	1	84:M07	2	84:M07	93:M11		0.20 ***	0.09	0.20 ***	0.46 ***	0.19 ***	0.18	0.13 **	-0.22		
Body and health care	1	95:M01	2	83:M06	96:M12		0.06 **	0.80 ***	0.30 **	0.32	0.26 ***	0.25	0.12 **	0.26		
Leisure and education	1	95:M04	1	95:M04			0.09 **	0.67 ***	0.23 **	0.36 *	0.10 ***	0.18				
Transport	1	81:M10	1	85:M04			0.20 ***	0.19 **	0.33 ***	0.26 *	0.16 ***	0.01				

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates. OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix. ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
Seasonal adjustment with TRAMO/SEATS applied to 3 subsamples: 1977:M01–1986:M12, 1987:M01–1996:M12, 1997:M01–2004:M12.
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 60 months and a maximum of 3 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Table 12: Structural Breaks, Intercept and Persistence Parameters for Inflation in Austria
CPI Subaggregate Indices (Montly Data, 1988:M02 – 2004:M12)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (48 Months) *)*

	Panel A: Structural Break Tests					**Panel B: Intercept and Persistence Parameters**					
	A-P Test		B-P Test *)			Total Sample		Regime 1		Regime 2	
	NB	BD	NB	Break dates 1	2	α	ρ	α	ρ	α	ρ
Aggregate series											
Consumer price index	1	95:M12	1	95:M12		0.04 **	0.78 ***	0.11 **	0.62 ***	0.08 **	0.42 **
Main groups											
Unprocessed food	0		0			0.21 ***	-0.21 *				
Processed food	1	90:M03	1	93:M06		0.14 ***	-0.04	0.12 ***	-0.16	0.14 ***	0.04
Energy	0		0			0.13 **	0.10				
Non-energy industrial goods	1	94:M08	1	94:M08		0.01	0.90 ***	0.12	0.52	0.03 **	0.20
Services	1	95:M07	1	95:M07		0.12 ***	0.54 ***	0.24 ***	0.30 *	0.16 ***	0.21
Use categories											
Food, beverages and tobacco	0		0			0.08 ***	0.53 ***				
Housing (rent and maintainance)	1	96:M09	1	96:M09		0.12 ***	0.59 ***	0.13 ***	0.63 ***	0.21 ***	0.10
Electricity and heating	1	2002:M04	1	95:M04		0.11 **	0.07	0.06	-0.10	0.15 **	0.09
Furniture and household	1	95:M02	1	95:M02		0.09 ***	0.34 ***	0.24 ***	-0.06	0.08 ***	-0.10
Clothing and personnel equipment	1	95:M01	1	95:M01		0.01	0.91 ***	0.16 **	0.46 *	0.01	0.47 **
Cleaning (apartment, linen and clothes)	0		0			0.18 ***	-0.14				
Body and health care	1	95:M01	1	95:M01		0.06 **	0.78 ***	0.27 ***	0.26	0.12 ***	0.30 **
Leisure and education	1	95:M04	1	95:M04		0.07 **	0.66 ***	0.27 *	0.25	0.10 ***	0.18
Transport	0		0			0.19 ***	-0.01				

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
Seasonal adjustment with TRAMO/SEATS applied to 2 subsamples: 1987:M01–1996:M12, 1997:M01–2004:M12.
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 48 months and a maximum of 2 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Table 13: Structural Breaks, Intercept and Persistence Parameters for Inflation in Austria
HICP Subaggregate Indices (Montly Data, 1988:M02 – 2004:M12)
*Total Sample and Various Regimes – Conditional on the Occurence of Structural Breaks (48 Months) *)*

	Panel A: Structural Break Tests					**Panel B: Intercept and Persistence Parameters**					
	A-P Test		B-P Test			Total Sample		Regime 1		Regime 2	
	NB	BD	NB	Break dates							
				1	2	α	ρ	α	ρ	α	ρ
Aggregate series											
Harmonized consumer price index	1	94:M09	1	94:M09		0.13 ***	0.20	0.19 ***	0.15	0.14 ***	-0.10
Main groups											
Unprocessed food	0		0			0.25 **	-0.15				
Processed food	1	90:M01	1	93:M01		0.09 ***	0.08	0.07 **	0.03	0.11 ***	0.07
Energy	0		0			0.15 **	0.20 *				
Non-energy industrial goods	1	95:M01	1	95:M01		0.01	0.89 ***	0.12 **	0.42	0.01	0.09
Services	1	97:M02	1	97:M02		0.19 ***	0.23 *	0.09 ***	0.70 ***	0.21 ***	-0.12

*Note: NB No. of structural breaks; Areas in light grey indicate persistence estimates; OLS Estimates with heteroskedasticity and autocorrelation consistent (HAC) covariance matrix; ***, **, * indicate statistical significance at the 1, 5 and 10 percent level, respectively.*
Seasonal adjustment with TRAMO/SEATS applied to 2 subsamples: 1987:M01–1996:M12, 1997:M01–2004:M12.
**) Structural break dates for various regimes are based on Bai-Perron's test with a minimum span of 48 months and a maximum of 2 breaks.*
A-P Test: Andrews and Ploberger test for a single break point.

Comment on "Inflation Persistence in Austria: First Results for Aggregate and Sectoral Price Series"[1]

Markus Knell

Oesterreichische Nationalbank

1. Introduction

The Inflation Persistence Network (IPN) has produced an impressive body of evidence concerning price-setting behavior and the stickiness and persistence of prices and inflation in euro area countries. In accordance with the fact that inflation persistence is a multi-facetted phenomenon the IPN researchers have used a wide variety of methods that range from micro-data analyses and survey studies to calibrated macroeconomic models. The present paper by Josef Baumgartner adds to this literature by using econometric time series techniques to document various relevant properties of Austrian price indices. There already exist some papers (cf. Lünnemann and Mathä, 2004; Cecchetti and Debelle, 2005) that have undertaken such an analysis of aggregated and disaggregated price indices. The aim of these papers, however, was an international comparison between different countries and thus I think it is a reasonable and valuable exercise that national experts look more deeply (and with the intricate knowledge of national insiders about index changes, tax increase and other typical peculiarities of such time series) at the behavior of particular variables.

My discussion of the paper by Josef Baumgartner is divided into two parts. In section 2, I will briefly summarize some of the crucial results of the paper. In section 3, I will comment on these results and I will offer some suggestions for possible extensions of the paper and possible topics for future research.

2. Short Summary

In this section I want to summarize the main results of the paper in brief bullet-point form:

- The paper uses univariate autoregressive models to analyze the inflation persistence of four aggregate price indices (GDP deflator [PGDP], private

[1] The comments refer to the version of the paper that was presented at the OeNB workshop "Price Setting and Inflation Persistence in Austria" on December 15, 2005.

consumption deflator [PCP], wholesales price index [WPI] and consumer price index [CPI]) and three groups of disaggregated price indices ("use" with 10 sectors; "main groups" with 5 sectors and the 181 individual goods from the CPI basket of goods).

- The longest time period (1966–2004) shows a high persistence (for the CPI series, e.g., one gets that ρ=0.91). Having account of structural breaks (i.e. of changes in the average inflation rate), however, reduces the extent of persistence considerably (for the CPI, e.g., to values of ρ between 0.29 and 0.72).
- For most time series one finds two to three of such structural breaks (in the mid-1970s, the mid-1980s and the mid-1990s).
- The benchmark estimation is based on (i) quarterly data, (ii) a long time sample (1966 - 2004), (iii) seasonal adjustment with the Tramo/Seats Method (for four subsamples) and (iv) while allowing for multiple structural breaks and testing for them with Bai-Perron tests (minimum regime length: 24 quarters, maximum number of structural breaks: 4). The validity of the results is, however, also analyzed under alternative assumptions. In particular with (i) monthly data, (ii) shorter time intervals, (iii) different methods for seasonal adjustment and (iv) under the assumption of only one structural break (Andrews-Ploberger test).
- The results of these robustness tests are rather ambiguous. The estimated dates for the structural breaks fluctuate to a lesser extend than the estimates for ρ (persistence) and α (intercept).

3. Comments on the Paper

3.1 Robustness of the Results and Interpretation

At the moment the paper contains a large number of inflation persistence estimations that refer to various indices, time periods, variables, estimation methods etc. This large number of estimations requires some efforts to structure, systematize and interpret the results. One crucial issue in this respect refers, e.g., to the robustness of the persistence estimations.

Table 1: Summary of Estimations Based on the CPI for the Last Regime (1995–2004)

Source	Description	α	ρ	π*=α/(1-ρ)
Table 4	Benchmark	0.19	0.54	1.65
Table 5	Short Period (1978-2004)	0.19	0.54	1.65
Table 6	Seasonal Dummies	0.20	0.26	1.08
Table 7	Fourth Seasonal Differences (D4)	0.47	0.72	1.68
Table 8	X12-Seasonal Adjustment	0.23	0.45	1.67
Table 9	Tramo/Seats II	0.25	0.48	1.92
Table 10	Monthly Data	0.07	0.49	1.65
Table 13	HICP, monthly	0.14	–0.10	1.53

Source: Various tables in Baumgartner (in this volume).

In table 1, I have collected the results of eight estimations that use the CPI and refer to the last regime (1995–2004). Given the public and political importance of the consumer price index and the crucial changes in monetary policy that took place over the last decade this subinterval seems to be of special interest. Table 1 reports the estimates of the intercept α, the persistence parameter ρ and the long-run inflation rate that is implied by this parameter values ($\pi^* = \frac{\alpha}{1-\rho}$). This last relation follows from the following equation:

$$\pi_t = \alpha + \rho\pi_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta\pi_{t-i} + \varepsilon_t, \qquad (1)$$

with $\Delta\pi_{t-i} = 0$ and $\varepsilon_t = 0$. Looking at table 1 we can make the following observations:

- The estimated structural break lies always in the vicinity of the second quarter of 1995. The timing of the break is thus rather robust and cannot be the source of differences in the estimated parameter values.
- The estimations of the implied long-run inflation rate fluctuate between 1.08 and 1.92 (or between 1.53 and 1.92 if we disregard the estimation that is based on seasonal adjustment with dummies). These rather moderate fluctuations are to be expected since the estimation method will necessarily lead to a π^* that will be close to the period average in the rate of inflation (with was around 1.6%).
- The fluctuations in the implied long-run inflation rate are, however, also reflected in the estimations of the persistence parameter. For five estimations (using quarterly data) it lies around 0.5 while for seasonal adjustment

according to D4 it is considerable larger (0.72) and with seasonal dummies considerably smaller (0.26). Probably this can be explained by the adjustment methods but it would be interesting to have a discussion along these lines in the paper. On the total I have to say, however, that I like the careful treatment of the seasonal adjustment topic in this paper. This issue is often neglected (or treated with some nonchalance) while it can have an essential impact on the results (as one can learn from the paper by Josef Baumgartner).

- The estimation based on monthly CPI data also arrives at a persistence parameter around one half. At first sight this might be interpreted as a comforting sign of the robustness of the $\rho=0.5$ result. At closer inspection, however, I don't quite understand this result since it seems to imply that inflation is as sticky across months as it is across quarters.
- The results based on the HICP is somewhat strange and lies completely outside the range of the other estimations ($\rho=-0.1$). Given that the index is not all that different from the CPI it would be interesting to read about the author's explanation for this behavior.

3.2 Comparison of the Results

Furthermore, it could be interesting to compare the results of the disaggregated price indices with the similar papers of Lünnemann and Mathä (2004) and Cecchetti and Debelle (2005). Is it, e.g., also true for Austria that food prices show more persistence than the one for services/durables? Given that the existing literature was not able to find robust results about this differential stickiness across sectors, I do not expect to find very consistent results about Austria. Nevertheless, it would be nice to have at least some paragraphs on this issue.

It could also be a useful "value-added" of the paper to collect information (perhaps in an appendix) about details and particularities of the construction and calculation of the Austrian price indices. For example, information about changes in sales taxes or details concerning the treatment of sales or of educational expenses or of the costs for housing. For international researchers such information is often difficult to gain and the paper could also serve as a valuable source of reference in this respect.

3.3 Possible Limitations of the Univariate Approach

In this section I want to discuss briefly main elements and possible criticisms of the univariate time series approach to a measurement of inflation persistence. I want to start this discussion with the "mission statement" of the IPN: "The main goal of the IPN is to understand the speed and pattern of inflation adjustment in response to shocks of different nature. Inflation persistence then refers to the tendency of inflation to converge slowly (or sluggishly) towards its long-run value following

such shocks" (Angeloni et al., 2004, p. 4). As expressed in this quotation there are two necessary ingredients for an accurate estimation of inflation persistence: (i) knowledge about the long-run value of inflation and (ii) knowledge about the occurrence and persistence of the "shocks of different nature".

The univariate approach to the measurement of inflation persistence is based on the estimation of equation (1) that uses a single time series of one price index (around 150 observations for quarterly data) and a number of rather restrictive assumptions to meet these informational requirements. The long-run value of inflation is associated with the intercept α which is assumed to change over time (structural breaks) in order to allow for changes in monetary policy and different inflation targets. In order to deal with the presence of shocks it is assumed that the ε_t are i.i.d. and thus show no persistence. This assumption does not seem to be very realistic since the decades since 1966 have been characterized by various cost and demand shocks (e.g. oil price shocks, trade shocks, productivity and wage developments), sometimes of a rather sticky and persistent nature. A high estimation of ρ might thus simply reflect the stickiness of real shocks rather than the persistence of inflation itself. A remedy for these short-comings of the univariate approach would be to amend it with additional data source. One could use, e.g., data on inflation expectation in order to proxy for the long-run value of inflation or one could use other macroeconomic time series in order to allow for the various kind of economic shocks. This, however, would push this approach closer towards other more structural econometric techniques that are based on the estimation of Phillips curves or various VAR approaches.

On the total, I would say that the univariate approach is a reasonable and useful instrument to get a first impression about the main properties of inflation and price index data. The interpretation of these results (in particular of the persistence parameter ρ), however, is somewhat more difficult and one should probably also use information from other data sources or from other related studies.

3.4 Suggestions for Extensions and Further Research

In general it would be interesting to compare the main results of the paper to similar findings of the related micro-data analyses and firm surveys. E.g., can one observe similar patterns of persistence and price-setting across sectors? Furthermore it would be worthwhile to investigate whether the sectoral differences could be (at least partly) explained by structural differences between the sectors, e.g.: market concentration and market form, openness and international competition, characteristics of wage-setting etc. These extensions would, however, involve rather time consuming efforts to collect data and should be interpreted as suggestions for future research.

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Estimates of the Open Economy New Keynesian Phillips Curve for Euro Area Countries[1]

Fabio Rumler[2]

Oesterreichische Nationalbank

Abstract

This paper extends the existing literature on the open economy New Keynesian Phillips Curve by incorporating three different factors of production, domestic labor and imported as well as domestically produced intermediate goods, into a general model which nests existing closed economy and open economy models as special cases. The model is then estimated for nine euro area countries and the euro area aggregate. We find that structural price rigidity is systematically lower in the open economy specification of the model than in the closed economy specification indicating that when firms face more variable input costs they tend to adjust their prices more frequently. However, when the model is estimated in its general specification including also domestic intermediate inputs, price rigidity increases again compared to the open economy specification without domestic intermediate inputs.

JEL codes: E31, C22, E12
Keywords: New Keynesian Phillips Curve, Open Economy, GMM

1. Introduction

There is vast evidence in the literature that the baseline New Keynesian Phillips Curve model with the labor share proxying real marginal cost as the driving

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[2] Oesterreichische Nationalbank, Economic Analysis Division, Otto Wagner Platz 3, A-1090 Vienna, Austria, E-Mail: Fabio.Rumler@oenb.at.

variable of inflation can explain inflation dynamics in many large industrial economies reasonably well; see Gali and Gertler (1999) and Sbordone (2002) for the U.S.A., and Gali, Gertler and Lopez-Salido (2001), McAdam and Willman (2002) for the euro area and Balakrishnan and Lopez-Salido (2002) for the U.K.

However, a number of studies have also shown that the baseline model is not always appropriate in tracking inflation dynamics in particular for open economies, see Balakrishnan and Lopez-Salido (2002) for the U.K., Bardsen et al. (2004) for European countries, Freystätter (2003) for Finland, Rubene and Guarda (2004) for Luxembourg, and Sondergaard (2002) for Germany, France and Spain. Reduced form estimates for the marginal cost term in the baseline model are often found to be insignificant in these studies.

The problem with the labor share as a proxy for real marginal cost is the fact that it covers only part of the total cost of production of the firm. It ignores the costs of material inputs which especially in the manufacturing industry account for a large part of the total costs of firms.[3] In addition, part of the intermediate inputs are imported from abroad, which consist of mainly raw materials and energy but also semi-manufactured inputs from other industrial economies. Usually the prices of imported inputs are more variable than of domestic labor as well as domestically produced intermediate inputs. This should – other things equal – induce firms to change their prices more frequently and possibly also by a larger amount in response to more variable input costs. If this behavior can be detected also in aggregate data, i.e. if additionally taking into account the costs of intermediate inputs in the marginal cost term of the New Keynesian Phillips Curve (NKPC) can explain price dynamics in the euro area countries more appropriately, will be examined in the second part of this paper.

In this paper the baseline model is extended in order to account for open economy effects as well as effects of intermediate goods in the production technology of the firm. Real marginal cost as a driving variable for inflation is decomposed into the relative prices of three different factors of production: real unit labor costs and the prices of imported and domestically produced intermediate goods. The formulation of our general model including imported as well as domestically produced intermediate inputs in production nests existing closed and open economy models of the hybrid NKPC.

The model is then estimated for the closed economy case, the case with only imported intermediate inputs and in the general formulation with imported and domestically produced intermediate inputs in different specifications for nine euro

[3] In Germany, for instance, the proportion of the costs of intermediate inputs compared to the wage costs in the total economy amounted to about 60:40 on average from 1991 to 2003. According to the German input-output tables for 2000 the intermediate inputs and wage costs together accounted for about 80% of the total value of nominal output, while wage costs alone would only account for about 30% of the value of output. Similar figures can be cited for other countries.

area countries and the euro area aggregate with data from 1970 to 2003 Q2 (for some countries the sample range might differ due to data availability). Our general finding from these estimations is that open economy aspects matter for the performance and the fit of the NKPC. We find that the degree of structural price rigidity as measured by the Calvo probability of changing a price is systematically higher for the closed economy specification than in the open economy specification with only imported intermediate inputs in production. This could be explained by the fact that when firms face more variable input costs as they import from volatile international markets they tend to adjust their prices more frequently. When comparing the open economy specification with only imported intermediate inputs and the most general specification with imported and domestically produced intermediate inputs structural price rigidity is found to be systematically higher in the latter case. This could be due to substitution of imported by domestic intermediate goods when the relative price of the former increases, thus mitigating the need for the firm to adjust prices.

This paper is structured as follows. Section 2 introduces the theoretical model with monopolistically competitive firms employing three different input factors in the production of their output which is then used for final consumption demand and by other firms as intermediate input. The open economy hybrid NKPC is derived from the profit maximization problem of the firm under the Calvo pricing assumption. The model is then put to the data of nine euro area countries and the euro area aggregate. Issues on the empirical implementation of the model, in particular the different specifications for which the model is estimated, are discussed and the results of the estimations are presented and interpreted in section 3. Finally, section 4 concludes the paper.

2. The Model

The open economy New Keynesian Phillips Curve is derived from an open economy model in which international trade takes place at two levels of production. Monopolistically competitive firms sell their products to consumers at home and abroad as well as to domestic and foreign firms for their use as intermediate input. So, the representative firm's output is used partly for domestic and foreign final demand and partly as intermediate input in the production of domestic and foreign firms. The production technology of a firm includes domestic labor, foreign and domestically produced intermediate goods as factors of production such that the relative prices of these factors affect marginal costs of production. The firm's price-setting behavior is derived from the maximization of future discounted profits assuming Calvo (1983) type pricing, i.e. firms are allowed to reset their price after a random interval of time. In addition, we assume that within the group of Calvo price setters some follow a rule of thumb updating their prices with past inflation while the rest sets its price optimally which gives rise to a

hybrid open economy NKPC. The model is based on the line of research started by Gali and Gertler (1999) and Gali, Gertler and Lopez-Salido (2001) on the hybrid specification of the NKPC. It draws heavily on the open economy NKPC model of Leith and Malley (2003) extending their model by introducing a third factor of production, i.e. domestically produced intermediate goods, in order to allow firms to shift between domestic and foreign inputs in production. Related models also specifying a variant of the open economy NKPC can be found in Balakrishnan and Lopez-Salido (2002), Razin and Yuen (2002) and Gali and Lopez-Salido (2001).

2.1 Product Demand

In our open economy model consumers derive their utility from a consumption bundle including domestic and foreign consumption goods:

$$C_t = \left[\chi^{\frac{1}{\eta}} \left(c_t^d \right)^{\frac{\eta-1}{\eta}} + (1-\chi)^{\frac{1}{\eta}} \left(c_t^f \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{1}$$

where $c_t^d = \left[\int_0^1 c_t^d(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}}$ and $c_t^f = \left[\int_0^1 c_t^f(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}}$ are again CES indices of consumption goods produced in the home and foreign country, ε is the elasticity of substitution of goods within one country and η the elasticity of substitution of consumption bundles between countries and χ is the parameter representing the home bias in consumption. By assuming $\varepsilon \neq \eta$ we allow the substitutability of goods within countries to differ from the substitutability of goods across countries.[4]

The associated consumption price index which minimizes the cost of purchasing one unit of the composite consumption bundle C_t is given by

$$P_t = \left[\chi \left(p_t^d \right)^{1-\eta} + (1-\chi) \left(p_t^f \right)^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{2}$$

where also $p_t^d = \left[\int_0^1 p_t^d(z)^{1-\varepsilon} dz \right]^{\frac{1}{1-\varepsilon}}$ and $p_t^f = e_t \left[\int_0^1 p_t^{*f}(z)^{1-\varepsilon} dz \right]^{\frac{1}{1-\varepsilon}}$ are the price indices associated with domestic and foreign production (in domestic currency), e_t

[4] See Tille (2001). Most other contributions like the well known paper by Obstfeld and Rogoff (1995) focus on the case where $\varepsilon = \eta$. In our application, however, η appears only implicitly in the NKPC and does not feature as a structural paramter to be estimated or calibrated.

being the nominal exchange rate (where foreign variables are denoted with an asterisk).

In addition to domestic and foreign consumers, the product of each individual firm is also demanded by domestic and foreign producers as intermediate input in their production. So, the output of each firm is partly used for final consumption and partly as intermediate inputs by other firms. Accordingly, the bundles of domestically produced goods used in domestic and foreign production as intermediate inputs are defined by $m_t^d = \left[\int_0^1 m_t^d(z)^{\frac{\varepsilon-1}{\varepsilon}} dz\right]^{\frac{\varepsilon}{\varepsilon-1}}$ and $m_t^{*d} = \left[\int_0^1 m_t^{*d}(z)^{\frac{\varepsilon-1}{\varepsilon}} dz\right]^{\frac{\varepsilon}{\varepsilon-1}}$ where the degree of substitutability between intermediate goods is assumed to be the same as between consumption goods.

Given that domestic and foreign consumers and domestic and foreign producers all demand the product of each individual firm and allocate their demands for consumption and intermediate goods across countries and products with the same pattern, the global demand for the output of firm z is given by[5]

$$y_t^d(z) = \left(\frac{p_t^d(z)}{p_t^d}\right)^{-\varepsilon} \left(c_t^d + c_t^{*d} + m_t^d + m_t^{*d}\right). \tag{3}$$

The demand for the firm's product depends on the price charged by the firm relative to the other domestically produced goods and the total demand of domestic and foreign consumers as well as producers allocated to domestic goods.

2.2 Production Technology

Each individual firm produces its output employing labor and domestic as well as foreign intermediate goods as variable factors of production and a fixed amount of capital

[5] Implicitly consumers and input demanding firms pursue a 2-step optimization by first allocating their demand across countries, which in the case of the domestic demand for domestically produced consumption goods yields $c_t^d = (p_t^d/P_t)^{-\eta} \chi C_t$, and in a second step within a country, which in the case of the demand for a specific domestic firm's consumption good yields $c_t^d(z) = (p_t^d(z)/p_t^d)^{-\varepsilon} c_t^d$ with c_t^d being given by the above expression. The total demand for a domestic firm's output is then the sum of the demand for its consumption good at home and abroad, c_t^d and c_t^{*d} (for which an equivalent expression can be found), as well as for its output employed as intermediate input by domestic and foreign firms, m_t^d and m_t^{*d}, which leads to expression (3).

$$y_t(z) = \left(\alpha_N N_t(z)^{\frac{\rho-1}{\rho}} + \alpha_d m_t^d(z)^{\frac{\rho-1}{\rho}} + \alpha_f m_t^f(z)^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{(\rho-1)\phi}} \overline{K}^{1-\frac{1}{\phi}}, \tag{4}$$

where $N_t(z)$, $m_t^d(z)$ and $m_t^f(z)$ are domestic labor, domestically produced and imported intermediate inputs used in production by firm z and α_N, α_d and α_f are the weights of these factors in the production function. The inputs enter the production function as imperfect substitutes where ρ is the constant elasticity of substitution between them and $1-\frac{1}{\phi}$ represents the weight of fixed capital in production.

To derive marginal costs from this production function we note that the variable factors of production when combined with fixed capital display decreasing marginal returns which induces an increasing marginal cost function and thus a dependence of marginal costs on firm specific output. Firm specific real marginal costs of firm z can then shown to be

$$MC_t(z) = \phi \left[\frac{W_t N_t(z) + p_t^d m_t^d(z) + p_t^f m_t^f(z)}{P_t y_t(z)} \right]. \tag{5}$$

2.3 Price Setting

Firms set their prices by maximizing real variable profits facing the constraints implied by Calvo contracts in that they can only change their prices after a random interval of time. Specifically, firms are allowed to change their price with a fixed probability $1-\theta$ in a given period while they keep their price constant with probability θ. Thus, when deriving the profit maximizing price firms take into account that the price may be in effect for a long period of time and therefore discount future profits with the probability θ. The optimization problem of the firm in period t can then be written as

$$\frac{\Pi_t(z)}{P_t} = E_t \sum_{s=0}^{\infty} \frac{\theta^s \left[\frac{x_t}{P_{t+s}} \left(\frac{x_t}{p_{t+s}^d} \right)^{-\varepsilon} \tilde{y}_{t+s} - MC_t \left(\frac{x_t}{p_{t+s}^d} \right)^{-\varepsilon\phi} \tilde{y}_{t+s}^{\phi} \right]}{\prod_{j=1}^{s} r_{t+j-1}}, \tag{6}$$

where $\Pi_t(z)$ denotes variable profit of the firm, x_t is the newly set optimal price, $\tilde{y}_{t+s}$ summarizes total demand for domestic goods $(c_{t+s}^d + c_{t+s}^{*d} + m_{t+s}^d + m_{t+s}^{*d})$ from

the demand function (3), MC_t is the part of real marginal cost that is not firm specific[6] and r_t is the time-varying discount rate.

Since under the Calvo pricing assumption only a fraction of firms are allowed to reset their price every period, the index of output prices can be shown – by making use of the Law of Large Numbers – to be a weighted average of prices reset in period t and the previous period's price index

$$\left(p_t^d\right)^{1-\varepsilon} = \theta\left(p_{t-1}^d\right)^{1-\varepsilon} + (1-\theta)\left(p_t^r\right)^{1-\varepsilon}, \tag{7}$$

where p_t^r is the reset price in period t. In addition to pure Calvo pricing we also assume that within the group of firms who are allowed to reset its price in a given period a fraction of firms do not set their prices based on the optimization but instead follow a simple rule of thumb. This deviation from optimality by part of the firms is common in the literature and can be rationalized by costs of price adjustment (not modeled here) which become severe especially for firms which receive the random signal of price adjustment within short intervals. With the fraction ω of firms who use the rule of thumb the average reset price in period t is given by

$$p_t^r = \omega p_t^b + (1-\omega)x_t, \tag{8}$$

where p_t^b is the price set according to the rule of thumb which is assumed to be the average reset price of the previous period updated with last period's inflation rate

$$p_t^b = p_{t-1}^r\left(1+\pi_{t-1}^d\right). \tag{9}$$

The assumption of part of the firms following a backward-looking rule of thumb gives rise to the hybrid formulation of the New Keynesian Phillips Curve which has been introduced by Gali and Gertler (1999) and widely used in the literature since then.

Maximizing the firm's real profits given in (6) with respect to x_t and applying the Calvo pricing assumptions just outlined and after log-linearizing the system around a zero-inflation steady state gives rise to an open economy hybrid New Keynesian Phillips Curve

[6] $MC_t(z)$ can be shown to equal $\phi y_t(z)^{\phi-1} MC_t$ where MC_t is a function of the prices of the factors of production and the parameters in the production function that are common to all firms.

$$\hat{\pi}_t^d = E_t \frac{\theta\beta}{\Delta}\hat{\pi}_{t+1}^d + \frac{\omega}{\Delta}\hat{\pi}_{t-1}^d + \frac{(1-\theta)(1-\omega)(1-\theta\beta)}{\left[\varepsilon(\phi-1)+1\right]\Delta}\left[\hat{MC}_t + \hat{P}_t - \hat{p}_t^d + (\phi-1)\hat{\tilde{y}}_t\right], \quad (10)$$

where $\hat{\pi}_t^d = \hat{p}_t^d - \hat{p}_{t-1}^d$ and $\Delta = \theta + \omega[1-\theta(1-\beta)]$ and $\beta = \frac{1}{\bar{r}}$ is the steady-state discount rate of future profits. Hatted variables denote deviations from steady state and barred variables represent steady state values.

In order to transform the open economy NKPC in (10) into a form appropriate for estimation we first note that the marginal cost term that is not firm specific can be decomposed in terms of the prices of all factors of production, namely wages and domestic and foreign intermediate input prices (in log-linearized form)

$$\hat{MC}_t = \frac{\frac{\bar{w}}{\bar{P}}\hat{w}_t + \frac{\bar{p}^d}{\bar{P}}\left(\frac{\bar{w}}{\bar{p}^d}\frac{\alpha_d}{\alpha_N}\right)^{\rho}\hat{p}_t^d + \frac{\bar{p}^f}{\bar{P}}\left(\frac{\bar{w}}{\bar{p}^f}\frac{\alpha_f}{\alpha_N}\right)^{\rho}\hat{p}_t^f}{\frac{\bar{w}}{\bar{P}} + \frac{\bar{p}^d}{\bar{P}}\left(\frac{\bar{w}}{\bar{p}^d}\frac{\alpha_d}{\alpha_N}\right)^{\rho} + \frac{\bar{p}^f}{\bar{P}}\left(\frac{\bar{w}}{\bar{p}^f}\frac{\alpha_f}{\alpha_N}\right)^{\rho}} - \hat{P}_t. \quad (11)$$

Plugging this expression into (10) and applying some further substitutions,[7] the term in square brackets in equation (10) can be expressed in terms of the relative prices of the factors of production and the labor share

$$[....] = \hat{s}_{nt} - (\phi-1)\frac{\bar{s}_{m^d} + \bar{s}_{m^f}}{1+(1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\hat{y}_t + \frac{\bar{s}_{m^f}}{1+(1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\left(\hat{p}_t^d - \hat{p}_t^f\right) -$$

$$\left[(1-\rho)\frac{\bar{s}_{m^d}}{\bar{s}_n + \bar{s}_{m^d} + \bar{s}_{m^f}} + \rho\frac{\bar{s}_{m^d}}{1+(1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\frac{\bar{s}_n}{\bar{s}_n + \bar{s}_{m^d} + \bar{s}_{m^f}}\right]\left(\hat{w}_t - \hat{p}_t^d\right) - \quad (12)$$

$$\left[(1-\rho)\frac{\bar{s}_{m^f}}{\bar{s}_n + \bar{s}_{m^d} + \bar{s}_{m^f}} + \rho\frac{\bar{s}_{m^f}}{1+(1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\frac{\bar{s}_n}{\bar{s}_n + \bar{s}_{m^d} + \bar{s}_{m^f}}\right]\left(\hat{w}_t - \hat{p}_t^f\right)$$

where $s_n = \frac{wN}{p^d y}$, $s_{m^d} = \frac{p^d m^d}{p^d y}$ and $s_{mf} = \frac{p^f m^f}{p^d y}$ are the shares of labor, domestic intermediate goods and imported intermediate goods in GDP and $\phi = \frac{(\varepsilon-1)(1+\bar{s}_{m^d}+\bar{s}_{m^f})}{\varepsilon(\bar{s}_n+\bar{s}_{m^d}+\bar{s}_{m^f})}$

[7] In the case of intermediate goods in production the definition of aggregate firm output appearing in our model differs from the definition of GDP (value added) which is normally used in empirical applications of the NKPC. Therefore, we need to reformulate (10) by substituting aggregate firm output, $\tilde{y}_t$, with GDP, y_t. The derivations are available on request.

can be derived from the steady-state markup and the steady-state labor and intermediate goods shares in production.

From (12) we see that the driving variable of inflation in the open economy case with intermediate goods depends on the log deviation of the labor share, $\hat{s}_{nt}$ (as in the closed economy case), the domestic real labor costs, $\hat{w}_t - \hat{p}_t^d$, representing the relative costs of domestic labor and domestically produced intermediate goods, the relative price of domestic labor and imported intermediate goods, $\hat{w}_t - \hat{p}_t^f$, the terms of trade, $\hat{p}_t^d - \hat{p}_t^f$, representing the relative price of domestically produced and imported intermediate goods, and a term reflecting the decreasing marginal return to production (second term). The weights with which these relative prices enter the expression are determined by the steady state shares of the three factors of production in GDP and the elasticity of substitution between them.

This general specification of the open economy hybrid NKPC nests other open and closed economy models of the NKPC. With the share of domestically produced intermediate goods, s_m^d, set to 0 it reduces to the open economy NKPC model of Leith and Malley (2003) and additionally setting the share of imported intermediate goods, s_m^f, to 0 yields the standard closed economy specification of the NKPC as for instance in Sbordone (2002) or Gali et al. (2004). Gali and Lopez-Salido (2001) and Balakrishnan and Lopez-Salido (2002) derive an open economy NKPC for Spain and the U.K. only taking into account imported intermediate goods in production but not trade in final consumption goods which is thus also nested in our general model.

3. Estimation and Results

3.1 The Data

The open economy New Keynesian Phillips Curve is estimated for nine euro area countries and the euro area aggregate. For Luxembourg, Ireland and Portugal the NKPC could not be estimated either due to the lack of appropriate data or too short time series. The data for the estimation of the country NKPCs have been obtained from two sources, the database of macroeconomic time series compiled for the Inflation Persistence Network and from the New Chronos database provided by Eurostat. The data for real and nominal GDP, the GDP deflator, compensation to employees, employment, real and nominal imports and the import deflator have been taken from the IPN database and the data on intermediate inputs have been downloaded from the national accounts database on New Chronos. Information on the share of imported intermediate goods in total imports have been calculated from input-output tables when available on the New Chronos database. In case the

input-output tables for some countries have been available for more years (New Chronos reports input-output tables for 1995, 1997 and 2000) the imported intermediate goods share has been averaged over the available years. The data on intermediate inputs which are available only at annual frequency have been disaggregated to quarterly frequency with the help of Ecotrim, a software for temporal disaggregation supplied by Eurostat. The shares of domestically produced and imported intermediate inputs, s_m^d and s_m^f, have been calculated as nominal intermediate inputs – decomposed into domestic and imported shares – divided by nominal GDP and the labor share, s_n, is total compensation to employees divided by GDP.

3.2 Empirical Specification

We estimate the structural parameters of the model outlined in the previous section employing a single equation approach. Equation (10) "including" (12) is estimated employing the generalized method of moments (GMM) estimator proposed by Hansen (1982) which has been widely used in solving the orthogonality conditions implied by forward-looking rational expectations models – as in our model, see Verbeek (2000). There is, however, a debate in the literature on the appropriate estimation method for the hybrid specification of inflation dynamics equations like the NKPC. A widely used alternative to the instrumental variables approach adopted in this paper is the estimation of the structural parameters of the NKPC by maximum likelihood (ML). As Gali et al. (2003) note, the debate which approach is most appropriate is completely open. There exists a trade-off of the form that GMM estimates are sensitive to the choice of instruments while ML relies on normality of the error term and on appropriate assumptions on the structure of the economy. Jondeau and Le Bihan (2003) have shown that estimated coefficients under both methods are biased in small samples and in case of misspecified model dynamics, but they are biased in opposite directions, thus not indicating the dominance of one approach over the other. In a recent note Gali et al. (2003) convincingly demonstrate that their GMM estimates of the hybrid NKPC obtained in Gali and Gertler (1999) and Gali et al. (2001) are robust to a variety of different estimation procedures – including also ML. Thus, we believe that the GMM estimator based on an appropriately chosen instrument set entails only a relatively small finite sample bias and delivers quite reliable parameter estimates of the NKPC. Apart from that, the GMM approach was also chosen for comparison with most existing studies on the NKPC which adopted this approach.

The structural parameters which are estimated in our empirical specifications include θ, the probability that a firm keeps a fixed price in a given period, β, the steady-state discount factor of firms, ω, the fraction of firms following the rule of thumb and ρ, the elasticity of substitution between labor, domestic and imported

intermediate inputs in production. However, the elasticity of demand of the firm's product, ε, cannot be estimated econometrically, as it does not appear in the estimation equation, but has to be calibrated in order to derive an empirical value for the elasticity of substitution between capital and the variable factors of production, ϕ. In calibrating ε we follow the literature (see Gali et al. (2001), Leith and Malley (2003)) and adopt a value of 11 as a baseline implying a steady-state markup of prices over marginal costs $\mu = \frac{\varepsilon}{\varepsilon - 1}$ of 1.1.

One important point concerning the empirical implementation of our open economy NKPC is the choice of the price index for the dependent variable domestic output inflation, π_t^d. In the model the price set by a firm is its output price. The output is then used for final consumption demand and intermediate inputs of other forms at home or abroad. Empirically, the appropriate index that measures aggregate output prices is the output deflator. However, output deflators are not available from current accounts statistics for the euro area countries. Another candidate as the empirical counterpart of aggregate output prices is the producer price index (PPI). There are, however, two considerations that limit the use of the producer price index for our estimations: First, also the producer price index for many euro area countries is available only for too short time periods (e.g. for Austria only since 2000) and, second, it does not exactly measure output prices as defined in our model since it only measures prices at the industrial producer level but not at the final demand level. Given this and in order for our results to be comparable to other studies the value added (GDP) deflator has been chosen as the dependent variable of our empirical model. While on conceptual grounds it is clear that the value added deflator is not the appropriate index to measure output prices, empirically, given the principle of double-deflation employed by statistical agencies in national accounts statistics, the output deflator and the value added deflator are not too different from each other if a rapid pass-through from input to output prices is assumed.[8] A rapid pass-through is not an unrealistic assumption at the annual frequency for which the output deflator is usually measured and given the fact that the output deflator and the value added deflator display the same seasonal pattern as they are converted from annual to quarterly frequency with the help of the same indicator variables (e.g. wholesale prices, producer prices, CPI components) considering the GDP deflator in our estimations at the quarterly frequency should not make any significant difference as compared to the output deflator. Moreover, given that in our model the firm charges the same price for its output regardless if it is used for final demand or intermediate inputs by other

[8] This has been verified for the Austrian case where the output deflator was directly available.

firms, the empirical price index used for the price of domestically produced intermediate goods is also the GDP deflator.[9]

For each country a number of different specifications of equation (10) are estimated by GMM and displayed in the tables below. Following Gali et al. (2001) two alternative specifications of the orthogonality conditions are considered. In the first specification (10) is estimated directly imposing the orthogonality conditions while in the second specification the nonlinearities are minimized by pre-multiplying the equation with Δ:[10]

$$E_t\left(\left[\pi_t^d - \frac{\theta\beta}{\Delta}\pi_{t+1}^d - \frac{\omega}{\Delta}\pi_{t-1}^d - \frac{(1-\theta)(1-\omega)(1-\theta\beta)}{\left[\varepsilon(\phi-1)+1\right]\Delta}(.....)\right]z_t\right) = 0 \tag{13}$$

$$E_t\left(\left[\Delta\pi_t^d - \theta\beta\pi_{t+1}^d - \omega\pi_{t-1}^d - \frac{(1-\theta)(1-\omega)(1-\theta\beta)}{\left[\varepsilon(\phi-1)+1\right]}(.....)\right]z_t\right) = 0 \tag{14}$$

where z_t is a vector of instruments. The set of instruments has been selected for each country individually based on the criteria that they should display a high correlation with the regressors and they satisfy the overidentifying restrictions of Hansen's J-test: From a matrix showing the correlations of a large number of potential instruments with all regressors the variables (and the lags) with the highest correlation have been selected as instruments. The results on the J-test of overidentifying restrictions has not been reported in the tables below because they turned out to be far from rejecting the validity of the overidentifying restrictions for any of the presented estimations (the lowest p-value was 0.4; the results are available on request). The hatted variables are calculated as deviations from a quadratic trend in order to induce stationarity.[11] Newey-West corrected standard

[9] The validity of this choice has also been checked for Austrian data. It turned out that the deflator of total intermediate inputs can be approximated by a weighted average of the GDP deflator and the import deflator with the share of imported and domestically produced intermediate goods being the weights.

[10] In case of a zero inflation steady state which is assumed in this model $\hat{\pi}_t^d$ and π_t^d are equivalent.

[11] Apart from a quadratic trend, alternative detrending methods have also been considered in the estimation of the different specifications: These include subtracting a linear trend, a cubic trend, an HP-filtered trend, and the sample mean from the series. Comparing these alternative estimations we find that the results for the cubic and the quadratic trend are very similar and that the specification with a simple deviation from mean is not sufficient to remove the trend present in most series and to induce stationarity. The results are available from the author on request.

errors which are robust to heteroskedasticity and autocorrelation of unknown form are employed in the coefficient's significance tests. This correction is especially important when the variance of the dependent variable (inflation) changes over time, which for instance could be due to one or more regime shifts of monetary or exchange rate policy in the sample period. The number of lags considered for the computation of the coviarance matrix was based on a rule proposed by Newey-West depending on the sample length (e.g. 4 lags for a sample of 120 quarters).

3.3 Results

The estimation results are summarized in tables 1 to 10 in the Appendix. All tables give the estimates of the structural parameters θ, β, ω and ρ along with the significance levels and report the expected duration of prices in months in the last column which has been derived from θ by the formula $\frac{3}{1-\theta}$. The estimation results of the different model specifications are listed in the rows of the tables: In model M1 we estimate the specification for the closed economy with only labor in production, i.e. the standard specification of closed economy hybrid New Keynesian Phillips curve models widely used in the literature, e.g. in Gali et al. (2001) and others. Model M2 includes imported intermediate goods in production but no domestically produced inputs which is the specification adopted in the previous literature on open economy NKPCs, as in Leith and Malley (2003). Model M3 is the most general formulation of the open economy NKPC as developed in this paper, as it includes domestic and imported intermediate inputs in production. Furthermore, the models with extension A are estimated according to the first specification mentioned above (equation (13)) and the models with extension B are based on the second specification (equation (14)). In addition to the baseline models of each class where the elasticity of substitution between the variable factors of production, ρ, is freely estimated, a second specification is displayed where ρ is restricted to 1, implying a Cobb-Douglas production function. In the lower part of the tables the estimates of the reduced form coefficients are reported for those specifications (M1, M2, M3) where the marginal cost term was significant. Specifically, the reduced form coefficients estimates along with their significance levels were obtained from the estimation of the following reduced form model (the notation follows Gali et al. (1999) $\hat{\pi}_t^d = E_t \gamma_f \hat{\pi}_{t+1}^d + \gamma_b \hat{\pi}_{t-1}^d + \lambda[.....]$. In the last row of each table the specific instrument set that was used in the estimations of the different specifications for each country is listed.

3.3.1 Comparison of Results across Countries

In discussing the results we want to focus on some systematic findings that emerge from the comprehensive evidence on estimations of different specifications of the hybrid NKPC for nine euro area countries and the euro area itself. When screening the tables one striking result is the large degree of heterogeneity in the estimated structural parameters of the price-setting model across euro area countries but also across specifications for each country. Concerning the estimated persistence of prices measured by both, θ and ω, we realize that persistence seems to be highest in Germany (table 3) and for the euro area aggregate (table 10) and lowest for Greece (table 7), the Netherlands (table 9) and Finland (table 5) while the results for Spain (table 4), France (table 6) and Italy (table 8) are fairly similar displaying an intermediate degree of persistence. The fact that persistence is found to be higher in countries with rather closed economies than in countries with rather open economies can be taken as a first indication that open economy considerations matter for the NKPC. This question, however, is formally tested across specifications within each country which will be presented in the next subsection.

When comparing the results with those of related studies and bearing in mind all the differences concerning instruments used and the sample length we find that they are more or less in line with Gali et al. (2001) and McAdam and Willman (2003) for the euro area. Our estimate for θ in the closed economy specification A of 0.78 is very similar to 0.79 in Gali et al. and 0.8 in McAdam and Willman while the estimates for β and ω are quite lower in Gali et al. but similar in McAdam and Willman. Comparing our results for Spain to those obtained by Gali and Lopez-Salido (2001) we realize a considerable difference in that our estimates for θ and ω are consistently lower and the estimates for β are consistently higher than in the other paper for both, the closed economy as well as the open economy specifications. There is, however, an important difference in the empirical implementation of the NKPC in that Gali and Lopez-Salido consider only the case of constant returns to labor in production while we assume decreasing returns to labor (and imported intermediate goods). Compared to Sondergaard (2003) our results for Italy, France and Spain yield somewhat lower estimates for the persistence parameter θ in the open economy specification but a comparison of the results between the two papers is difficult as the empirical implementation of the NKPC is rather different in Sondergaard (he uses other price indices and focuses on the traded sector only). Finally, our results for Germany, France and Spain are quite similar to the results in Leith and Malley (2003) who estimate an open economy NKPC (corresponding to M2 in this paper) for the G7 countries. In particular, the ranking of the three countries with respect to price rigidity is the same in both papers with Germany showing the most rigid price-setting behavior, followed by France and Spain.

3.3.2 Comparison of Results across Specifications

Next we focus on the question if structural price rigidity as derived from our results differs for different specifications of the same country. When comparing the estimates of the "price rigidity parameter" θ between the closed economy formulation M1 and the open economy formulation M2 a systematic difference emerges of the form that estimated price rigidity tends to be lower when imported intermediate prices are allowed to affect firm's marginal costs.[12] This is consistent with the idea that firms whose input prices vary more (due e.g. to volatile raw material prices) also adjust their prices more frequently than others. Exceptions from this tendency are Spain, Greece and Austria where the coefficients are basically unaffected by the introduction of open economy effects. The comparison of coefficients across models is summarized in table 11 which shows the difference in the estimates of θ and ω between M1 and M2 in the first row of each country panel, the %-difference in parenthesis and the t-value for a t-test of statistically significant parameter difference of non-nested models.[13] Table 11 reveals that in 70% of all comparisons of M1 and M2 (14 out of 20 total specifications, i.e. specification A and B for each country) θ is higher for M1 than for M2, the average %-difference between the two models is 15.8% but the difference is never statistically significant for these 14 cases. There is only one statistically significant difference when comparing θ between M1 and M2 for France in specification B, but the difference goes the other direction, i.e. $\hat{\theta}_{M1} - \hat{\theta}_{M2} < 0$. In general it is very

[12] There is a discussion in the literature which parameter of the model appropriately indicates the degree of price rigidity in the case of a hybrid NKPC. Besides the probability of a price change, price rigidity can also be associated to the share of backward looking firms, ω, as they introduce some past-dependence in the pricing process. Based on this reasoning, Benigno and Lopez-Salido (2001) propose a formula that combines θ and ω to derive the average duration between price changes: $D = \frac{1}{1-\theta}\frac{1}{1-\omega}$. However, as this derivation is valid only under certain assumptions and in order to be comparable to other studies we report the implied duration between price changes in the conventional form $D = \frac{1}{1-\theta}$ and interpret θ as the parameter indicating price rigidity.

[13] The test statistic is $\frac{\hat{\theta}_{M1} - \hat{\theta}_{M2}}{\sqrt{\hat{\sigma}^2_{\theta_{M1}} + \hat{\sigma}^2_{\theta_{M2}}}}$ where $\hat{\sigma}_{\theta_{M1}}$ and $\hat{\sigma}_{\theta_{M2}}$ are the empirical standard deviations of the coefficient estimates of $\hat{\theta}_{M1}$ and $\hat{\theta}_{M2}$. This test statistic is t-distributed with $(n_1 + n_2 - k_1 - k_2)$ degrees of freedom where n_1 and n_2 are the number of observations underlying the estimation of M1 and M2, respectively, and k_1 and k_2 are the number of coefficients to be estimated in M1 and M2.

hard to find significant results in table 11 on the difference of coefficients that are bounded between 0 and 1 (most of them even vary within a much smaller range between 0.4 and 0.7 in the case of θ) but a difference of more than 10% implying a difference in price duration of 1 to 2 months can be interpreted to be at least economically significant. The result that structural price rigidity turned out to be smaller in the open economy specification compared to the closed economy specification has also been found in Rubene and Guarda (2004) for Luxembourg, while no significant difference across closed and open economy specifications has been found in Leith and Malley (2003) for the G7 countries.

Interestingly, when moving from the open economy specification M2 to the most general model M3 – with imported and domestically produced intermediate inputs – θ is systematically found be be higher than in M2, many times also higher than in the closed economy case. This could reflect substitution of imported intermediate goods by domestic intermediate goods when the relative price of the former increases, thus mitigating the need for the firm to adjust prices. table 11 reveals that in all but one cases (95%) θ increases from M2 to M3 and for 5 out of 10 countries even significantly. The average %-difference between θ in M2 and M3 over all specifications is 24.7%. In 75% of the cases price rigidity as measured by θ in M3 is also higher than in the closed economy specification M1, for 3 countries even significantly.

A similar pattern as has been described for θ can also be found for the parameter indicating the importance of backward-looking price setting ω: It is found to be lower in the open economy specification than in the closed economy and the general specification M3, however the pattern is somewhat less systematic (in 65% of all comparisons between M2 and M3 in table 11 ω is higher in M3). Contrary to the findings of Leith and Malley (2003), these two parameters seem to be positively correlated across models in our analysis.

The estimates of the discount rate of firm's future profits, β, are found to be in a reasonable range between 0.9 and 1, in some cases even larger than 1 but never significantly larger than 1. Compared to related studies, e.g. Leith and Malley (2003) and Gali et al. (2001), our estimates of β are much closer to 1 which is also theoretically more plausible given that it reflects the quarterly subjective discount rate of future profits. Furthermore, the estimates of β are not systematically affected by the specification of the model.

The elasticity of substitution between the variable factors of production ρ can only be estimated imprecisely, as it is found to be significant only in very few cases. This implies that – with the exception of these few cases, e.g. M2B in France and M3B in Greece – assuming a Cobb-Douglas production technology, i.e. $\rho = 1$, or a Leontief production technology, i.e. $\rho = 0$, would fit the data equally well. This finding, which is also in line with the results in Leith and Malley (2003),

could be explained – as they state – by the fact that at the quarterly frequency firms may not be able to substitute between the different inputs in response to quarterly price movements, resulting in an imprecise estimation of this parameter.

3.3.3 Results Related to the Reduced form Specification

When trying to assess which model (M1, M2 or M3) is most appropriate to characterize the inflation process in the euro area countries we turn to the performance of the model estimated in its reduced form. The reason is that when the reduced form coefficient on the marginal cost term λ cannot be estimated significantly we have an identification problem of the structural parameters of the model which then become unreliable (see Guay and Pelgrin (2004)). Thus, the structural parameters of the model given in the tables are only conditional on a well specified reduced form. Comparing the reduced form coefficients on the marginal cost term we note that the general model M3 with imported and domestically produced intermediate inputs in production and the model M2 with only imported intermediate goods in production are found to be more appropriate to track the inflation process in all euro area countries than M1 as λ was found to be significant for M1 only in France and Finland (remember that the reduced form specification is only reported in the tables for those models where λ is significant). Thus, we conclude that open economy aspects matter for the performance and the fit of the NKPC. More pronounced, based on these results one could also claim that for most euro area countries the closed economy model of the NKPC is misspecified and the open economy model should therefore be preferred.

Another finding that emerges quite consistently from the estimates of the reduced form coefficients shown in the tables in the Appendix is that the weight on the forward looking coefficient, γ_f, is predominant in most countries (with the exceptions of Austria and Italy), thus confirming the dominance of forward looking behavior in the hybrid NKPC found in most other studies for European countries, see e.g. Gali et al. (2001) and Sondergaard (2003).[14] It should be noted also that for many countries differences in coefficients estimates between specifications A and B are more pronounced than differences between the model types M1, M2, M3 which indicates that the way of normalization is

[14] A qualification to this finding could be the result of Jondeau and Le Bihan (2003) that the forward looking coefficient in a hybrid NKPC estimated by GMM appears to be biased upwards in small samples and in case of misspecification of the model's dynamics. This potential undermining of the reliability of the coefficients estimates doesn't seem to be a severe problem for our results as γ_f did generally not turn out to be particularly large in our estimations. Specifically, it was found to be larger than 0.65 only for Spain.

important for the results. This fact is also the reason why in table 11 only models within specification either A or B are compared and not across specifications.

Some sensitivity analysis with the calibrated parameters of the model has shown that assuming a higher steady state markup μ increases the estimate of the persistence parameter θ consistently across models and specifications.[15]

The estimates of the average duration of prices implied from θ which in our analysis vary between 6 and 12 months for most specifications are found to be consistently lower than suggested by the evidence in the studies on the micro consumer price data in the IPN where the average duration turns out to be about one year for most countries. As our estimates are derived from aggregate data as opposed to micro data in the other studies, aggregation – besides the fact that different price indices are considered – could explain part of the difference.

4. Conclusions

In this paper an open economy hybrid New Keynesian Phillips Curve is estimated for nine euro are countries and the euro area aggregate. The model is estimated in three different variants (specifications): in the closed economy specification with only the labor share as the driving variable of inflation, in the open economy specification with imported intermediate goods in production, and in the more general open economy specification which additionally includes also domestically produced intermediate inputs in production. From the comparison of our results across these specifications we find that the degree of structural price rigidity as measured by the Calvo probability of changing a price is systematically higher for the closed economy case than in the open economy case with only imported intermediate inputs in production. A reason for this could be that when firms face more variable input costs as they import from volatile international markets they tend to adjust their prices more frequently. This is in contrast to the existing literature on the open economy NKPC, see e.g. Leith and Malley (2003) on the G7 countries and Gali and Lopez-Salido (2001) on Spain, who found that the structural parameters of the model were largely unaffected by the introduction of open economy factors. However, these papers estimated the open economy NKPC for relatively large and closed economies for which our results are also less clear cut than for the whole set of countries.

When comparing the open economy case with only imported intermediate inputs and the most general specification with imported and domestically produced intermediate inputs, structural price rigidity is found to be systematically higher in the latter case. This could be due to substitution of imported by domestic intermediate goods when the relative price of the former increases, thus mitigating

[15] The results for varying μ from 1.1 to 1.4 are available on request.

the need for the firm to adjust prices. The general open economy model was also found to be the most appropriate specification to characterize the inflation process in most euro area countries as it could fit the data best in the reduced form estimations of the model.

From the viewpoint of monetary policy makers the results indicate that when taking into account open economy effects, estimated price rigidity turns out to be less pronounced than the closed economy model of the New Keynesian Phillips Curve used in the literature so far would suggest. This furthermore implies that prices react faster to monetary and other shocks than indicated in the existing literature and, conversely, that the real effects of monetary policy could be less substantial than implied from this literature. The degree of openness of an economy, thus, becomes an important determinant of aggregate price rigidity and the way supply and demand shocks are transmitted to the rest of the economy.[16] The results also give some indication that the closed economy model at least for the data set used in this study is misspecified by omitting important (open economy) variables and that the open economy specification should be preferred instead.

The main contribution of this paper is to deliver a comprehensive evidence on the empirical performance of the open economy NKPC in different variants and specifications. In that, however, it can only be a starting point as more refined models would have to be developed to incorporate some stylized facts of price setting in open economies, like pricing to market, exchange rate dynamics, current account issues, etc. A further extension would also be to apply the open economy NKPC to alternative estimation techniques like maximum likelihood, the three-step GMM (3S-GMM) or the continuously updated GMM (CUE) estimators (as has been done in Guay and Pelgrin (2004) for the U.S.A.).

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[16] The finding that firms operating in more open sectors of the economy tend to adjust their prices more frequently has also been confirmed in the analysis of micro data on producer prices in Spain; see Álvarez et al. (2005).

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Appendix

Table 1: GMM Estimates for Austria, Dependent Variable Quarter-on-Quarter GDP Inflation

AT	θ	β	ω	ρ	Implied duration (in months)
M1A	0.65***	0.96***	0.34**	-	8.7
M1B	0.59***	0.98***	0.16**	-	7.3
M2A	0.62***	0.96***	0.34***	2.6	7.9
M2A	0.64***	0.95***	0.34**	1	8.4
M2B	0.52***	0.99***	0.15**	6.6	6.3
M2B	0.51***	0.92***	0.18**	1	6.1
M3A	0.59***	0.94***	0.35***	-0.2	7.3
M3B	0.60***	0.97***	0.16**	1	7.6
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.47***	0.54***	0.10**		
M3A	0.46***	0.53***	0.07*		
Instrument list: price inflation (2,4), wage inflation (1-4), labor share (1-6)					
Time span considered: 1964 Q1 - 2003 Q2					

Note: The stars attached to the coefficients estimates show the significance levels, where * *denotes significance at the 10%,* ** *at the 5% and* *** *at the 1% level. Models M1, M2 and M3 refer to expression (10) "including" (12) estimated for the closed economy case (M1), i.e.* $s_{m^f} = 0$ *and* $s_{m^d} = 0$*, for the open economy case with imported intermediate inputs (M2), i.e.* $s_{m^f} \neq 0$ *and* $s_{m^d} = 0$*, and the most general specification with imported and domestically produced intermediate inputs (M3), i.e.* $s_{m^f} \neq 0$ *and* $s_{m^d} \neq 0$*. M1 is estimated without* ρ *as this parameter does not appear in the closed economy specification. Specifications A and B refer to expressions (13) and (14), respectively. The duration of prices implied from* θ *is calculated as* $\frac{3}{1-\theta}$ *and given in months for comparison with other papers in the IPN.*

Table 2: GMM Estimates for Belgium, Dependent Variable Quarter-on-Quarter GDP Inflation

BE	θ	β	ω	ρ	Implied duration (in months)
M1A	0.47***	0.99***	0.63***	-	5.7
M1B	0.56***	0.999***	-0.24*	-	6.9
M2A	0.56**	0.98***	0.40***	-0.61	6.9
M2A	0.59***	1.04***	0.49***	1	7.5
M2B	0.49***	0.94***	-0.19**	0.03	6
M2B	0.52***	1.05***	0.44***	1	6.2
M3A	0.73***	0.99***	0.19	-3.8**	11.4
M3B	0.60***	0.86***	-0.08***	-1.3***	7.5
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.55***	0.46**	0.08*		
Instrument list: price inflation (2-4), wage inflation (1-4), labor share (1-4), detrended output (1-4), ratio of wages to import prices (1-4) Time span considered: 1980 Q1 - 2003 Q2					

Table 3: GMM Estimates for Germany, Dependent Variable Quarter-on-Quarter GDP Inflation

DE	θ	β	ω	ρ	Implied duration (in months)
M1A	0.73***	0.99***	0.59***	-	11.1
M1B	0.80***	1.02***	0.20	-	15.2
M2A	0.58***	1.07***	0.53***	5.3**	7.2
M2A	0.76***	0.98***	0.65***	1	12.3
M2B	0.70***	1.03***	0.39**	5.9*	9.9
M2B	0.80***	0.99***	0.30**	1	15
M3A	0.86***	0.97***	0.72***	1	21.4
M3B	0.83***	1.01***	0.45**	3.04	17.4
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.58***	0.43***	0.05*		
Instrument list: price inflation (2-4), wage inflation (1-4), labor share (1-4), ratio of wages to import prices (1-6) Time span considered: 1970 Q1 - 2003 Q2					

Table 4: GMM Estimates for Spain, Dependent Variable Quarter-on-Quarter GDP Inflation

ES	θ	β	ω	ρ	Implied duration (in months)
M1A	0.56***	0.99***	0.18**	-	6.9
M1B	0.49***	0.99***	0.10*	-	5.9
M2A	0.55***	1.01***	0.18***	1.16**	6.6
M2A	0.61***	0.997***	0.16***	1	7.8
M2B	0.52***	0.98***	0.10**	0.59*	6.3
M2B	0.56***	0.995***	0.12**	1	6.9
M3A	0.70***	1.00***	0.18***	1	10.0
M3B	0.66***	1.00***	0.14***	1	8.9
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.56***	0.45***	0.11***		
M2B	0.92***	0.09*	0.12*		
M3A	0.78***	0.23***	0.24***		
Instrument list: price inflation (2-4), wage inflation (1-4), labor share (1-4), detrended output (1-4), ratio of wages to import prices (1-4) Time span considered: 1980 Q1 - 2003 Q2					

Table 5: GMM Estimates for Finland, Dependent Variable Quarter-on-Quarter GDP Inflation

FI	θ	β	ω	ρ	Implied duration (in months)
M1A	0.57***	1.00***	0.49*	-	6.9
M1B	0.37***	1.05***	0.07*	-	4.8
M2A	0.53***	0.99***	0.58***	-2.6	6.4
M2A	0.64***	0.999***	0.55*	1	8.4
M2B	0.41***	0.99***	0.09*	-0.75	5.1
M2B	0.40***	1.11***	0.11*	1	5.1
M3A	0.65***	0.93***	0.46***	-4.3	8.7
M3B	0.50***	0.99***	0.30**	-2.4***	6
Reduced form estimates					
	γ_f	γ_b	λ		
M1A	0.57***	0.46***	0.28***		
M2A	0.54***	0.45***	0.14***		
M3B	0.49***	0.52***	0.05**		
Instrument list: price inflation (2-6), wage inflation (1-4), commodity price inflation (1-6), labor share (2-6), detrended output (2-6), ratio of wages to import prices (2-4) Time span considered: 1975 Q1 - 2003 Q2					

Table 6: GMM Estimates for France, Dependent Variable Quarter-on-Quarter GDP Inflation

FR	θ	β	ω	ρ	Implied duration (in months)
M1A	0.71***	0.99***	0.57**	-	10.3
M1B	0.32**	1.15***	0.16***	-	4.5
M2A	0.65***	0.99***	0.48***	2.6	8.7
M2A	0.65***	0.99***	0.51***	1	8.7
M2B	0.50***	0.98***	0.10**	1.9***	6
M2B	0.50***	1.00***	0.12***	1	6
M3A	0.71***	0.94***	0.56***	-4.3	10.5
M3B	0.62***	0.975***	0.13**	-0.6	7.8
Reduced form estimates					
	γ_f	γ_b	λ		
M1B	0.42***	0.60***	0.25***		
M2A	0.63***	0.40***	0.33***		
M2B	0.51***	0.54***	0.38***		
Instrument list: price inflation (2-4), wage inflation (1-4), commodity price inflation (1-4), labor share (1-4), detrended output (1-4), ratio of wages to import prices (1-6) Time span considered: 1978 Q1 - 2003 Q2					

Table 7: GMM Estimates for Greece, Dependent Variable Quarter-on-Quarter GDP Inflation

GR	θ	β	ω	ρ	Implied duration (in months)
M1A	0.62*	0.99***	0.38**	-	7.9
M1B	0.32**	0.97***	0.30***	-	4.5
M2A	0.43**	0.98***	0.21	-17.7	5.3
M2A	0.45***	0.995***	0.41***	1	5.5
M2B	0.30***	0.99***	0.19***	-0.6	4.3
M2B	0.34***	0.99***	0.22***	1	4.5
M3A	0.41***	0.99***	0.40***	1.6**	5.1
M3A	0.52***	0.99***	0.39***	1	6.3
M3B	0.57***	1.00***	0.32***	2.8***	7.0
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.55***	0.42**	3.83**		
M3A	0.62**	0.40*	0.18*		
Instrument list: wage inflation (1-4), labor share (1-4) detrended output (1-4), ratio of wages to import prices (1-4), the share of imported intermediate goods in production (1-4) Time span considered: 1970 Q1 - 2003 Q2					

Table 8: GMM Estimates for Italy, Dependent Variable Quarter-on-Quarter GDP Inflation

IT	θ	β	ω	ρ	Implied duration (in months)
M1A	0.66**	0.98***	0.42*	-	8.7
M1B	0.45***	0.99***	0.12***	-	5.5
M2A	0.68***	0.99***	0.34**	-0.3	9.6
M2A	0.68***	0.997***	0.35**	1	9.6
M2B	0.41***	1.08***	0.14***	-0.98	5.4
M2B	0.44***	1.08***	0.17***	1	5.4
M3A	0.72***	0.99***	0.49**	1	10.7
M3B	0.54***	1.00***	0.29***	-1.96	6.5
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.33***	0.67***	0.20**		
M3A	0.23**	0.60***	0.02***		
Instrument list: price inflation (2-4), commodity price inflation (1-4), labor share (1-4), detrended output (1-4), ratio of wages to import prices (1-6) Time span considered: 1970 Q1 - 2003 Q2					

Table 9: GMM Estimates for the Netherlands, Dependent Variable Quarter-on-Quarter GDP Inflation

NL	θ	β	ω	ρ	Implied duration (in months)
M1A	0.61***	0.98***	0.31***	-	7.8
M1B	0.42***	0.93***	0.13***	-	5.1
M2A	0.49***	0.95***	0.31***	0.3	5.9
M2A	0.52***	0.97***	0.32***	1	6.3
M2B	0.37***	0.92***	0.17***	0.3	4.8
M2B	0.39***	0.91***	0.17***	1	4.9
M3A	0.62***	0.97***	0.30***	0.17	7.8
M3B	0.53***	0.95***	0.20***	1	6.4
Reduced form estimates					
	γ_f	γ_b	λ		
M2B	0.66***	0.30***	0.115***		
M3B	0.65**	0.30***	0.06***		
Instrument list: price inflation (2-4), wage inflation (1-4), labor share (1-4), detrended output (1-4) Time span considered: 1977 Q1 - 2003 Q2					

Table 10: GMM Estimates for the Euro Area, Dependent Variable Quarter-on-Quarter GDP Inflation

EA	θ	β	ω	ρ	Implied duration (in months)
M1A	0.78***	1.02***	0.48***	-	13.6
M1B	0.59***	0.99***	0.37***	-	7.3
M2A	0.67***	1.02***	0.50***	5.7	9.1
M2A	0.68***	1.02***	0.50***	1	9.6
M2B	0.51***	0.999***	0.19**	0.41	6.1
M2B	0.51***	1.00***	0.21***	1	6.1
M3A	0.64***	1.03***	0.44***	1	8.4
M3B	0.52***	1.02***	0.20*	1.01*	6.3
Reduced form estimates					
	γ_f	γ_b	λ		
M2A	0.29***	0.72***	0.11***		
M3A	0.52***	0.49***	0.09***		
Instrument list: price inflation (2-4), wage inflation (1-4), commodity price inflation (1-4), labor share (1-6), ratio of wages to import prices (1-4) Time span considered: 1970 Q1 - 1998 Q4					

Table 11: Difference in Coefficients Estimates across Models M1, M2 and M3 and Corresponding T-Tests for all Countries

		Specification A		Specification B	
		θ	ω	θ	ω
AT	M1-M2 (%-difference)	0.030 (5.5)	0.003 (0.9)	0.082 (16.2)	-0.017 (-9.7)
	t-value	0.161	0.019	0.676	-0.173
	M2-M3 (%-difference)	-0.018 (-3.0)	0.010 (3.0)	-0.099 (-19.5)	0.011 (6.4)
	t-value	-0.082	0.063	-0.890	0.113
	M1-M3 (%-difference)	0.011 (1.8)	0.013 (4.1)	-0.017 (-2.7)	-0.006 (-3.5)
	t-value	0.049	0.080	-0.127	-0.054
BE	M1-M2 (%-difference)	-0.088 (-15.7)	0.226 (56.1)	0.069 (14.0)	-0.048 (25.4)
	t-value	-0.498	0.852	0.552	-0.330
	M2-M3 (%-difference)	-0.173 (-30.1)	0.210 (52.1)	-0.109 (-22.2)	-0.112 (58.9)
	t-value	-1.437	0.905	-2.498***	-1.707*
	M1-M3 (%-difference)	-0.261 (-35.5)	0.436 (226.2)	-0.040 (-6.7)	-0.161 (205.3)
	t-value	-1.504	1.643*	-0.344	-1.175
DE	M1-M2 (%-difference)	0.150 (26.0)	0.063 (12.0)	0.106 (15.2)	-0.188 (-48.4)
	t-value	0.721	0.291	0.534	-0.638
	M2-M3 (%-difference)	-0.281 (-48.6)	-0.191 (-36.2)	-0.131 (-18.9)	-0.060 (-15.4)
	t-value	-1.096	-0.744	-0.650	-0.205
	M1-M3 (%-difference)	-0.131 (-15.3)	-0.128 (-17.8)	-0.026 (-3.1)	-0.248 (-55.3)
	t-value	-0.469	-0.470	-0.133	-0.788
ES	M1-M2 (%-difference)	-0.048 (-7.9)	0.020 (12.9)	-0.070 (-12.5)	-0.020 (-17.4)
	t-value	-0.436	0.221	-0.830	-0.267
	M2-M3 (%-difference)	-0.084 (-13.7)	-0.026 (-16.1)	-0.100 (-17.8)	-0.027 (-22.8)
	t-value	-0.901	-0.321	-1.318	-0.381
	M1-M3 (%-difference)	-0.132 (-19.0)	-0.005 (-2.8)	-0.170 (-25.7)	-0.047 (-32.7)
	t-value	-1.248	-0.053	-2.063**	-0.578
FI	M1-M2 (%-difference)	0.047 (8.9)	-0.098 (-16.8)	-0.047 (-11.2)	-0.022 (-24.8)
	t-value	0.187	-0.278	-0.607	-0.321
	M2-M3 (%-difference)	-0.126 (-23.9)	0.129 (22.1)	-0.083 (-20.8)	-0.211 (-235.4)
	t-value	-0.569	0.481	-0.904	-1.571*
	M1-M3 (%-difference)	-0.079 (-12.1)	0.031 (6.8)	-0.133 (-26.5)	-0.234 (-77.6)
	t-value	-0.371	0.096	-1.433	-1.801*
FR	M1-M2 (%-difference)	0.060 (9.1)	0.089 (18.4)	-0.178 (-35.7)	0.053 (52.5)
	t-value	0.191	0.293	-3.607***	0.767
	M2-M3 (%-difference)	-0.058 (-8.8)	-0.082 (-17.1)	-0.119 (-23.9)	-0.027 (-26.1)
	t-value	-0.285	-0.355	-1.997**	-0.359
	M1-M3 (%-difference)	0.002 (0.3)	0.006 (1.1)	-0.297 (-48.1)	0.027 (20.9)
	t-value	0.007	0.021	-5.767***	0.368

Table 11 continued: Difference in Coefficients Estimates

		Specification A		Specification B	
		θ	ω	θ	ω
GR	M1-M2 (%-difference)	0.175 (39.9)	-0.026 (-6.4)	0.026 (8.8)	0.110 (57.5)
	t-value	0.395	-0.106	0.191	1.115
	M2-M3 (%-difference)	-0.074 (-16.5)	0.021 (5.1)	-0.276 (-92.6)	-0.125 (-65.5)
	t-value	-0.271	0.095	-2.438**	-1.162
	M1-M3 (%-difference)	0.102 (19.6)	-0.005 (-1.4)	-0.250 (-43.5)	-0.015 (-4.9)
	t-value	0.241	-0.021	-1.680*	-0.126
IT	M1-M2 (%-difference)	-0.026 (-3.8)	0.074 (21.0)	0.042 (10.4)	-0.020 (-14.1)
	t-value	-0.069	0.028	0.406	-0.264
	M2-M3 (%-difference)	-0.034 (-5.0)	-0.143 (-40.7)	-0.130 (-32.0)	-0.143 (-99.5)
	t-value	-0.133	-0.493	-1.790*	-1.536
	M1-M3 (%-difference)	-0.060 (-8.3)	-0.069 (-14.0)	-0.088 (-16.3)	-0.163 (-57.0)
	t-value	-0.170	-0.204	-0.833	-1.804*
NL	M1-M2 (%-difference)	0.120 (24.5)	-0.0003 (-0.1)	0.047 (12.6)	-0.041 (-23.7)
	t-value	0.616	-0.002	0.549	-0.538
	M2-M3 (%-difference)	-0.129 (-26.3)	0.014 (4.5)	-0.157 (-42.3)	-0.024 (-14.4)
	t-value	-0.929	0.109	-1.790*	-0.258
	M1-M3 (%-difference)	-0.009 (-1.4)	0.014 (4.6)	-0.111 (-20.9)	-0.065 (-33.3)
	t-value	-0.047	0.100	-1.261	-0.721
EA	M1-M2 (%-difference)	0.093 (13.7)	-0.020 (-4.0)	0.082 (16.2)	0.178 (93.6)
	t-value	0.414	-0.090	1.102	1.219
	M2-M3 (%-difference)	0.042 (6.2)	0.065 (13.0)	-0.018 (-3.5)	-0.012 (-6.4)
	t-value	0.313	0.377	-0.255	-0.081
	M1-M3 (%-difference)	0.136 (21.2)	0.045 (10.3)	0.065 (12.3)	0.166 (81.9)
	t-value	0.649	0.210	0.728	0.991

Note: M1-M2 gives the difference of the estimated coefficients values of θ *and* ω *for specification A according to expression (13) and specification B according to expression (14) for M1 and M2 and in parenthesis the %-difference between M1 and M2: 100(M1-M2)/M2. The t-values are based on the test statistic* $\frac{\hat{\theta}_{M1}-\hat{\theta}_{M2}}{\sqrt{\hat{\sigma}^2_{\theta_{M1}}+\hat{\sigma}^2_{\theta_{M2}}}}$ *where* $\hat{\sigma}_{\theta_{M1}}$ *and* $\hat{\sigma}_{\theta_{M2}}$ *are the empirical standard deviations of the coefficient estimates of* $\hat{\theta}_{M1}$ *and* $\hat{\theta}_{M2}$*. This test statistic is t-distributed with* $(n_1+n_2-k_1-k_2)$ *degrees of freedom where* n_1 *and* n_2 *are the number of observations underlying the estimation of M1 and M2, respectively, and* k_1 *and* k_2 *are the number of coefficients to be estimated in M1 and M2. The stars attached to the t-values show the significance levels, where* * *denotes significance at the 10%,* ** *at the 5% and* *** *at the 1% level.*

Comment on "Estimates of the Open Economy New Keynesian Phillips Curve for Euro Area Countries"

Johann Scharler[1]

Oesterreichische Nationalbank

I would like to start my discussion with a brief review of the relevant literature. This will allow us to assess how the paper fits into the literature. The "new theories" of short run inflation dynamics are mostly based on staggered price and/or wage setting. Calvo (1983) has introduced a tractable way to obtain a New Keynesian Phillips Curve:

$$\pi_t = \lambda mc_t + \beta E_t(\pi_{t+1}),$$

where π_t is the inflation rate at time t and mc_t denotes marginal cost. Thus, the inflation rate is a function of marginal costs and expected future inflation. However, this simple formulation is known to have two major drawbacks. First, inflation appears to be more persistent than this formulation captures and second, it is not clear how to measure marginal cost. The traditional solution to the first problem is to introduce backward looking firms. That is, a certain fraction of the firms follows a backward looking rule when setting prices. This gives rise to the following, slightly more general Phillips Curve:

$$\pi_t = \lambda mc_t + \gamma_f E_t(\pi_{t+1}) + \gamma_b \pi_{t-1}$$

Although this is a very ad hoc assumption is appears to work in terms of the improved fit of the equation.

[1] Oesterreichische Nationalbank, Economic Analysis Division, Otto-Wagner-Platz 3, POB 61, A-1011 Vienna, Austria, Phone (+43-1) 404 20-7419, Fax (+43-1) 404 20-7499, E-Mail: johann.scharler@oenb.at. The views expressed in this paper are those of the author and do in no way commit the Oesterreichische Nationalbank.

The traditional solution to the second issue was to simply assume that mc_t is proportional to the output gap. However, this assumption holds only true under restrictive assumptions and in addition, the output gap is hard to measure as well. In particular, the output gap has to be the deviation of actual output from the flexible price solution and not from some sort of smoothed GDP series. More recently, Galí et al. among others have suggested to use the labor income share as a proxy for mc_t. Under the assumption that input costs are well approximated by unit labor costs. As pointed out by Leith and Malley (2003) this assumption is hard to defend for open economies where a substantial part of the input costs might be the cost of imported intermediate goods. However, in their empirical analysis, they conclude that open economy aspects do not significantly change the results.

Rumler (in this volume) stresses this point as well and proposes yet another extension. He includes not just foreign but also domestically produced intermediate goods. However, it is not convincingly motivated in the paper for what purposes this extension may be useful.

Next, I would like to discuss how we can interpret the quantitative results of Rumler. Basically, the purpose of the empirical analysis is to uncover structural parameters which govern the degree of price stickiness. Most relevant are the parameters θ and ω. Table 1 shows the estimates from Rumler for the euro area and also for the sake of comparison, parameter estimates frequently found the literature.

Table 1: Structural Parameter Estimates

	θ	ω
closed economy estimates See e.g. Galí et al., (2001); Leith and Malley, (2005)	≈ 0.75	≈ 0.3
Rumler (2005) A	0.64	0.44
Rumler (2005) B	0.52	0.20

So far, the consensus appears to be $\theta \approx 0.75$ and $\omega \approx 0.3$. According to Rumler, θ turns out to be lower when open economy aspects are taken into account. This conclusion is based the lower estimate of θ. Thus prices should be less sticky than previously thought. However, depending on the precise formulation of the orthogonality condition ω may also be higher compared to earlier studies.

The question remains, whether these differences in the estimated parameters matter economically. One way, to answer this question is to simulate a New Keynesian Business Cycle model in the spirit of Woodford (2003) under the different

parameterizations for price-setting behavior. That is augment the Phillips Curve by an Euler equation and an interest rate rule and simulate the response to shocks.[2]

Chart 1: Impulse Response Functions

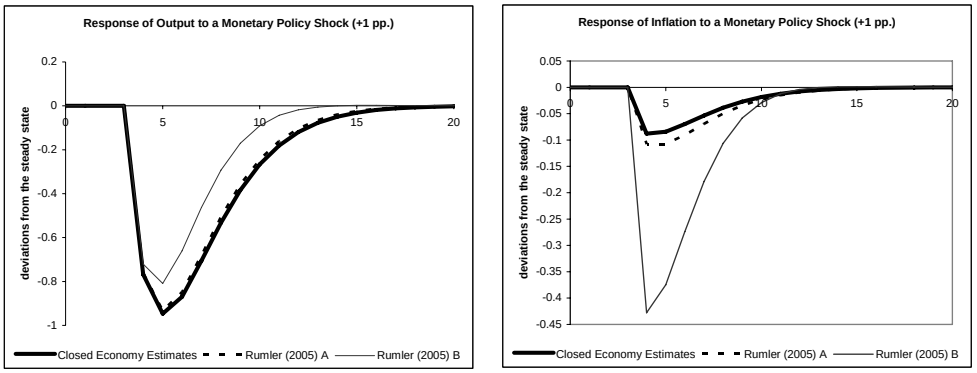

Chart 1 shows the response of the output gap and the inflation rate to a monetary policy shock for the three different calibrations of the price-setting behavior. That is, an expected increase in the nominal interest rate that lasts for one period. We can see that estimates obtained with specification A do not produce any substantial differences in the response of the macroeconomic
variables. The inflation response is somewhat muted whereas the difference inthe output response is negligible. However, the parameter estimates obtained with specification B produce substantially different results. Monetary policy have much smaller real effects under this parameterization.

Thus, although open economy issues appear to play some role in this respect, large differences in macroeconomic outcomes are more likely to result from the different formulations of the orthogonality condition.

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Perceived Inflation and the Euro: Why High? Why Persistent?

Helmut Stix[1]

Oesterreichische Nationalbank

1. Introduction

It is now a well established fact that the euro cash changeover has been accompanied by perceptions of strong price increases. At the same time, official inflation indices have shown only moderate price developments. The wedge between what was measured on the one hand and what was perceived by consumers on the other hand, first, can be observed in most member countries of the euro area and second, has been sizeable. Third and somewhat surprisingly, the gap has turned out to be very persistent. How can this development be explained?

The literature has provided various answers. Some focus on the difference between how consumers perceive inflation and the way official indices reflect price changes (Brachinger, 2005). Other explanations are directly related to the euro cash changeover. Dziuda and Mastrobuoni (2005) highlight the role of consumers' ability to adapt to the new currency, i.e. the role of difficult conversion rates. Traut-Mattausch, Schulz-Hardt, Greitemayer and Frey (2004) attribute high inflation perceptions to the widespread existence of expectations of price increases prior to the cash changeover. Another reason could be that a sizeable fraction of the population still compares euro prices with legacy currencies prices that, in the meantime, are four years old (e.g. Mastrobuoni, 2004).

These approaches provide interesting insights. Nevertheless, the underlying hypotheses have either not been empirically falsified or have only been indirectly confirmed (in experiments or through cross-country comparisons). And if the hypotheses have been tested, they have only been tested in isolation, omitting other

[1] My workshop presentation was based on a paper that I have written jointly with Manfred Fluch ("Perceived Inflation in Austria – Extent, Explanations, Effects", *Monetary Policy & the Economy* 3/2005, p. 22–47) as well as on the paper presented here. I would like to thank Manfred Fluch and Erich Kirchler for comments. Contact details: helmut.stix@oenb.at, Phone.: (+43)-1-40420-7205.

potentially relevant explanations. Also, what has not been shown is more direct evidence from individual data. The present paper extends the literature in both directions. In particular, it provides evidence from a survey conducted in summer 2004 about perceived inflation. This survey, commissioned by the Oesterreichische Nationalbank (OeNB), and conducted in the summer of 2004 in Austria allows for a judgment about how people think about price increases and what factors drive price perceptions.

Why should we care? We think that understanding the reasons behind the increase in perceived inflation is important for several reasons – some of them going well beyond the specific case of the euro changeover in 2002: First, if a currency conversion is associated with the nimbus of prices increases, then this might undermine the credibility of official price measures and/or aversely affect public support for the new currency. Empirical evidence of the former will be provided in this paper, the latter is reflected in survey responses, which indicate that the share of those saying that they view the new currency negatively is much higher for those that have perceived strong price increases (although, admittedly, the direction of causality is ambiguous). Second, increased price perceptions might have real effects. For example, this might be the case if consumers' overestimation of inflation results in an underestimation of their purchasing power, causing suboptimal consumption decisions (ECB, 2002). Experimental results of Hofmann, Kamleitner, Kirchler and Schulz-Hardt (2006) provide supportive evidence for this conjecture. Furthermore, Janger, Kwapil and Pointner (2005), who conducted a survey among Austrian individuals about (weak) consumption spending in 2004, find that consumers name higher prices as the most important reason why they spent less. Third, price perceptions might also have an impact on the formation of inflation expectations. Evidence that inflation expectations grew with inflation perceptions is provided in Fluch and Stix (2005). And finally, a profound knowledge about the factors affecting inflation perceptions is important in light of the forthcoming introduction of euro cash in some of the new Member States.

The paper is structured as follows. The literature which explains this development is briefly reviewed in section 2. Our hypotheses are discussed in section 3. In section 4 we present the empirical model and in section 5 our results. section 6 concludes.

2. Why Have People Perceived High Inflation Rates? Results from the Literature

In this section we will briefly and selectively summarize the main arguments that have been given in the literature to explain the wedge between perceived and actual inflation. We will first focus on explanations about how consumers realize price

changes and then will discuss some explanations that are specific to the euro cash changeover.[2]

It has been stipulated by various authors that the level of perceived inflation is positively correlated with price increases of frequently purchased goods (ECB 2002 and others). A rigorous formulation of this idea is provided in Brachinger (2005), who utilizes elements from Prospect Theory to formulate a theory of inflation perceptions. In particular, the theory rests on two main hypotheses: First, it is maintained that consumers recognize price changes in the context of an act of purchase. This implies that price changes of more frequently purchased goods are weighted more by consumers than price changes of less frequently purchased goods. Second, Brachinger (2005) assumes that consumers are loss averse in the sense that consumers weight price increases (losses) more strongly than price decreases.[3]

In the case of the euro conversion, this theory would thus imply an increase in perceived inflation if prices of frequently bought goods increased more than prices of less frequently bought goods. For Austria, Haschka (2004) presents evidence that this actually happened. In particular, a price index consisting of a basket of (typically) daily purchased goods, increased on average by 3.3% from 2001 to 2004, while one consisting of a typical weekly purchase increased by 2.5%. In comparison, the HICP grew by only 2%. Furthermore, the proportion of goods which experienced price increases from 2001 to 2004 was higher for daily or weekly goods than for the overall HICP-basket of goods.[4] Similar evidence has been reported for many other countries (cf. Del Giovane and Sabbatini, 2005a) as well as for the euro area as a whole (ECB, 2003).

By making use of the same micro-price data that are used for the compilation of the consumer price index and by utilizing information on the purchase frequency of these goods, Brachinger (2005) recently calculated an index of perceived inflation for Germany. As expected, the index substantially deviates from the consumer price index. In particular, perceived inflation was as high as 10% around 2002 in Germany while HICP-inflation was around 2%. Based on specific parameter assumptions, this index also indicates that, in contrast to evidence derived from

[2] We will neglect the role of psychological prices (e.g. el Sehity, Hoelzl and Kirchler, 2005; Mostacci and Sabbatini, 2005; Fluch and Stix, 2005) and other explanations that are mainly country-specific.

[3] More specifically, each consumer has a value function. For each price movement, the consumer evaluates his value function where the evaluation is asymmetric with respect to price increases and decreases. The loss aversion parameter is assumed to lie in a range from 1.5 to 2.5 – price increases are perceived 150% to 250% as strong as price decreases.

[4] In the basket of daily and weekly goods, 89% and 87% of all goods got more expensive over the period from 2001 to 2004. In the HICP-basket the corresponding number is 78% (Fluch and Stix, 2005).

surveys, perceived inflation in Germany has not faded and is still about 5 percentage points higher than HICP-inflation (see the appendix on how perceived inflation is measured).

It is well known that prior to the changeover the fear of price increases was very widespread. According to a Flash Eurobarometer survey from November 2001, 70% of the euro area population were afraid of price cheating; for Austria this figure was more modest (52%).[5] The impact of these expectations has been demonstrated by Traut-Mattausch et al. (2004) who have conducted several experiments where three groups of German probands received menus in Deutsche mark and afterwards menus in euro. For one group, prices were converted correctly, the other two groups faced prices that were 15% too high and too low, respectively. Then, the probands were asked to estimate the price changes. The results reveal that price increases were overestimated even when prices were converted correctly. When euro prices were too low, price increases were estimated to be zero and when euro prices were too high, the price increases were estimated to be even higher. Thus, evidence of illusionary price increases due to the euro introduction is found "in spite of the fact that clear disconfirming evidence was available" (Traut-Mattausch et al., 2004, p. 756). The authors assign this effect to a selective error correction mechanism meaning that errors that are consistent with expectations are less likely to be realized than errors that run counter to expectations. For example, if price increases are expected and prices are in fact mistakingly overestimated then this error will less likely be detected by a person which had expected price increases than by a person which had no such expectations.

Hofmann et al. (2006) have repeated this experiment in 2004 for Austria and, even after two years of experience with the euro, obtained similar results. Furthermore the experimental setting has been extended to wages, which were to a large extent perceived correctly. Therefore, the authors conclude that a combination of higher perceived inflation and unchanged wages can result in a subjective loss of purchasing power, probably affecting consumption decisions.

When conducting price comparisons, the reference values which are used by individuals are of great relevance. In this context it is very important that legacy currency prices have been widely used as reference prices for judging price developments. For example, Fluch and Stix (2005) show that as late as in the summer of 2004, almost 40% of all Austrians still always or frequently converted euro prices into Austrian schilling. Since the Austrian schilling prices are now several years old, the level of perceived inflation increases with the temporal distance from the schilling area just due to the normal inflation process. Brachinger (2005) also accounts for the widespread use of legacy currency prices in a variant

[5] Flash Eurobarometer 11/2001, Question 8: "You're afraid of abuses and cheating on prices."

of his index of perceived inflation. In particular, it is assumed that people estimate price changes relative to a moving reference period which both contains Deutsche mark and euro prices and with the latter getting more weight as time passes by. The results suggest that it is mainly this factor which accounts for the persistent deviation of his index from official measures of inflation.

Another aspect of the conversion has been highlighted by Mastrobuoni (2004) and Dziuda and Mastrobuoni (2005). In particular, these models build upon the idea that a new currency decreases transparency of prices, i.e. consumers are not used to the new currency and recognize prices, due to difficult conversion rates, only with some error. For retailers, this generates an incentive to increase prices. Since the costs of erroneous conversions that arise to consumer are small for goods with a low price, the model predicts that the incentive to increase prices is inversely related to the initial price level. Thus, the model predicts that cheaper goods were subjected to a higher rate of inflation than more expensive goods.

This aspect of the model is tested for Economic and Monetary Union (EMU) and non-EMU countries and an inverse relationship between the price level and inflation can be observed in some EMU-countries. Another aspect of the model is that the strength of this inverse relationship should be positively related to the market power of retailers, which can also be confirmed empirically.[6] Also, it is stipulated that price increases should be correlated with consumers' ability to adapt to the new currency. Dziuda and Mastrobuoni (2005) test for this effect indirectly by approximating consumers' ability by the (aggregate) share of the population which uses old currency prices when making price comparisons and by the share which feels uncomfortable with the euro. In a cross-country regression both variables seem to be correlated with the size of the inverse relationship between inflation and the price level.[7]

Actually, this model provides a plausible explanation of why more frequently purchased goods experienced above average price increases – as these goods typically are the ones which are relatively cheap. Also, the model's assumption that conversion errors are less costly for low priced than for more expensive goods is

[6] Gaiotti and Lippi (2004) assembled a panel of 2500 restaurants in Italy and also find that local market power was associated with a larger price increase. They also propose a theoretical model for this observation. Hobijn, Ravenna and Tambalotti (2004) use a sticky-price model to argue that the increase in restaurant prices can be explained by menu costs.

[7] In particular, Dziuda and Mastrobuoni (2005) run both a country-wise and a panel regression to estimate the relationship between the price level of goods and the inflation rate. In the latter case, they find a negative correlation for almost all EMU countries, as predicted by the model. In the former case of country-wise regressions, however, the effect is significant only for a few countries. In particular, it is not significant for Germany and Austria, which is somewhat surprising given the evidence presented in our paper.

consistent with how Austrians make price comparisons. In particular, the survey used in this paper shows that exact conversions (with a conversion table or a calculator) are mainly carried out for high price goods. The prices of cheap goods, in turn, are barely converted in this way.[8]

To sum up, we think that all of the discussed hypotheses are very important in explaining the wedge between actual and perceived inflation. Furthermore, their empirical plausibility has been shown in various ways: some explanations are consistent with price movements (in particular some of the propositions from Brachinger 2005) or with cross-country differences in consumers' ability to adapt to the euro (Dziuda and Mastrobuoni's hypotheses). Other hypotheses have been confirmed in experiments (Traut-Mattausch et al., 2004; Hofmann et al., 2006). However, these hypotheses are typically tested in isolation. We think that the use of survey data would allow to answer the following questions: Can these results also be confirmed when all other effects are controlled for? Are some explanations more important than others? Is it possible to identify the reasons why the disparity was so persistent?

3. Data and Hypotheses

To shed some light on these questions we will utilize data from a representative survey conducted in July and August 2004 among the Austrian population. In particular, 2000 persons above the age of 14 were interviewed on a whole range of questions relating to perceived inflation.[9] As the survey questions range from an assessment of whether prices have changed and the specific reasons therefore, to difficulties with euro conversion and the attitude and assessment of the euro, we can test for the relevance of some of the above mentioned hypotheses. In particular, we will test the following three hypotheses which also appear most prominently in the policy debate.

First, Brachinger (2005) has hypothesized that perceived inflation should be higher if prices of frequently bought goods or services increase more than prices of less frequently bought goods and services. Since we do not have information on the frequency of purchases of individual persons, we will not be able to test for this effect directly. However, the survey allows us to follow an indirect approach. In particular, we can utilize information on whether a person runs a household ("HOUSEHOLD"), i.e whether a person is responsible for daily purchases. As these prices grew more strongly than the prices of less frequently purchased goods,

[8] 33% of those saying that they still convert prices into Austrian schilling, say that they do exactly convert for high price goods. For goods which are bought daily (low price goods), the corresponding percentage is only 6%. In case of the latter goods, 65% do not convert, but buy regardless.

[9] The survey was commissioned by the OeNB and conducted by FESSEL-GfK.

we expect that persons who run the household perceive a higher inflation rate than persons who are not responsible for running the household.

The second hypothesis deals with the way how individuals form their individual price perception. The survey allows to approach this from several directions. The first deals with the conversion into the old currency. If individuals still convert euro into Austrian schilling, then they will perceive higher prices because they compare actual prices with prices that are frozen as of 2001. We can address this issue because the survey contains questions about whether respondents convert into schilling and how regularly they do so. Specifically, the corresponding answers are grouped into those that always ("CONVERT A"), frequently ("CONVERT F") or occasionally ("CONVERT O") convert and those that rarely or never convert into schilling. That this effect can be of relevance is reflected by the fact that two and a half years after the cash changeover, still 13% of the population converted always and 27% converted frequently. Further 34% did so occasionally.[10]

The second set of variables deals with the way how prices are converted. The correct conversion rate for the Austrian schilling is 1 (EUR) = 13.7603 (ATS). Obviously, this conversion rate is difficult to handle in day-to-day situations and hence the typical approximation used is 1:14. However, this approximation can be very misleading as it implies an "inflation rate" of 1.7% which, for example, is higher than the annual HICP-inflation rate in 2003. In fact, 61% of the Austrian population fully agree to the statement "when converting from euro to Austrian schilling, I round tolerantly and convert with 1:14". In the regression we make use of this information by including a dummy variable for this answer ("CONVERT 1:14"). An additional way to cope with how people convert is to directly measure respondents' conversion ability. In particular, survey participants were asked to spontaneously convert the amount of 1.80 euro into schilling. For those that over- or underestimate the correct amount by 10% we define the dummy variables "CONVERT +10%" and "CONVERT –10%".

Our third hypothesis is related to the role of expectations, in particular to the finding that widespread expectations of price increases prior to the euro cash changeover are related to the perception of price increases. The survey contains a question about the attitude towards the euro before the cash changeover. The question was "Which attitude towards the euro did you have prior to the euro's introduction?". The answers are grouped into those with a positive ("ATT POS"), a neutral and a negative attitude ("ATT NEUTRAL", "ATT NEG"). About 37% of the population had a positive, 30% a neutral and 33% a negative attitude. As this question is not directly related to the expectation of price increases we alternatively use the results from another question which directly deals with expected price

[10] It is clear that the use of dummy variables is a gross simplification of the often complex strategies to learn new prices.

increases:[11] "Do you agree/disagree with the following statement: It was clear to me before the introduction of the euro that prices will increase." This variable is labeled "EXP. INCREASES". Here, the survey shows that a majority (55%) agreed, while 37% disagreed. The rest had no clear opinion.

Regardless of which question is selected, it is clear that the use of recall-questions is not optimal as the ability of respondents to remember their attitude of the year 2002 might be affected by respondents' perception of prices, i.e. the variable might be endogenous.[12] In principle, one could circumvent this by applying some form of instrumental variable approach, however, this is difficult to handle in the context of an ordered response model. In lack of an alternative, we will follow a pragmatic route by testing whether the inclusion of these recall variables affects the other estimated coefficients and standard errors. Furthermore, there are two facts which suggest that endogeneity might not pose a serious problem. First, we can cross-tabulate the answers about the current attitude (at the time of the survey) with the answers on the recalled attitude (referring to the time prior to the cash changeover). This exercise yields that 59% of all respondents had a different view about the current situation than they had before the euro cash changeover. This suggests that the majority of persons differentiated in their answers about the current and the recalled attitude. Moreover, for the recall-question on expected price increases, we are able to check our results with an external data source, in particular a survey by the European Commission which was conducted in November 2001. Reassuringly, we find very similar results indicating that, on aggregate, people remember well (or reveal correctly) their past attitude.[13]

4. Model

To test for the influence of the above mentioned variables we regress several individual characteristics on three separate variables which are assumed to proxy inflation perceptions.

The first dependent variable is derived from a question about whether the introduction of euro cash has induced price increases ("price increases through euro introduction"). In total, 56% of all Austrians answered that many products had become more expensive with the introduction of the euro, 34% said that some products had become more expensive. Since only a very small fraction of

[11] The question on the attitude towards the euro captures a general assessment which, however, is likely to be positively correlated with expected price increases.

[12] In particular, if a person has perceived price increases, then this might affect the person's answer about his attitude before the cash changeover.

[13] According to the EC survey from November 2001, 52% of all Austrians feared price increases due to the cash changeover. According to the recall question we use, this applies to 55% of all Austrians.

respondents answered that prices got cheaper, we merge this category with the answers that prices stayed the same, applying in total to 10% of respondents.

The second dependent variable is very similar but refers only to price changes during the last six months before the survey, essentially covering the first six months of 2004 ("price increases during the last six months").[14] Here, 33% and 51% respectively answered that many or some products got more expensive.

The third dependent variable is a direct quantitative estimate of the level of inflation survey participants were asked for ("estimated rate of inflation"). We find that individuals estimate an inflation rate of 5% on average, which is more than twice as high as the HICP-inflation rate which was 2.3% in June 2004. However, the answers also show a excessive degree of variation with estimates of up to 75%! Eliminating all answers with inflation rate estimates above 20%, which applies to 2.5% of the sample, results in a substantially lower estimated mean inflation rate of 2.7%.

We will treat results on the third dependent variable as a proxy and not as a direct measure of perceived inflation. This is because of the exact wording of the question. In particular, respondents were asked for the level of inflation and if respondents didn't know the answer they were asked for an estimate. The fact that we do not know whether individuals actually gave an estimate or whether they knew the level of inflation – or put differently, to what extent answers reflect perceived rather than measured inflation – calls for some cautiousness when interpreting the results. In particular, it could be the case that individuals perceived a higher level of inflation than indicated by the official inflation measure but nevertheless replied the official measure because they knew its level. Thus, this measure is likely to represent a lower bound of the level of perceived inflation.

As the first two dependent variables are first categorical and second ask for an assessment about how many products got more expensive (and not about an categorical assessment of the level of inflation), the question arises whether these variables are in fact correlated with the level of perceived inflation. As the latter is unobserved we cannot provide a direct test. However, we can analyze whether answers on the categorical questions are correlated with survey participants' estimates of the rate of inflation. This is done in table 1 which shows the mean levels of survey participants' estimates of the rate of inflation for each category of the first two dependent variables ("price increases through introduction of the euro", "price increases during the last six months"). The results by and large suggest that the assumption that categorical answers on how many products got more expensive are correlated with the estimated rate of inflation is not unwarranted. For example, those who answered that there were no changes or

[14] The exact wording is: "In the last months there have been many discussions about price developments. Personally, how do you view the price development during the last 6 months ...."

products got cheaper estimate on average an inflation rate of 3.1%; the corresponding value for those that answered that many goods got more expensive is 6.4%.[15]

Given the categorical nature of the first two dependent variables, the estimation model is specified as the following ordered probit model:

$$y_i = \beta_1 \cdot SD_i + \beta_2 \cdot E_i + \beta_3 \cdot C_i + \varepsilon_i \quad (1)$$

where y_i represents the inflation perception of individual *i*, SD_i is a vector of various socio-demographic variables, E_i is a vector of variables capturing the expectations of individual *i* and C_i is a vector of variables controlling whether individual *i* converts into schilling and if so how this is done. ε_i is an error term assumed to be normally distributed with mean zero and unit variance. Instead of observing the perceived inflation rate y_i^* directly, we have data on y_i, the categorical survey response of individual *i*. If there are m categories, then y is in the *j*-th category if it is in the range given by $\alpha_{j-1} < y < \alpha_j$, where the α's are parameters to be estimated.[16]

For the estimated level of inflation, our third dependent variable, the above model is estimated by ordinary least squares.

5. Estimation Results

We start our discussion with perceived price changes through the cash changeover as the dependent variable (table 2). As the responses of this variable are ordered from "no change" to "many goods got more expensive", a positive sign of the coefficients β indicates that a variable positively affects the probability that individual *i* perceives a higher inflation.[17]

To control for socio-demographic characteristics, we add dummies variables for six household income classes ("INC") as well as for the age of respondents ("AGE"). The idea is that price increases have a different impact for a high income

[15] For the question on the price increases during the last six months, there is one inconsistency, namely that the mean inflation rate for those who said that many goods got more expensive is slightly lower than the mean inflation rate for those answering that some goods got more expensive. This however, is due to some outliers and to the weighting of the sample (in table 1 we apply population weights). If either outliers are excluded or the sample is not weighted, as is done in the estimations, then this inconsistency disappears (lower panel of table 1).

[16] The model is estimated by maximum likelihood.

[17] To be precise: a positive β coefficient indicates that a variable positively affects the probability of the event "many goods got more expensive".

household than for a low income household because of liquidity constraints (a low income household spends most of its income with little variation left for savings; the relative costs of price increases are thus higher for low income households). Also, it could be argued that age is important. For example, retired people with low nominal increases of their pensions are more affected by perceived price increases than younger households who can adjust labor supply. On the other hand, one could view this from the side of an information problem. Old persons, specifically those who are retired, have more time to get informed about price movements than young people. Another set of dummy variables controls for the educational level of a person ("EDU"). We include these variables first because they provide additional information on personal income, which is not available in the survey, and second because the level of education might have implications on perceived inflation directly. For example, less educated people might have less information on price movements than more educated people.

Factors determining price perceptions caused by the euro cash changeover: The findings in column 1 of table 2 imply that people aged 65 or over perceive fewer price changes than those aged 35 to 54.[18] Furthermore, the results show a significant influence of education, with the level of perceived inflation decreasing with the level of education. In particular, the point estimates imply that the probability that a person answers that many goods got more expensive is higher by 13% and 9% if this person does not have a university degree or a high school leaving certificate, respectively.

The point estimates from the household income dummies indicate that higher income households (with an income above EUR 2,200) perceive fewer price increases than lower income households, although this effect is not significant statistically. However, if the personal education dummies proxy personal income, the results suggest that income plays some role to what extent prices increases are perceived–in particular for the highest educated or highest income groups against all other income groups. Given that persons without a university degree constitute about 86% of the sample and that people whose household income is not in the highest income group constitute about 75% of the sample, the results support the view that the perception of price increases is prevalent across a wide range of the population.

Next, we turn to our hypotheses: First, the variable which measures whether a person runs an household is highly significant, suggesting that persons who are more often confronted with prices (through daily purchases) perceive a higher rate of inflation. Also, the variables which measure the attitude towards the euro are significant. In particular, persons who had a negative attitude before the changeover have a higher inflation perception than persons who had a neutral or

[18] The test $\beta_{AGE3544} > \beta_{AGE65+}$ and $\beta_{AGE4554} > \beta_{AGE>65}$ yield test statistics $\chi_1^2 = 6.6$; $p<0.05$ and $\chi^2_1 = 9.5$; $p<0.01$ respectively (test statistics for column 1 in table 2).

negative attitude. Similarly, persons who expected price increases before the cash changeover are found to perceive higher inflation.

The effects we find are not only statistically but also economically significant: In particular, the probabilities of the event "many goods got more expensive" increases with "HOUSEHOLD" by 7%, with "EXP. INCREASES" by 10% and with "ATT NEGATIVE" by 5%.

Finally, we turn to the variables which indicate whether people convert and if so how they convert into schilling. First, the results do not only indicate that conversion per se matters but also that the frequency with which a person converts is important. In particular, we find that if prices are always converted then this results in higher perceived inflation than if prices are frequently converted. And if prices are frequently converted then this results in higher perceived inflation than if prices are only occasionally or not converted – the probability of the event "many goods got more expensive" is found to be higher by 17% and 10% respectively for persons who always or frequently convert. Second, the results suggest that the use of a conversion rate of 1:14 also seems to significantly increase perceived inflation.

Columns 2 to 5 of table 2 summarize the results of several different specifications. To account for the possibility that the variables measuring the attitudes before the cash changeover ("ATT NEGATIVE", "ATT NEUTRAL") and the variable measuring expected price increases ("EXP. INCREASES") are correlated, we alternately omit one of them in column 2 and 3. We find that the precision of the point estimates decreases while parameter signs are unchanged. Due to the possible endogeneity of these variables, we omit them altogether in column 4. The fact that the results do not change qualitatively suggests that endogeneity might not pose a problem. Finally, in column 5 we omit the variable measuring the 1:14 conversion, which rests on self assessment of the participants in the survey, and include the variables which measure if respondents over- or underestimated the euro amount of 1,80 by 10%, respectively. As can be seen, people whose way of conversion results in a euro price that is 10% too high have a higher likelihood of reporting price increases.

Do these factors also influence inflation in 2004? The results of applying the same specifications to the perceived price increases within the last six months are summarized in table 3. These results allow to determine whether the factors responsible for higher inflation perceptions in the course of the euro changeover also have an impact on perceived inflation two years after the euro introduction.

Again, the same five empirical specifications as before have been estimated. The results for the socio-demographic variables, which are not shown, indicate that education, again, plays an important role for inflation perceptions with the same sign as in the previous table (the higher the education the fewer price changes are perceived). Also, the results for household income are comparable to the previous

results. In contrast to previous results, we find that people above the age of 55 now perceive a higher rate of inflation than people between 25 and 54.[19]

Concerning the role of expected price increases we find a significantly positive impact whereas the attitude towards the euro is only significant in one specification (when the variable measuring whether a person expected price increases is omitted). Furthermore, we find that the frequency with which a person converts into schilling has the same impact as discussed above whereas the method of conversion ("1:14") is not significant. The calculation error is again significant, in this specification however not only for those who overestimate but also for those who underestimate the euro amount by 10%. Maybe this finding reflects that both variables capture those who still had problems with the euro (irrespective of whether a person under- or overestimates the amount). In contrast to previous results we do not find a significant effect for "HOUSEHOLD".

Thus, these results show that the perception of price increases during the first six months of 2004 – a period for which the euro changeover has no direct bearing – is still significantly influenced by some euro-specific factors. This suggests that cash changeover effects are very persistent. However, we find that fewer variables are significant than in the case of perceived inflation through the cash changeover. An analysis of marginal effects reveals that "EXP. INCREASES" has about the same effect as for perceived inflation in the course of the euro changeover while the effect of converting ("CONVERT ALW") is smaller (the event "some goods got more expensive" increases by 6% compared to 17% before).

Finally, table 4 summarizes the results with the quantitative measure of the inflation rate as the dependent variable, again in various specifications. As discussed, the answers of respondents show a great deal of variation with some extreme outliers. In order to prevent that these outliers dominate our results, we cut off the highest and lowest 2.5% of the individual answers (estimated inflation rates below 0.6% and above 20%). Furthermore, the dependent variable is transformed into its logarithm.

For the socio-demographic variables we find again that years of schooling is negatively correlated with perceived inflation. For income, no significant effects are found. Interestingly, age seems to be important with all persons above the age of 25 having lower inflation estimates than younger persons.[20] Concerning the point estimates for those variables which control for our hypotheses, we obtain very similar results than in the previous ordered probit regressions. Thus, those running a household, those with a negative attitude and those who convert into Austrian

[19] Why age plays a different role than before is difficult to answer. One reason could be that the price index for different age groups evolved differently between 2002 and 2004 than during the first six months of 2004.

[20] This result is driven by the fact that persons below the age of 25 estimate on average an inflation rate of 12.2% (median 3%). When outliers are eliminated the mean is still 5% (median 3%).

schilling perceive a higher rate of inflation. In contrast to previous results, conversion errors or the way how euro are converted ("1:14 conversion") do not have a significant impact. The point estimates imply that "HOUSEHOLD" increases the mean estimated rate of inflation by 6% and a negative attitude by about 9%.[21] Persons who always convert estimate the inflation rate 18% higher than persons who never or rarely convert. Those converting frequently still estimate the inflation rate to be 8% higher.

To summarize, the results show that all three of the tested hypotheses are important in determining the level of perceived inflation caused by the euro changeover. The highest impact is given by the mental conversion into the old currency, followed by the role of expected price increases or a negative attitude towards the euro and by the role of frequent purchases. The findings also demonstrate that some of these factors have a persistent impact. In particular, this accounts to the mental conversion into the old currency. Although, the results for our two measures of perceived inflation during the last six months differ somewhat, a persistent effect also seems to originate in expected price increases.

Does the disconnect of perceived from measured inflation also have other effects? As survey participants were asked whether the inflation rate can truthfully represent the price development we will finally analyze whether the credibility of the measured inflation rate is correlated with perceived inflation.[22]

How Credible are Official Measures of Inflation? In total, 97% of respondents have heard of the term "inflation rate". Amongst them, 13% think that the inflation rate is very credible in representing price movements and 28% think that it is credible. Further 41% give an answer in the "middle" while 16% think that it is not credible. This amounts to 57% who do not have an explicit positive assessment which is quite surprising given the fact that the inflation rate has a long tradition and is such a central measure for economic activity in general and monetary policy in particular.[23] Given this result, the question arises whether the factors which influence perceived inflation also influence the inflation rate credibility. We study this question by re-running previous regressions with the credibility measure as the dependent variable.

As the dependent variable ranges from values of 1 (no credibility) to 5 (high credibility), higher coefficients indicate that individuals assign higher credibility to the inflation rate. The results, which are presented in table 5 show that many of the variable which significantly influence perceived inflation also influence attached credibility. In particular, this applies to education where higher education is

[21] Calculated as $\exp(\beta_i) - 1$.

[22] The exact questions is: "Do you believe that the inflation rate can truthfully represent the price development. I mean how credible is the rate of inflation in your view."

[23] Since we do not have comparison results from a period when inflation perceptions and measured price increases were closer to each other the results do not allow the conclusion to be drawn that the credibility is bad.

associated with higher credibility. For income no significant effect is found. The findings suggest that credibility significantly declines as age increases, at least for persons above the age of 24. Furthermore, we find that persons with a negative attitude, those who care for daily purchases and those who convert into schilling all have a significantly worse opinion of the inflation rate as a measure of price changes. The way of conversion (e.g. 1:14) however, has no significant impact.

6. Conclusions

This paper empirically analyzes why inflation perceptions got disconnected from official inflation measures in the course of the euro cash changeover. In particular, we employ a micro-dataset to study the role of price increases of frequently purchased goods, expectations and the conversion ability of Austrian individuals – those three factors assigned the greatest relevance by the literature. In contrast to the literature which mainly tests for one effect in isolation, this approach allows to test for all three factors simultaneously while also accounting for socio-demographic differences.

Our results can be summarized as follows: First, we find that persons who are confronted with prices of frequently purchased goods perceive a higher rate of inflation. This provides support for the hypothesis of Brachinger (2005) and others stating that consumers' record price changes through frequently purchased goods. The fact that prices of frequently purchased goods rose faster after the cash changeover than overall inflation has therefore become manifested in higher inflation perceptions. Second, our results point towards a substantial role for expectations of price increases as argued by Traut-Mattausch et al. (2004) and Hofmann et al. (2006). In particular, person who believed prior to the changeover that prices will increase have later perceived a significantly higher rate of inflation than other persons who did not expect price increases. Third, those who mentally convert euro prices into Austrian schilling prices, and thus compare actual prices with prices prior to 2002, perceive a higher rate of inflation. The same effect is obtained for people, who do convert euro into schilling very imprecisely. Thus, our evidence from individual data is largely consistent with the hypotheses stated in the literature as well as with indirect evidence from experiments and aggregate data. Moreover, we find that it is not one of these factors alone which is responsible but all three together.

Astonishingly, we find that the above mentioned factors are rather persistent in the sense that they influence the assessment of inflation even as late as in 2004. In particular, the impact of expectations and of the use of the old currency for price comparisons turn out to be important in this context. As expectations of price increases prior to the cash changeover are fixed as of now, the main driving force behind the persistence seems to be the very large fraction of the Austrian

population which still uses old currency prices as a mental benchmark when making price comparisons.

Furthermore, our results suggest that the factors which influence individual price perceptions also influence the credibility of official measures of inflation. Thus, the more perceived inflation deviates from measured inflation the less people believe that the official measure can truthfully represent price developments. Though we are not aware of any evidence which shows that this actually poses a problem, it is certainly better for economic policy if people believe the published inflation number than if they do not.

Although our results are obtained from Austrian data, we think that they also have some implications for other countries – in particular concerning the role of price comparisons in old currency and of expectations. A European Commission survey in November 2004 confirms that price comparisons in legacy currencies are still very widespread in many countries. In particular, 49% of citizens in euro area countries used old currencies when counting mentally, only 19% counted in euro when purchasing (European Commission, 2004b). For Austria, this survey reports that 46% used old currencies when counting mentally. Thus, the case of Austria is basically comparable to the euro area average. Furthermore, survey results also indicate that expectations of price increases have already settled in the new Member States – 71% of the population fear abuses and cheating on prices in connection with an eventual introduction of the euro (European Commission, 2004a). This development is surprisingly similar to old euro area members where the corresponding number was 70%.

The policy implications from our result affect mainly those countries which will face a cash changeover. In particular, this regards policy measures which prevent price increases of frequently purchased goods, which convince the population that the expectations of price increases are not warranted – probably very difficult to achieve – and which promote the evolution of a good feeling for the new currency and prices. There might be other important factors which were not analyzed in this paper, however we think that addressing those three issues will contribute a great deal towards preventing similar developments than those experienced in many euro area countries.

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Appendix: By How Much Has Perceived Inflation Deviated From Measured Inflation?

It is not easy to answer how strongly consumers' perceptions deviated from official inflation statistics as it is not clear how inflation perceptions should be quantified. Consequently, several indicators can be found in the literature (cf. Del Giovane and Sabbatini, 2005b).

In the monthly Consumer Confidence Barometer of the European Commission survey respondents around Europe are asked about their assessment of the price development in the past 12 months. An indication of how strongly consumers perceive price increases is obtained by calculating the balance between the share of those answering that prices rose and the share of those who believe prices stayed constant or decreased. chart 1 juxtaposes these balance scores with changes of the Harmonized Index of Consumer Prices (HICP). This chart reveals that in most countries HICP-inflation and the balance score ran almost parallel prior to the year 2000. Then, before or around the cash changeover the close relation markedly loosened. This can be observed for all countries shown. Also, in most countries, the wedge persisted for several years and in some countries it has not closed yet.

Although the balance score is indicative about price trends it has some shortcomings. Most importantly, it is not informative about the level of perceived inflation – it just expresses the relation between the share of the population perceiving price increases relative to those who do not perceive price increases.[24]

Information on the level of perceived inflation can be obtained by applying a method proposed by Berk (1999) which utilizes the distribution of survey responses to estimate perceived inflation rates.[25] Results for Austria are presented

[24] There are other shortcomings as well: First, assessing the level of perceived inflation solely by visual inspection of the wedge between the plotted balance statistics and HICP-inflation can be misleading insofar as the "proximity" of the two curves is affected by the choice of the starting date – choosing a different starting date can lead to a different visual impression. Second, as countries differ in their average level of the balance statistics, these values are difficult to compare internationally, e.g. it is not possible to say that one country has a higher perceived inflation rate than another country because the wedge is higher in the former country. Of course, one could analyze the deviation of the balance statistics from the historic average. However, then the results depend on the starting date again.

[25] The method rest on the assumption that the answers are normally distributed such that the share of answers falling into a certain category (e.g. "prices have risen") can be interpreted as probabilities that perceived inflation lies in a range between a (numeric) lower and upper bound. The perceived inflation rates are then estimated on the assumption that, on average, consumers perceive inflation rates which are equal to actual inflation rates. Despite of its advantage of providing a quantification of perceived

in chart 2. Again, the wedge between perceived inflation and measured inflation is clearly visible. If one takes these estimated values literally, then at times inflation perceptions were higher by as much as 1.9 percentage points. On average, perceived inflation was above measured inflation by 0.85, 1.28 and 0.95 percentage points in 2002, 2003, 2004 respectively.[26] Only in the first months of 2005 does the wedge seem to have declined to values comparable to those prevailing in the 1990s.

An alternative approach is presented by Brachinger (2005) who, as discussed, utilizes results from Prospect Theory to postulate a theory of price perception. Based on this theory, he proposes an index of consumer prices where goods are weighted by their purchase frequency, where price increases are weighted more strongly than price decreases and where price comparison are made with respect to reference prices, which are partly denominated in legacy currency. This index was recently calculated for Germany in collaboration with the German national statistics institute ("Statistisches Bundesamt"). Interestingly, it is found that perceived inflation was as high as 10% around 2002 in Germany while HICP-inflation was around 2%. Based on specific parameter assumptions, Brachinger (2005) furthermore reports that, in contrast to the visual impression from the balance score, perceived inflation in Germany has not faded and is still about 5 percentage points higher than HICP-inflation.

Despite the lack of a consensus about how price perceptions should be measured, we think that the presented evidence allows to identify three stylized facts which seem to hold irrespective of the particular method: First, most countries of the euro area experienced an increase in perceived inflation relative to HICP-inflation rates. Second, the difference between these two measures was sizeable. And third, it is a surprising facet of the euro conversion that this wedge turned out to be very persistent.

inflation, it is clear that this method can be criticized because of doubts about the adequacy of some of the assumption made, in particular concerning the latter assumption.

[26] We thank Ernst Glatzer for providing the data.

Table 1: Estimated Level of Inflation for Different Categorical Answers on Price Increases

	price increases with introduction of euro cash	price increases during the last six months
	class means of estimated rate of inflation	
categorical responses:		
no change or products got cheaper	3.1	3.7
some products got more expensive	3.6	5.5
many products got more expensive	6.4	4.8
	class means of estimated rate of inflation – reduced sample	
no change or products got cheaper	2.3	2.3
some products got more expensive	2.8	2.6
many products got more expensive	2.8	3.2

Note: "estimated rate of inflation" refers to survey participants' estimates of the inflation rate. For the reduced sample all observations with an estimated inflation rate above 20% are excluded.

Source: Author's estimations.

Table 2: Estimation Results: Price Increases through Introduction of the Euro

	Dependent Variable: Price Increases Through Introduction of the Euro (1=no change, 2=some goods more exp., 3=many goods more exp.)				
	(1)	(2)	(3)	(4)	(5)
EDU APP.	-0.14	-0.15	-0.13	-0.14	-0.14
	(0.09)+	(0.09)+	(0.09)	(0.09)+	(0.09)+
EDU HIGH S.	-0.22	-0.24	-0.22	-0.25	-0.23
	(0.09)*	(0.09)*	(0.09)*	(0.09)**	(0.09)*
EDU UNIV.	-0.34	-0.36	-0.35	-0.40	-0.37
	(0.11)**	(0.11)**	(0.11)**	(0.10)**	(0.11)**
INC 1,100 - 1,500	0.05	0.01	0.08	0.03	0.03
	(0.12)	(0.12)	(0.12)	(0.11)	(0.12)
INC 1,500 - 1,850	0.12	0.10	0.13	0.09	0.13
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
INC 1,850 - 2,200	-0.00	-0.03	0.01	-0.03	-0.00
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
INC 2,200 - 2,900	-0.10	-0.13	-0.10	-0.13	-0.10
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
INC > 2,900	-0.08	-0.10	-0.07	-0.11	-0.07
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
AGE 2534	0.07	0.06	0.09	0.07	0.07
	(0.13)	(0.13)	(0.13)	(0.13)	(0.13)
AGE 3544	0.07	0.05	0.10	0.08	0.07
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
AGE 4554	0.12	0.11	0.15	0.13	0.14
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
AGE 5564	-0.01	-0.02	0.02	-0.00	0.01
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
AGE >65	-0.16	-0.18	-0.14	-0.18	-0.13
	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)

Note: See continuation.

Table 2 continued: Estimation Results: Price Increases through Introduction of the Euro

	(1)	(2)	(3)	(4)	(5)
HOUSEHOLD	0.19	0.20	0.17	0.19	0.19
	(0.06)**	(0.06)**	(0.06)**	(0.06)**	(0.06)**
ATT NEGATIVE	0.12		0.22		0.12
	(0.07)+		(0.07)**		(0.07)+
ATT NEUTRAL	-0.07		-0.04		-0.08
	(0.07)		(0.07)		(0.07)
EXP. INCREASES	0.26	0.30			0.27
	(0.06)**	(0.06)**			(0.06)**
CONVERT ALW	0.45	0.45	0.49	0.51	0.46
	(0.11)**	(0.11)**	(0.11)**	(0.11)**	(0.11)**
CONVERT FRE	0.25	0.25	0.24	0.26	0.26
	(0.08)**	(0.08)**	(0.08)**	(0.08)**	(0.08)**
CONVERT OCC	0.01	-0.00	0.02	0.02	0.02
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)
CONVERT 1:14	0.16	0.16	0.15	0.16	
	(0.06)**	(0.06)**	(0.06)**	(0.06)**	
CONVERT +10%					0.30
					(0.15)*
CONVERT -10%					0.01
					(0.07)
Observations	1911	1919	1915	1923	1915
LL	-1696.18	-1707.85	-1712.17	-1727.65	-1701.76

*Note: Ordered probit regressions; robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Results of regional dummies not shown.*

Source: Author's estimations.

Table 3: Estimation Results: Price Increases During the Last 6 Months

	Dependent Variable: Price Increases During the Last 6 Months (1=no change, 2=some goods more exp., 3=many goods more exp.)				
	(1)	(2)	(3)	(4)	(5)
HOUSEHOLD	0.04	0.05	0.04	0.06	0.04
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
ATT NEGATIVE	0.07		0.16		0.06
	(0.07)		(0.07)*		(0.07)
ATT NEUTRAL	0.04		0.07		0.04
	(0.06)		(0.06)		(0.06)
EXP. INCREASES	0.27	0.28			0.27
	(0.06)**	(0.05)**			(0.06)**
CONVERT ALW	0.17	0.20	0.20	0.25	0.08
	(0.10)+	(0.10)*	(0.10)*	(0.10)*	(0.10)
CONVERT FRE	0.12	0.13	0.12	0.14	0.04
	(0.07)+	(0.07)+	(0.07)	(0.07)+	(0.08)
CONVERT OCC	0.01	0.01	0.02	0.02	-0.08
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
CONVERT 1:14	-0.08	-0.08	-0.06	-0.06	
	(0.05)	(0.05)	(0.05)	(0.05)	
CONVERT +10%					0.26
					(0.13)*
CONVERT -10%					0.14
					(0.06)*
Observations	1909	1918	1915	1924	1914
LL	-1860.66	-1868.65	-1880.33	-1890.66	-1862.70

*Note: Ordered probit regressions; robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Results of socio-demographical and regional dummy variables not shown.*

Source: Author's estimations.

Table 4: Estimation Results: Estimated Rate of Inflation

	Dependent Variable: Estimated Rate of Inflation (quantitative estimates of survey respondents)				
	(1)	(2)	(3)	(4)	(5)
EDU APP.	-0.09	-0.10	-0.10	-0.10	-0.10
	(0.05)*	(0.05)*	(0.05)*	(0.05)*	(0.05)*
EDU HIGH S.	-0.18	-0.18	-0.18	-0.18	-0.18
	(0.05)**	(0.05)**	(0.05)**	(0.05)**	(0.05)**
EDU UNIV.	-0.24	-0.24	-0.23	-0.24	-0.24
	(0.05)**	(0.05)**	(0.05)**	(0.05)**	(0.05)**
INC 1,100 - 1,500	0.01	-0.01	0.00	-0.01	0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
INC 1,500 - 1,850	0.05	0.03	0.04	0.03	0.05
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
INC 1,850 - 2,200	-0.01	-0.02	-0.01	-0.02	-0.01
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
INC 2,200 - 2,900	0.01	-0.00	0.01	-0.00	0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
INC > 2,900	-0.01	-0.02	-0.01	-0.02	-0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
AGE 2534	-0.25	-0.25	-0.25	-0.25	-0.25
	(0.09)**	(0.09)**	(0.09)**	(0.09)**	(0.09)**
AGE 3544	-0.28	-0.28	-0.29	-0.29	-0.28
	(0.09)**	(0.09)**	(0.09)**	(0.09)**	(0.09)**
AGE 4554	-0.27	-0.27	-0.27	-0.27	-0.26
	(0.09)**	(0.09)**	(0.09)**	(0.09)**	(0.09)**
AGE 5564	-0.31	-0.31	-0.31	-0.31	-0.31
	(0.09)**	(0.09)**	(0.09)**	(0.09)**	(0.09)**
AGE >65	-0.24	-0.25	-0.25	-0.25	-0.24
	(0.09)**	(0.09)**	(0.09)**	(0.09)**	(0.09)**

See continuation.

Table 4 continued: Estimation Results: Estimated Rate of Inflation

	(1)	(2)	(3)	(4)	(5)
HOUSEHOLD	0.05	0.06	0.06	0.06	0.06
	(0.03)*	(0.03)*	(0.03)*	(0.03)*	(0.03)*
ATT NEGATIVE	0.09		0.07		0.09
	(0.04)*		(0.03)*		(0.04)*
ATT NEUTRAL	0.01		0.01		0.01
	(0.03)		(0.03)		(0.03)
EXP. INCREASES	-0.04	-0.02			-0.04
	(0.03)	(0.03)			(0.03)
CONVERT ALW	0.15	0.17	0.14	0.16	0.15
	(0.05)**	(0.05)**	(0.05)**	(0.05)**	(0.05)**
CONVERT FRE	0.07	0.08	0.07	0.08	0.07
	(0.03)*	(0.03)*	(0.03)*	(0.03)*	(0.04)*
CONVERT OCC	0.06	0.07	0.06	0.06	0.06
	(0.03)*	(0.03)*	(0.03)+	(0.03)*	(0.03)+
CONVERT 1:14	0.02	0.02	0.02	0.02	
	(0.03)	(0.03)	(0.03)	(0.03)	
CONVERT +10%					0.03
					(0.06)
CONVERT -10%					-0.00
					(0.03)
Constant	1.05	1.06	1.03	1.05	1.05
	(0.13)**	(0.12)**	(0.12)**	(0.12)**	(0.12)**
Observations	1381	1385	1384	1388	1386
Adjusted R-squared	0.05	0.05	0.05	0.05	0.05

*Note: OLS regressions; robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Results of regional dummies not shown.*

Source: Author's estimations.

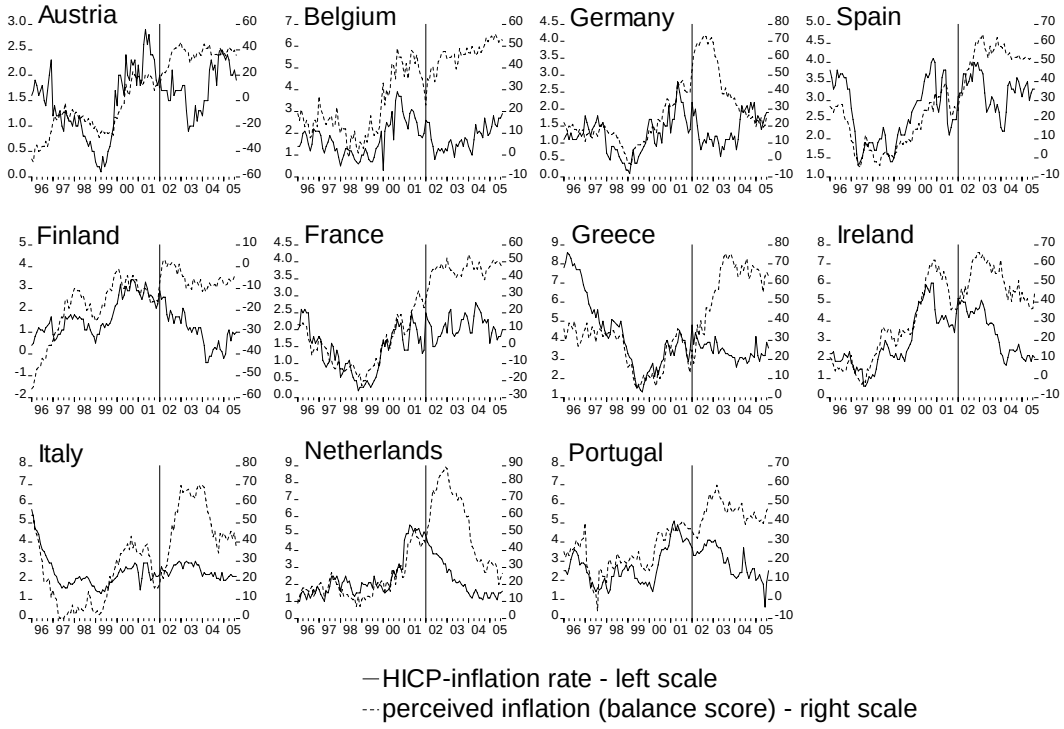
Table 5: Factors Affecting the Credibility of the Inflation Rate

	Dependent Variable: Credibility of the Inflation Rate (1=no credibility, ... 5=high credibility)				
	(1)	(2)	(3)	(4)	(5)
HOUSEHOLD	-0.15	-0.16	-0.15	-0.17	-0.14
	(0.06)*	(0.06)**	(0.06)**	(0.06)**	(0.06)*
ATT NEGATIVE	-0.14		-0.16		-0.14
	(0.07)*		(0.06)*		(0.07)*
ATT NEUTRAL	-0.07		-0.08		-0.07
	(0.06)		(0.06)		(0.06)
EXP. INCREASES	-0.08	-0.11			-0.09
	(0.05)	(0.05)*			(0.05)+
CONVERT ALW	-0.36	-0.38	-0.37	-0.41	-0.31
	(0.10)**	(0.10)**	(0.10)**	(0.10)**	(0.10)**
CONVERT FRE	-0.10	-0.12	-0.10	-0.12	-0.05
	(0.07)	(0.07)+	(0.07)	(0.07)+	(0.07)
CONVERT OCC	-0.02	-0.02	-0.02	-0.03	0.03
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
CONVERT 1:14	-0.03	-0.02	-0.03	-0.04	
	(0.05)	(0.05)	(0.05)	(0.05)	
CONVERT +10%					-0.13
					(0.13)
CONVERT -10%					-0.13
					(0.06)*
Observations	1842	1849	1847	1854	1846
LL	-2535.37	-2545.68	-2543.50	-2555.04	-2538.56

*Note: Ordered probit regressions; robust standard errors in parentheses + significant at 10%; * significant at 5%; ** significant at 1%. Results of socio-demographical and regional dummy variables not shown*

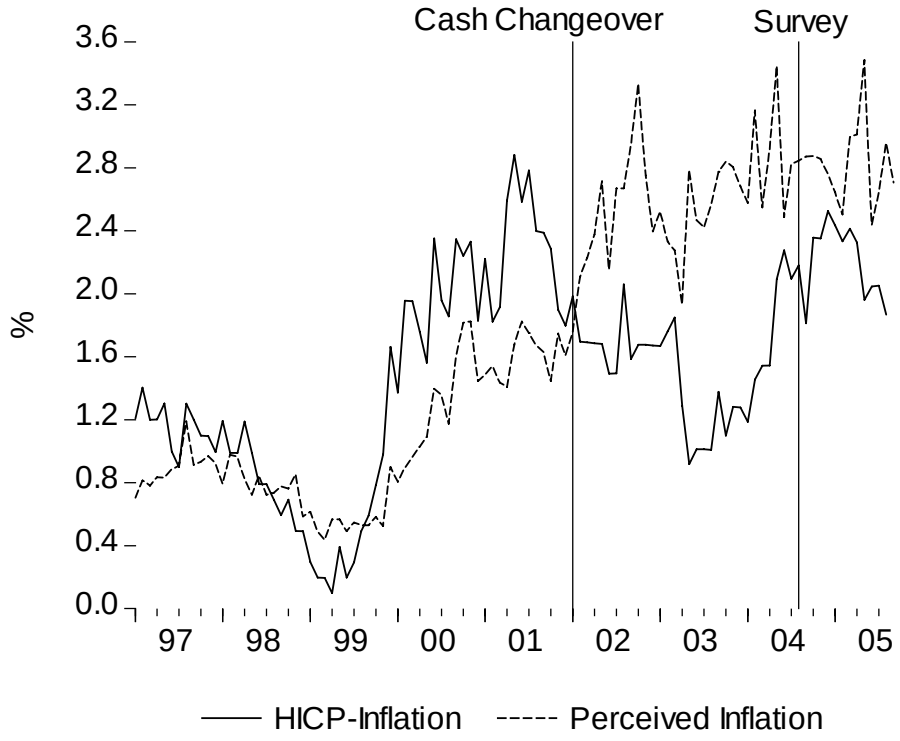
Source: Author's estimations.

Chart 1: Perceived Inflation (Balance Scores) and HICP-Inflation



Source: EU-Commission (balance scores), OeNB.

Chart 2: HICP-Inflation Rate and Perceived Inflation Rate in Austria



Source: OeNB.

Comment on "Perceived Inflation and the Euro: Why High? Why Persistent?"

Erich Kirchler

University of Vienna

The introduction of the euro as a noncash currency in 1999 and in cash form in 2002 went smoothly thanks to professional preparation and efficient changeover. Nevertheless, in all EU Member States, and, as expected, mainly in the countries of the European Economic and Monetary Union (EMU), the euro prompted discussions in which the people expressed their fears and hopes, developed social ideas about the "new unit" and formed expectations about changes in the economic situation for the individual and the nation. Of particular interest were the price changes caused by the currency changeover or attributable to the euro.

While the statistically measured inflation rates (e.g. the Harmonized Index of Consumer Prices, HICP) were and still are relatively low throughout the EMU, the inflation "perceived" by the general public has been much higher. In the euro area the gap between the HICP and perceived inflation continues to be significant. According to Stix (in this volume), there is still a divergence between perceived inflation and actual inflation. Why do the price increases perceived by consumers differ substantially from those actually recorded? In his study, Stix (in this volume) deals with possible causes.

The people of the EMU were asked to say goodbye to their familiar national currencies, to handle new banknotes and coins and to develop a subjective perception of the prices in euro. Over the last decade, economic and social psychology studies have dealt with the currency changeover, trying to find some evidence why and how people have come to perceive the euro as "Teuro" ("Teuro" being a German portmanteau word combining "euro" and "teuer", the German word for expensive). One explanation lies in the change of the currency as such: With the introduction of the euro, subjective, readily available routines for what was expensive or cheap became ineffective and new standards had to be developed to be able to assess prices (Kühberger and Keul, 2003; Meier-Pesti and Kirchler, 2001, 2003). Hardly surprising, a phase of uncertainty started, which was partly accompanied by distrust and hesitant spending. Meier-Pesti and Kirchler (2001) identified four adaptation strategies used by Austrian consumers to be able to evaluate prices: (a) exact conversion, (b) no conversion at all, (c) learning of

individual prices mainly of frequently bought goods, which served as points of reference for evaluating other prices and (d) learning of the conversion values of specific markers (e.g. EUR 5.00 equals about ATS 70.00 and ATS 100.00 is about EUR 7.00) to make rough estimates. Even though conversion is the most accurate of all strategies mentioned, it will take quite a bit longer to get used to the euro. Data collected for Austria (Kirchler and Fessel GFK, 2002) and Ireland (Ranyard, Burgoyne, Saldanha and Routh, 2003) show that people were likely to use exact conversion mainly for expensive products (Kühberger and Keul, 2003; Meier-Pesti and Kirchler, 2003). Further results for Austria illustrate that the frequency of exactly converting also prices of goods purchased on a daily basis was increasing with advancing age and in the lower income and education classes (Meier-Pesti and Kirchler, 2003). For convenience goods, Austrian consumers mostly used individual reference prices or benchmarks (see also Lemaire and Lecacheur, 2001). In Germany, the majority of consumers formed their price judgments relatively early, regardless of external anchors. This may suggest that either the certainty in dealing with the euro increased markedly already few months after its introduction or that the simple conversion rate of the Deutsche mark against the euro accelerated the learning process (Mussweiler and Englich, 2004). In an annual survey of the general status of adjustment to the euro the European Commission (2005) concluded for all EMU states that in autumn 2005 the adjustment process had still not been fully completed (e.g. Marques and Dehaene, 2004; Strazzari, Nori, Bensi and Giusberti, 2005). Well over one third of the euro zone population still convert less frequently bought, expensive products into their original currency. In addition to the difficulties involved in the changeover to the new currency, frequent – albeit slight – price changes were recorded when euro cash was introduced (Baumgartner, Glatzer, Rumler and Stiglbauer, 2005). In particular at the beginning of 2002, when the uncertainty and the difficulties of adapting to the euro were greatest, prices were changed frequently. Moreover, psychological prices (i.e. prices ending with 00, 50, 90 or 99) disappeared during the time of the euro cash changeover; about one year later psychological prices were back again (el-Sehity, Hölzl and Kirchler, 2005). Such a situation of uncertainty, caution and a considerable degree of distrust may easily lead to price changes being perceived as price increases rather than as price reductions. In fact, Stix (in this volume) also reports that most of the goods contained in the micro and mini baskets became more expensive while only few became slightly cheaper. According to Brachinger (2005a, 2005b), it is not surprising that a general perception of price increases developed. Brachinger criticizes that the basket of goods used by the statistical authorities differs significantly from a consumer's daily purchase, i.e. the psychological basket. Consumers do not perceive price changes as actual price changes of goods in the official basket but attach greater weight to price fluctuations of goods they buy more frequently than of goods they buy less frequently. Furthermore, price increases are perceived more powerfully than price

reductions. Regardless whether Brachinger's formula suggested for calculating perceived inflation is met with approval or not, it is no doubt relevant to consider that greater weight is placed on frequently bought goods and – in line with the findings of *Prospect Theory* (Kahneman and Tversky, 1979) – that losses are perceived more strongly than gains. If price increases were perceived to have been caused mainly by price changes in frequently bought goods and if the majority of goods in the micro and mini baskets became more expensive and only few products became cheaper, this will partly explain the "bias of the euro toward the Teuro" (e.g. Fischer, Katzer and Kiell, 2002).

Dealing with the new currency essentially depends on the understanding of the nominal euro values, which can be derived from two different sources. On the one hand, euro amounts can be evaluated on the basis of an interaction of nominal and real representations, which leads to a bias toward nominal evaluation (Shafir, Diamond and Tversky, 1997). This bias is influenced, *inter alia*, by the salience of nominal values as well as simple and careful mental calculation processes and is referred to as money illusion (Fisher, 1928; Patinkin, 1965). In the context of the influence of the respective former currencies and conversion factors on the perception of euro amounts also the term "euro illusion" was coined (Burgoyne, Routh and Ellis, 1999; Gamble, Gärling, Västfjäll and Marell, 2003). On the other hand, the evaluation of euro amounts can be influenced by specific other values, such as the price one remembers in the former currency or random values. This influence of specific external values on the perception of euro amounts is referred to as anchoring effect (Tversky and Kahneman, 1974). Anchoring effects are of a mere cognitive nature and may also lead to euro illusion. Euro illusion may be also driven by motivation (Gamble, Gärling, Charlton and Ranyard, 2002) and may occur if no or only insufficiently salient anchors are available. With the introduction of the euro, the nominal values on banknotes, salary slips and price tags fell in all EMU Member States, except for Ireland. The resulting lower nominal values (in most EMU Member States) may give rise to euro illusion and also prompt higher spending, since low nominal values lead to prices being perceived as low (Ferrari and Lozza, 2005; Fischer et al., (2002); Jonas, Greitemeyer, Frey and Schulz-Hardt, (2002); van Raaij and van Rijen, (2003)). Euro illusion may facilitate spending and, eventually, the available money has been spent faster, creating the illusion that there is no longer enough money. Moreover, van Raaij and van Rijen (2003) presume that due to euro illusion the difference between cheap and expensive products seems smaller and, therefore, the more expensive product is chosen more easily. Gamble et al. (2003) found evidence for this phenomenon. Both apparently lower euro amounts and seemingly minor price differences between individual products may lead to a total of higher expenses. The fact that there is less money left at the end of the month is, however, not attributed to one's own spending habits but is externalized and blamed on the euro (van Raaij and van Rijen, 2003).

Jonas et al. (2002) had prices of various goods estimated in Deutsche mark and euro prior to the introduction of the euro and found that the price estimates in euro were higher. The authors attributed this result to the fact that the nominally higher amounts in Deutsche mark acted as anchor. Accordingly, in Germany price judgments in euro are modeled on the nominally higher but familiar prices in Deutsche mark, which is reflected in an upward bias of the euro prices.

Finally, perceived inflation may result from the influence of expectations on perception. In almost all Member States, the euro was expected to lead to price increases; this expectation was confirmed by most people through their own perceptions (e.g. el-Sehity and Kirchler, 2003; Greitemeyer, Schulz-Hardt, Traut-Mattausch and Frey, 2002; Traut-Mattausch, Schulz-Hardt, Greitemeyer and Frey, 2004; Kamleitner, Kirchler and Hofmann, 2004; Hofmann, Kamleitner, Kirchler, and Schulz-Hardt, in print; Ranyard et al., 2003). If consumers do not convert exactly, susceptibility to distortions in perceiving price increases will be additionally heightened. In 2002, for example, 60% of the Austrians who were still converting only rarely expected prices to rise at least slightly in the wake of the currency changeover (Kirchler and Fessel GFK, 2002). In addition, Fischer et al. (2002) showed that expected inflation varies between different product groups. Especially "perceptible" products, which Fischer et al. consider to be, for example, eating out or groceries, are presumed to be subject to price increases. In connection with the "Teuro" expectation also seen in Germany, Traut-Mattausch et al. (2004) showed in several studies that price increases were perceived even if prices in Deutsche mark and in euro were compared simultaneously and directly. The researchers focused on one field where particularly large price rises were presumed and showed the study participants menus of an Italian restaurant first with prices listed in Deutsche mark and then in euro. The participants were asked to choose dishes from both menus and eventually estimate in percent the differences between the two price lists. Strikingly, in all experimental conditions the euro prices were sometimes perceived to be higher or at least unchanged compared with former prices in Deutsche mark, even when the prices had actually been reduced by 15%. Furthermore, it was surprising that price increases were also misperceived when the study participants were asked to compare the prices of all products separately. The authors attribute these persistent distortions in perception to a phenomenon that is in accordance with the hypothesis theory of social perception (Bruner and Postman, 1949), i.e. "selective error correction", which describes the expectation-induced selective error detection in calculation processes. Calculation errors supporting one's own hypothesis or expectation are more likely to be overlooked than those contradicting expectation. Price increases, despite being objectively verifiable, were generally perceived in a replication for Austria as well. Kamleitner et al. (2004) and Hofmann et al. (in print) showed that even a price reduction of 15% was perceived as an average price increase of 1.7%. In the same fashion, unchanged prices were also significantly overestimated and only with price

increases of 15% was the actual change observed. The influence of expectations and the existence of distortions in perception were also demonstrated for salaries and wages. Contrary to the prices, salaries and wages tended to be perceived as constant and actual changes were underestimated.

In conclusion, there seem to be several causes for the divergence between perceived inflation and actual inflation, as described by Stix (in this volume). The author summarizes possible causes in a remarkably clear fashion and puts forward convincing arguments. One aspect of concern/point of criticism may be that it is debatable to directly compare psychologically substantiated "formulas" for calculating perceived inflation – which in themselves are not unproblematic – and actually measured indices. It is also considered tricky to question consumers directly for prices, inflation rates and other economic indices. Not even the family members who do the daily shopping are usually entirely familiar with the prices of the goods (Gabor and Granger, 1961). Finally, it is questionable to which periods persons relate estimated inflation rates and to what extent time leads to distorted perceptions. Kemp and Willetts (1996), for example, showed that inflation rates tend to be overestimated by far for the more recent past, while subjective estimates for longer periods lead to a gross underestimation of inflation rates.

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Consequences of Rigid Prices for Competition and Structural Policy

Panel Discussion

Karl Aiginger

Austrian Institute of Economic Research

The project's focus is monetary, between basic research and an empirical exploration of behavior, on producing stylized facts that can later be explained in theory. Consequences for competition and structural policy are not the focus of the studies, nor should conclusions be drawn offhand. I see my task as follows:

- highlighting the results, which could inspire further research in this area
- presenting these results in relation to the current body of common knowledge
- suggesting theories that can consistently explain the stylized facts
- putting forward hypotheses that can be examined in future work

1. The Most Salient Results

1. Prices change less frequently in Austria and Europe than they do in the United States. In Austria and Europe, 15% of prices change each month. In other words, prices change once a year on average. In the United States, 25% of prices are changed each month. Thus, loosely speaking, they change twice as often.
2. When prices are changed in Austria, they are changed considerably. The average price increase is 10% and the average price reduction is 15%. Just how great a change this is becomes apparent when it is compared with an average inflation rate of 1 ½% or an average price-cost margin of perhaps 10%.
3. Downward price rigidity is not greater than upward price rigidity. This result is interesting from a theoretical perspective since the administered-price theory has substantiated downward rigidity and used it to explain economic cycles and non-market-clearing at the national economy level. Of all price changes, 45% are reductions and 55% are increases. This is interesting for the non-professional observer (the consumer, journalist, or layperson), who assumes

that price changes are always upward. "Perceived" inflation is high. We will see later that this observer is right, that prices rise when costs rise but do not drop when costs fall.

4. Even in the strong economy of 1998–2000, with growth rates around 3%, prices were not raised more often or more sharply. Not until the introduction of the euro in 2002 drew nearer was there a marked difference in the frequency of price changes. And no, the shift was not to markedly more frequent increases (as the layperson suspects) but rather to markedly more frequent changes. The fact that this happened as a result of the euro and not as a result of accession to the EEA and the EU, suggests that the common currency made the changes more comparable. It also suggests that companies had put this moment off somewhat.

2. Assessment of the Results

Economists see both advantages and disadvantages in frequent price changes. Price changes increase the uncertainty under which economic decisions are made, and uncertainty can reduce consumption and investment, that is, the consumption that occurs on the basis of given incomes and production that is planned on the basis of a given level of demand. On the other hand, price changes are important signals of changes in costs and productivity. And price changes that are too small can later result in volume imbalances, which limit the possibilities for production and demand.

When weighing the advantages and disadvantages of price rigidity, I tend to be of the opinion that more frequent price changes than are currently occurring in Austria would be beneficial. This is because, firstly, the current frequency of change – once per year – is truly the bare minimum and, secondly, the price changes that then become necessary after long periods of rigidity are relatively large. A Change that takes place in several steps cannot result in feelings of insecurity. According to uncertainty theory, it is a "petty uncertainty", or a calculable risk. Particularly for businesspeople and people with a low risk aversion, price changes affect production decisions either very little or not at all. On the other hand, volume shortages – when a product is not available at all or can only be delivered later – present a severe uncertainty (Keynesian uncertainty, see Aiginger, 1998).

Companies' hesitation to meet the initial steps toward European integration with rapid price changes suggests a lack of aggressiveness on their part to seek market opportunities and make shortages known. In the same way, reactions to changes in costs or demand suggest that focusing on cost is still far more important in Austria and Europe than taking advantage of differences in demand. As a result, structural adjustments are delayed and innovations are less profitable. Companies that have lower costs thanks to process innovations do not gain market share quickly enough.

3. Explanations for Price Rigidities

In the end, short-term optimization cannot completely explain the pattern of behavior described above, but an implied agreement aimed at maintaining market share can. Before we get to that, a word on the range of explanations for price rigidity selected from various authors and writings.

Of 11 theories aimed at explaining price rigidities, 2 are compatible with high levels of price rigidity: direct written agreements between companies and customers (vertical agreements) and implied agreements between providers (horizontal agreements or patterns of behavior), also referred to as "coordinated behavior" in the terminology of competition policy.

Just less than three-quarters of the companies surveyed have supply relationships with their customers that are governed by long-term contracts. Six out of ten of these companies generate at least half of their revenues from such agreements, of which just less than 80% have terms of at least one year.

Much the same situation is reflected in the very high proportion of regular customers. Eight out of ten companies generate at least 60% of their revenues from business with regular customers. The companies surveyed describe their behavior very similarly in this respect, as if they had written agreements with their customers (implied vertical agreements). Similar surveys of U.S. companies indicate a far lesser importance of express and implied agreements.

But, in the end, this explanation is not sufficient. If it were to become necessary to change prices more rapidly, the circumstances could be incorporated into the long-term agreements. Besides, not all long-term agreements are made at the same point in the year. And even price changes made by the remaining quarter would constitute price changes.

In game theory, price continuity is the most important tool for "calming a market", that is, for achieving positive profit margins on a market with little innovation and potentially intense competition (large number of market participants or strong reactions to slight price differences). The oligopoly theory predicts that a homogeneous market will reach a balance in which companies just earn their average costs and are happy when the competition does not go so far as to bring prices down toward marginal costs. This would be true even if there were just a few market participants, given some degree of price competition – the Bertrand model applies when as few as two companies are involved. A far better result can be achieved by starting with a high price and then seeing whether the other market participants understand the signal. It is difficult enough to "guess" at this high, common price (problem of coordination). In practice, it can be the cost price plus a standard recognized margin. What is important then is that this price not change or change only in a clearly predictable manner. Once a year and in accordance with a cost formula is a wonderful coordinating mechanism.

This is called implicit collusion. In principle, it is not prohibited as long as it is not supported by records or signals. However, it is dubious from a structural policy perspective.
Firstly, companies that work to achieve cost advantages, for example, by using new technologies will not gain market share quickly enough, so companies have little incentive to innovate. Secondly, economic sectors that become essentially unattractive (homogeneously mature industries with narrow profit margins) will remain relatively more attractive than sectors with rapid innovation (where there is little need for price stability as a coordinating mechanism). Thirdly, companies will have higher costs because they will pay higher input prices.
Of course, there are no empirically visible behaviors that cannot also theoretically yield benefits for society. Mature industries that have higher profits due to coordinated behavior and infrequent price changes can use these profits to achieve especially sharp cost reductions or to establish new production lines. Monopoly profits can also be used for innovation. They can, but they do not have to.

4. Symmetry of Reactions by Type and Direction of Shocks

Another interesting structure of the results suggests the significance of price rigidity as a coordinating mechanism.

1. Companies generally react more strongly to cost changes (shocks) than to changes in demand.
2. Prices go up quickly and sharply when costs increase, but are not lowered when costs decrease.
3. On the other hand, companies often refrain from increasing prices when demand increases while they do lower prices when demand declines.

All of these results of the new studies replicate results presented by Aiginger (1989). For me, these stylized facts suggest that companies resist incurring losses (as in the rapid price increases, when costs increase and price reductions when demand drops). By comparison, achieving the highest possible profit is less important since companies can earn more when demand increases and will have avoided supply bottlenecks. Missed demand due to backlogged orders is not as important (see Aiginger, 1985). Perhaps companies are also speculating that their competitors will also be unable to deliver.
The survey results indicate a strategy aimed at preventing the collapse of an implied cartel in the event of recession (Porter vs. Saloner – discussion).
The stronger reaction to changes in costs compared with changes in demand suggests either a dominance of cost-oriented pricing (mark-up pricing) or avoidance of profit fluctuations. But it may also be interpreted within the scope of game theory. Cost fluctuations often do not affect individual companies but rather entire sectors (as in pay rounds or energy price fluctuations). It is also easier to estimate whether changes in a competitor's actions are a signal of a price war or a

reaction to cost increases. Fluctuations in demand can vary by customer segment, particularly in heterogeneous markets, and be difficult to interpret. However, I do not want to overemphasize this point since changes in prices have been viewed as the truly most important "natural" and "moral" justification for price changes for decades in Austria, where formal price regulation and the subsequent agreements between employers and employees have been determined primarily on the basis of costs. Changing prices in accordance with changes in demand or perhaps even using price elasticity has always smelled of profit-oriented behavior. Take, for example, the places I would stay while on vacation. They were always hopelessly overbooked during the Christmas week and the late-winter school break. When asked why they did not differentiate their prices more, they invariably responded that it would be unfair to families with children. I understand this social behavior, even if it is uneconomical. But what I do not understand is why companies do not make use of another option that I encountered in the United States. When an American hotel owner sees that his hotel is empty during the week, he offers a special price for Monday through Thursday. Such deals are even offered at extremely popular ski areas like Lake Tahoe and are officially advertised in the media. In Europe, hotel owners keep prices relatively constant, granting discounts on the basis of individual negotiation and accepting considerable volume imbalances.

5. Hypotheses for Future Studies

With a little imagination, the results can be summarized into the following hypotheses:
European companies change prices relatively seldom, but when price changes become necessary they are sharp. In particular, there is no fine tuning of prices. Prices are not adjusted seasonally or on the basis of short-term changes in demand. Avoiding losses seems to be more important than exploiting market opportunities or avoiding supply bottlenecks. Costs are more important for adjustments than changes in demand. Moreover, cost reductions are not passed on to customers, either because it is not possible to increase demand or because doing so would increase the risk of price wars. When costs rise, the competition can be expected to follow suit because cost increases often affect entire industries rather than individual companies. These tendencies are not entirely unproblematic for structural change and competition.
In any event, the studies must be continued in order to see which industries have greater price rigidities, whether there is a correlation between price rigidities and intensity of competition, and whether structural change occurs more quickly in areas where price changes are more frequent. The studies have provided testable, interesting hypotheses for which I would like to thank the authors and the studies' funder.

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Table: Overview: Reactions to Demand and Cost Shocks

Type of shock	Fraction of firms holding the price constant	Mean lag
Small positive demand shock	82%	6.1
Large positive demand shock	63%	4.6
Small negative demand shock	82%	4.6
Large negative demand shock	52%	3.6
Small cost-push shock	38%	4.8
Large cost-push shock	8%	3.8
Small decreasing cost shock	71%	4.8
Large decreasing cost shock	38%	4.2

Source: Kwapil,Baumgartner and Scharler (2005A).

Consequences for Economic Policy

Panel Discussion

Günther K. Chaloupek

Chamber of Labor

In view of the quite dramatic increases in the oil price in the past few years, inflation persistence has become a highly topical and relevant issue. Even though inflation rates were considerably lower at the onset of the latest oil price shock than in 1973 or 1978, the extent and the duration of the after effects of the most recent shock will have a great relevance for the issue of price stability.

The central result of Baumgartner's very detailed empirical study leaves no doubt: Inflation persistence has decreased substantially since the first and second oil price shocks. This means that no or almost no secondary effects, which tend to prolong or even intensify the original inflation impulse, are to be expected. From my point of view, this result suggests that the latest inflation developments can – and should – be watched calmly.

However, it seems to me that the European Central Bank (ECB) has not taken note of the inflation research results refereed here because the latest increase in the key interest rate, which was carried out despite warnings and protests not only by notorious critics but also by institutions like the Ecofin Council and the Organization for Economic Cooperation and Development (OECD), does not imply at all that there is no need to worry. To explain that the interest rate had to be increased because of inflationary risks although the euro area HICP climbed to 2.5% in October 2005 (against October 2004) and 2.4% in November 2005 and, at 1.5%, the inflation rate, excluding energy prices, was even declining slightly, implies "obsession" rather than a calm attitude. Let us hope that no more such steps will be taken and lower inflation persistence will eventually find reflection.

I am convinced that the U.S.-Federal Reserve's growth and employment policies over the past ten years have been much more favorable than those of the ECB, with the Federal Reserve giving greater consideration to reduced inflation persistence after economic shocks, in addition to allowing a somewhat higher inflation tolerance than the ECB's 2% inflation ceiling.

There is one important aspect of the studies on price formation and inflation persistence that seems to be insufficiently explicit, which harbors the risk that conclusions could be drawn without the necessary awareness of what they are

really based on. Subliminally, this topic captures the neoclassical idea that we would be living in the best of all possible worlds if all prices and, especially, all wages were completely flexible, which would also include downward flexibility. Then, we would always have a perfect balance on all markets, with full employment of all resources and with immediate adjustment to external shocks. It was no less a person than Keynes who in (chapter 19) of his General Theory of Employment, Interest and Money[1] put an end to this abstruse idea and pointed out the necessity for a "nominal anchor" for the price system, arguing, above all, that a falling price level would have serious negative consequences. Since the interest rate can never drop below zero and the companies' nominal debt remains the same, the companies will become insolvent increasingly. Even today, this "risk of deflation" is not a mere calling of the ghosts, as the number of companies affected by dropping nominal sales rates due to falling prices will turn into a problem even before the general inflation rate has reached zero[2].

Another essential argument supporting the positive aspects of price rigidities was already presented by Karl Aiginger: The "New Institutional Economics" shows that it will not be possible to stabilize the expectations by relying on various "implicit contracts" if there are wild price and wage fluctuations. Especially the more recent experiences with the euro changeover have demonstrated clearly to what extent prices and price structures are rooted in the lower layers of consciousness.

These considerations, however, must not lead to the anti-competitive conclusion that price rigidities are to be deemed generally positive and price reductions are therefore negative. On the contrary, competition is necessary, above all, to effect price reductions in situations where product or process innovations facilitate cost and price reductions that will enable large quantitative sales increases if the demand is price elastic. Karl Aiginger has already described this in greater detail and I agree with him.

Finally, I would like to address some questions relating to price formation, which would also deserve closer examination, maybe even by the OeNB.

- Where is the critical range of the inflation rate when deflationary effects start to occur to an degree that is relevant to the economy as a whole?
- In recent years, the phenomenon of very high, even excessive profits has been increasingly seen to occur – this should raise questions relating to the competitive situation and the mark-ups in the respective areas and should not be limited to elated reports from the stock exchange.

[1] Keynes, J. M. (1936) The General Theory of Employment, Interest and Money. Macmillan Cambridge University Press.

[2] From this perspective, the ECB's inflation target that allows such zero inflation is also questionable. However, as regards the euro, the central bank's actual reaction has not been put to the test yet.

- Finally, there is the "persistent" phenomenon of large price differences for one and the same service in the tertiary sector. Even though – or maybe just because – available data are rather scarce, from the consumer's point of view it would be useful to conduct a study on this subject.

Conclusions for Economic Policy:

A Business Perspective

Panel Discussion

Harald Kaszanits
Clemens Eder

Austrian Federal Economic Chamber

The Inflation Persistence Network (IPN) has generated a great number of scientific contributions to the issue of price setting and inflation, out of which we can only tackle the most remarkable ones here, judged from the point of view of a business representative. Thus, we have selected the connections between price development and competition as well as the link of wages and prices as the topics of our contribution to this event.

1. Price Rigidity and the Case for More Competition in Austria

The IPN's research reveals that consumer prices in Austria, just like in the rest of the euro area, are relatively rigid, especially in comparison with the United States. While this general result alone is not necessarily disturbing, the sectoral breakdown yields interesting results: especially services, health care and education prices in Austria are very sticky, changing once a year or even less frequently. Strikingly, it is exactly this group of services whose prices are changed – and in this case, changes are almost always increases and hardly ever decreases – in a largely synchronous way. The authors point out that "this reflects the fact that prices of some of these products are either directly administered or strongly influenced by public authorities"[1].

The IPN has also investigated the entrepreneurs' own view of their price setting-behavior, showing that a large majority of Austrian firms normally uses time-dependent pricing rules, with 38% of all respondents using them exclusively – i.e., they do not even review their prices in the face of economic shocks. This

[1] ECB Working Paper No. 523, p. 5.

percentage is higher than in most other euro area countries, indicating again rather rigid prices in Austria.

In more general terms, the researchers find that economic reality deviates from the idealistic model of perfect competition, illustrated, for example, by the dominant use of mark-up pricing. Another result is that companies seem to be reluctant to reduce prices when their input costs fall, but also seem to dislike raising prices as a consequence of higher demand because this could be regarded as "unjust enrichment" by the customers. The latter finding suggests that many Austrians view the normal market mechanism of supply and demand as something that can lead to unfair results and that firms sometimes abstain from setting prices flexibly, according to demand fluctuations, because of "moral concerns". Finally, Europe-wide surveys reveal a clear link between competition and pricing behavior[2]: Companies that face severe competitive pressure change their prices more often, use mark-up pricing less frequently and consider underlying economic factors more in their price setting than others.

The arguments mentioned above lead to the conclusion that, while significant progress has been made in liberalizing the Austrian economy, there are still some important sectors in which competition remains weak, where public influence is omnipresent and these sectors, consequently, fail to exhibit a price dynamic that is characteristic of a free market. Therefore, we propose the following measures in order to stimulate competitive forces in those business areas that still suffer from undue public interventions:

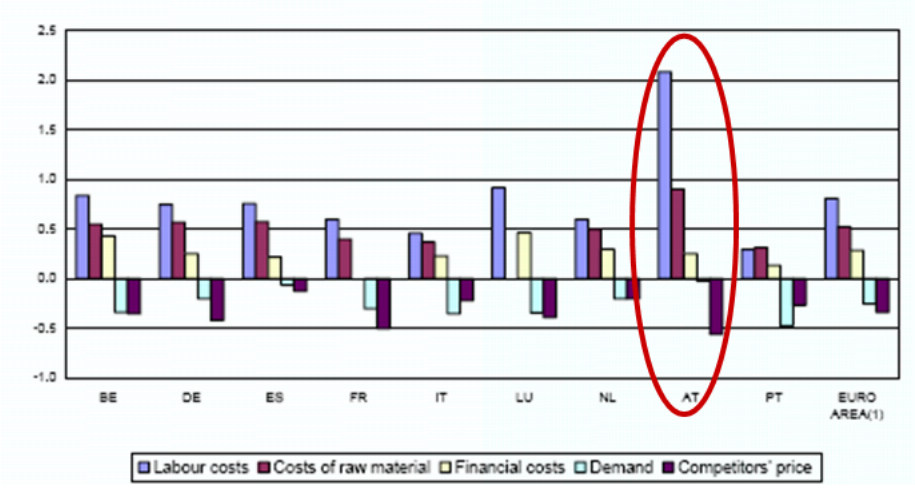
- Encourage Public Private Partnership (PPP) solutions for large public investments, combining the efficiency gains from private (instead of public) business operations with a certain security element provided by the state.
- Review whether public services, such as those that have been traditionally performed by municipalities (energy provision etc.), can be carried out more efficiently by privately-held companies.
- Create a market-oriented environment for the health care system, introducing elements of competition also for social security agencies.
- Ensure a smooth transition from formerly public monopolies to deregulated markets by establishing regulatory authorities with adequate competences. However, the ultimate goal must be to adapt these industries to completely free markets that no longer need a special regulator; i.e., the regulator's role is important, but it should not become a permanent institution.

[2] ECB Working Paper No. 535, p. 5.

2. Wage Development – the Key Factor for Price Stability

Another IPN survey that we found particularly insightful is the identification of the factors that cause price changes to be implemented. The following chart illustrates the problem very clearly:

Chart 1: Asymmetries in Price Driving Factors
(Difference between Scores Regarding Price Rises and Price Decreases)



Source: ECB Working Paper No. 535, p. 26.

The differences between Austria and the other euro area countries are striking: labor costs are the major factor responsible for price increases, while they – in contrast to other countries – give hardly ever any motivation to lower prices. Other factors, such as demand and competitors' price, play a very limited role in comparison to labor costs, giving further support to our demand to intensify competition in Austria.

Another valuable concept for a better understanding of price changes is the New Keynesian Phillips Curve, which has also been analyzed by the IPN. One important aspect tackled by this curve is the connection between labor share and the price level. Labor share can be expressed as average hourly wage divided by productivity, implying that if wages are increased stronger than productivity, the companies' marginal costs increase (ceteris paribus), which in turn forces them to raise their own sales prices.

From the above, the importance of wages for price development in general, but even more so in Austria, becomes obvious. The immense importance of labor costs as a price driving factor is not surprising in view of the dramatically high non-wage

labor costs in Austria. In 2004, they amounted to 82.6% of direct wages. The figures for almost all other European economies with a comparable size are considerably lower: e.g. Finland 77.0%, Sweden 70.9%, Switzerland 51.9%, Norway 48.0%, Ireland 39.7%, Denmark 33.6%; only Belgium has even higher non-wage labor costs (90.0%)[3]. Interestingly, the Scandinavian countries, well-known for their extensive social systems, manage to finance their inhabitants' social security without laying an excessive financial burden on the production factor labor. This should serve as an example for Austria. The biggest potential to bring our non-wage labor costs more in line with the European average lies in a comprehensive reform of the social insurance system, the structure of which is obsolete and has lost its functionality in today's dynamic economic environment.

Another reason why labor costs are such an important factor for price increases in Austria is the rather inflexible labor market which prevents companies from quickly reacting to changes in demand by adjusting their wage payments. One solution, which has increasingly become popular already in the last few years, is to promote alternative types of employment, such as part-time work, temporary employment etc. Even more important to mitigate the price-driving effects of labor costs is making stronger use of flexible forms of payment. Introducing elements of performance-related remuneration on all hierarchical levels would make Austrian companies considerably more competitive: it becomes easier to survive difficult business situations, since wage payments are reduced automatically, and it makes them also more attractive as employers, since potential employees recognize that good work is financially rewarding there. The link between performance-related payment and sales prices is clear too: Wages become less of a burden for companies, they only rise strongly when business is going well and the firm can afford to pay more; therefore, they can no longer automatically force a sales price increase, as is often the case at the moment.

In his presentation, Stiglbauer cited the price trajectory of car mechanics' services as a typical example of price paths in the service sector. The researchers found out that these prices are changed exactly once a year and left constant for the remaining time.[4] This result is not surprising: the service sector is very labor-intensive, its most important input costs are wages. Wages in Austria are changed once a year, namely after termination of the negotiations for a new collective agreement, in which the annual raise is determined for the whole industry. Completely in line with the findings above, this increase in labor costs makes it inevitable for many entrepreneurs to raise the sales price, which causes the singular annual price jump observed in the analysis. Thus, a direct link between collective wage bargaining and Austrian price dynamics can be established, and has important implications for economic policy: Wage restraint is imperative to secure the competitiveness of

[3] WIFO Monatsbericht 11/2005, p.753.
[4] ECB Working Paper No. 523, p. 66.

Austrian firms; demands for raises that fully compensate for inflation and productivity gains cannot be met in an open economy with substantial unemployment. Excessive wage increases lead to cost-push inflation and, simultaneously, hamper growth and employment.

3. Central Banks and Their Responsibility for Economic Development

While the importance of containing inflation and doing research in this field in order to better understand the economic interrelations remains undisputed, we cannot turn a blind eye to the fact that in recent years, the paramount economic problem in the European Union has not been excessive inflation, but persistently weak growth and a lack of investment.

Monetary policy, which lies exclusively in the hands of the European System of Central Banks, is an important instrument that can be used to control inflation, but which has a crucial influence on investment and growth as well. Article 105 of the Treaty on the European Community reflects this thought: "Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2." Article 2 lists, among others, the following goals: "a high level of employment" and "sustainable and non-inflationary growth".

In view of Europe's currently difficult situation and its pursuit to become the most dynamic economic area of the world (Lisbon Agenda), we appeal to the European System of Central Banks to take this aspect of its mandate very seriously. We hope that monetary policy will make its contribution to Europe's growth strategy, and we are confident that the extensive research work conducted in the course of the IPN helps the ESCB to fulfil its task even more effectively and precisely.

Macroeconomic Consequences of Inflation Persistence in Austria

Panel Discussion

Martin Zagler

Vienna University of Economics and BA/
European University Institute, Firenze

The purpose of this note is to discuss the macroeconomic implications of the Inflation Persistence Network (IPN), and to review some of the arguments made during the panel discussion at the workshop. First and foremost, one needs to emphasize the significance of the results obtained by the IPN concerning the analysis of price behaviour in Austria. I think that the research undertaken gives a systematic, structured and deep insight into the evolution of prices as never before. In that respect, one needs to praise the Oesterreichische Nationalbank (OeNB) for its courage to undertake this research, particularly as it could imply a deviation from the dogma of dichotomy in real and monetary economics. The note is organized in three parts. First, I will emphasize some of the stylized facts that I found particularly significant. Then, I will bring some theoretical implications before turning to issues of economic policy.

1. Stylized Facts

The most startling fact of the research program has been the enormous degree of price flexibility. Whilst inflation rates per se tend to exhibit a lot of inertia, individual prices do not. Prices change at rather high frequency, and both upward and downward. Indeed, the fact that only slightly fewer price changes are upward than downward has important implications for economic policy, as will be discussed below.

The second surprising fact is that prices are sticky in the sense that a price increase is not likely to be followed by a price decrease, or price innovations tend to be persistent. This may be due to the fact that (permanent) supply shocks or much more common than (temporary) demand shocks. However, this fact rules out

the possibility that registered price reductions are purely special offers, sales and discounts, but have a deeper economic rationale.

The third surprising fact is that prices react differently to different kinds of shocks. In particular, prices tend to be downward sticky and upward flexible following a cost shock, whereas prices are downward flexible and upward sticky following a demand shock. This, too, has important policy implications, as will be analyzed below.

2. Theoretical Considerations

In a way, the research undertaken by the IPN may lead to a rethinking of the theory of prices. Given the fact that individual prices are highly mobile, but inflation is not, one imagines a theoretical approach that models inflation with a flow approach, where price increases enter and price decreases exit, leading to an equilibrium rate of inflation, in an approach not dissimilar from the flow approach to unemployment, where job creation and job destruction are modelled to explain the inert behaviour of unemployment rates. Just like the flow approach to unemployment has changed our understanding of labour markets, the flow approach to prices may change our understanding of inflation.

On a more modest scale, the analysis also challenges a well established dogma of monetary economics, the dichotomy of money and the real economy. In one form or another, monetary economists tend to believe in the quantity equation, stating that nominal spending (prices P times real GDP Y) equals nominal balances (velocity of money V times the money supply M), PY = MV. The general perception is that monetary velocity and real GDP are set exogenously, so that changes in inflation are purely due to changes in money supply, or as Milton Friedman[1] has so beautifully put it, "Inflation is always and everywhere a monetary phenomena." This of course implies that at least in the long run prices should behave differently, depending on whether the shock is monetary or not. Indeed, a monetary shock (that is not actively reversed by central bank policy) should lead to a permanent increase in prices, whereas a (temporary) demand shock should lead to a temporary increase in prices only. But of course, firms faced with an increase in demand cannot possibly observe whether the shock is monetary or not. Hence, reactions to shocks should be treated with a lot of caution.

3. Consequences for Economic Policy

As mentioned above, the results obtained by the IPN exhibit important policy implications. First, the fact that prices are downward mobile is worrisome. Contrary to suspicion, prices are not sticky downwards, like for instance wages are.

[1] Friedman, Milton, Monetarist Economics, Cambridge MA: Basil Blackwell, 1991.

This of course implies that there are no mechanisms to prevent a majority of prices to fall, and therefore to prevent periods of deflation. Monetary policy would need to react to this fact by not only introducing an upper bound to inflation, but also a lower bound for inflation. In that respect, the revision of the ECB strategy in 2003, which before has been "below two percent" and now reads "close to, but below 2 percent" is certainly an important policy change to prevent periods of deflation.

The research has also shown that prices exhibit a certain degree of inertia. That fact that prices do not immediately adjust to supply and demand shocks implies that prices, at least in the short to medium run, have an impact on the real economy. Monetary policy may therefore matter for real output, the business cycle, and employment. In that respect, monetary policy has to be undertaken with much more caution. A sudden increase in money supply may not only alter prices, but have major implications for real economic activity and the business cycle. Given different reactions to shocks in different sectors (e.g. tourism may react much faster to shocks than e.g. the intermediate supply sector) monetary policy will have an impact both on the industrial structure and on regional economic growth. Volatile monetary policy will foster tourism and hurt the intermediate supply sector. As tourism is predominantly located in the west and south of Austria, whereas the intermediate supply sector is located in the north and east, active monetary policy would also favour the west and south at the expense of the north and east.

Finally, the research has shown that prices react differently to cost and demand shocks. Under this light, a reassessment of policy strategies appears justified. We will undertake this for three specific shocks, the (positive) productivity shock due to the New Economy in the second half of the 1990s in the U.S.A., the recent oil price shock as a (negative) demand shock, and the apparent surge in the European business cycle at the end of 2005.

First, the New Economy can be considered a positive supply shock that leads to a reduction in producer costs. With prices sticky downward, this leaves ample room for expansionary monetary policy. An expansionary monetary reaction is a positive demand shock that also benefits from sticky prices (this time upward). Thus, offsetting a positive supply shock with a positive demand shock will lead to a business cycle boom without fear of inflation, supporting the Greenspan strategy. Second, the oil price shock can be considered a negative cost shock. Prices are flexible following negative cost shocks, hence the appropriate reaction would be to tighten monetary policy. This can be considered a negative demand shock, and prices are flexible there, too, so that indeed the appropriate reaction to an oil shock is tight money, which European and American central banks have followed. Finally, looking at the indications of an improvement of the business cycle, which was triggered by an increase in orders (and hence can be considered a demand shock), we would conclude that prices would have remained constant for a while, given the inert reaction to a positive demand shock. The appropriate reaction would have been an accommodating monetary policy. However, monetary policy reacted

by tightening interest rates, and thus may have prematurely turned off the economic recovery

Price Setting and Inflation Persistence: Some Policy Conclusions from a Central Bank's Perspective

Panel Discussion

Ernest Gnan[1]

Oesterreichische Nationalbank

1. Introduction

The empirical findings on price stickiness and inflation persistence presented at the workshop "Price Setting and Inflation Persistence in Austria", organised by the Oesterreichische Nationalbank (OeNB) in Vienna on 15 December 2005, raise a number of issues both for monetary and structural policies.

Prices were shown to be stickier in the euro area than in the United States. Most economists would agree that flexible prices are a desirable feature for an economy, since, for instance, sticky prices entail that after a demand shock deviations of an economy from potential output take longer. This notion is confirmed by the empirical observation of more pronounced output gap persistence in the euro area as compared to the U.S.A:

Structural reforms in the context of the Lisbon Agenda which enhance competition in goods and services markets make prices more flexible. Labour market reforms which make wages more flexible and, where still applicable, abolish wage indexation reduce inflation persistence. In short, structural reforms not only serve the aim of enhancing long-term potential growth but should also have beneficial consequences in terms of smoother business cycles.

This contribution to the panel discussion on policy conclusions focuses on two issues. First, it summarizes tentative conclusions for the euro area's monetary policy. Second, it performs a brief "benchmarking exercise", comparing Inflation

[1] I am grateful to Claudia Kwapil and Fabio Rumler for comments, and to Wolfgang Harrer for research assistance.

Persistence Network (IPN) findings for Austria with those for other euro area countries.

2. Some Tentative Policy Conclusions for the Euro Area

The rich research findings from the IPN will take some time to be grasped fully in the academic and policy discussion. A number of preliminary and tentative conclusions for the euro area's monetary and economic policies emerge, some of which with relevance for the definition of price stability, some for the optimal design of the monetary policy strategy, some for the ongoing implementation of monetary policy, some for structural policies in the context of the Lisbon Agenda. Bearing in mind the preliminary nature of any conclusions at the present juncture, eight issues are ventured here.

1. Micro Price-Setting Behaviour and the Optimal Inflation Rate

The IPN research showed that price reductions are frequent and sizeable and that prices are frequently cut in response to low demand. The case for pursuing an inflation objective well above zero due to downward price rigidity is weakened by this finding. However, two important qualifications need to be born in mind: First, services prices in the euro area, which have a substantial weight in the consumer price basket, do show significant downward price rigidity. This may be due to various reasons.

For instance, it may simply reflect the higher service price inflation over the observation period, which would – almost by definition – reduce the number of price cuts in the service sector. It may also reflect the higher labour input content in services prices. Research conducted in the context, for example, of the International Wage Flexibility Network (see e.g. Stiglbauer, (2002), Dickens et al., forthcoming) shows that wages in the euro area do exhibit real and/or nominal downward rigidity. Thus, at least for the time being, downward nominal wage rigidity continues to provide a rationale for the central bank to pursue an inflation objective above zero. This is not to say that downward wage rigidities need to persist for all future. It is quite possible that a monetary regime of long-lasting and credible price stability, possibly combined with stiffened international competition in goods and labour markets, also changes wage setting.

2. Price Stickiness and Wage Rigidity

This point about the link between price setting and wage setting is reinforced by research conducted in the context of the IPN. Survey results (Fabiani et al., 2005) and research on the New Keynesian Phillips Curve (Rumler, in this volume) have shown that input costs drive producer prices. In other words, "extrinsic inflation persistence" was found to be the main driving force for inflation persistence, while intrinsic persistence (dependence of inflation on its own past values) as well as

"expectational persistence" (arising from the formation of inflation expectations) were found to be of minor importance. Sectors with a high labour share were found to change prices less frequently than others. Also, the higher price flexibility found in the U.S.A. coincides with more flexible wages. Thus, increased wage flexibility in the euro area might be expected to support higher price flexibility, not least in the service sector.

3. Price Stickiness and Competition

The IPN showed that the outlet type (hyper markets versus corner shops) influences the frequency of consumer price changes (Dhyne et al., 2005). It was also found that producer prices change more often in a more competitive environment; sectors more exposed to imports change prices more frequently (Vermeulen et al., 2005). Also, surveys confirmed that firms in more competitive sectors change prices more frequently (Fabiani et al., 2005). Thus, it could be expected that liberalisation and the opening up of markets should enhance price flexibility, both at the producer and retail levels, and particularly on services markets.

4. Sticky Prices, Inflation Persistence and Optimal Monetary Policy

Sticky prices and inflation persistence have a bearing on the optimal design of monetary policy. If prices are sticky, inflation responds less to output gap variations. After shocks, relative prices take longer to adjust to a new equilibrium. Sticky prices also raise inflation persistence, as can be illustrated, for instance, with the New Keynesian Phillips Curve. Inflation variability is more costly if inflation persistence is high. It takes longer periods of negative output gaps to bring inflation back to target once it has risen. Thus, it can be argued that, to avoid the need for protracted periods of disinflation, in an economy with higher inflation persistence (which can, in turn, be the result of higher price rigidity), the central bank should put greater weight on inflation stabilisation (relative to output growth stabilisation) in its policy reaction function (Levin et al., (2005)).

5. Endogeneity of Inflation Persistence: Learning and Optimal Monetary Policy

Under the assumption of rational expectations, inflation expectations do not by themselves contribute to inflation persistence. If, by contrast one assumes that agents have less-than-perfect information, e.g. about the structure of the economy or about the nature of shocks, their expectations may be formed through "learning". This may lead to more persistent responses of inflation to shocks.

It also implies that the monetary policy regime, in particular the central bank's inflation track record and its credibility to maintain price stability, can affect agents' learning about inflation. Thus, monetary policy would itself influence price setting and inflation persistence, it becomes conditional on the successful

anchoring of inflation expectations and on any perceived risks of failure to do so (Gaspar et al., (2005a), (2005b)).

This has several implications. First, the relatively low inflation persistence measured for the euro area may be the result of a sustained track record of maintaining price stability, which has managed to anchor inflation expectations firmly in line with the ECB's definition of price stability. Second, one may argue that as long as inflation expectations are well anchored, stable and low, the central bank can take a "wait and see" attitude in the face of adverse supply shocks, in line with a "medium term perspective to price stability". However, inflation expectations can also become unanchored if "undesired learning" occurs: for instance, a series of supply shocks results in inflation exceeding the target for an extended period of time; or, second-round effects at the wage front perpetuate a rise in inflation; or, a change in the institutional set-up within which the central bank operates raises inflation expectations. To prevent such undesired learning, the central bank may have to raise interest rates substantially and for a sustained period.

6. Monetary Policy under Inflation Persistence Uncertainty

Estimates of inflation persistence are highly uncertain (see also table 1 below). They depend heavily on estimation methods (see e.g. Robalo Marques, (2004)), inflation measures and price samples (e.g. time periods covered; including or excluding sales prices), and are surrounded by sizeable confidence bands.

Given this uncertainty, one may argue (Moessner, (2005)) that a robust monetary policy should rather err on the side of higher inflation persistence: If the monetary policy maker overestimates inflation persistence, the economy adjusts flexibly to the mistaken monetary policy. This error would thus imply a relatively low welfare loss. If, by contrast, the central bank underestimates inflation persistence, it will take rather long for inflation to return to its target value, implying a comparatively higher welfare loss.

7. What if Price Stickiness Differs across Countries/Sectors?

Empirical findings from the inflation persistence network have shown that inflation persistence differs considerably between sectors, and also (albeit less so) between euro area countries. Non-processed food and energy prices are little persistent, while services and industrial goods prices are highly persistent.

The argument has been made (see e.g. Goodfriend et al., (1997)) that in this case, monetary policy should place greater weight on developments in the sectors or countries with more rigid prices, since these sectors or countries bear higher welfare costs during their (slower) adjustment to shocks. This argument can be extended to justify the use of core inflation measures rather than headline inflation as the central bank's measure for the price stability objective.

There are a number of counterarguments, though: First, it would by no means be straightforward which sectors or countries should be excluded, when measuring inflation for monetary policy purposes. How should the central banks in practice derive such alternative weights? Second, from a utility maximization perspective, consumers care about overall inflation, rather than some truncated or partial measure of inflation. Third, accommodating those sectors or countries with more rigid prices would perpetuate behavioural and structural inefficiencies by discouraging reforms which facilitate market-based adjustment to shocks.

Still, this discussion emphazes that it is important for a central bank to use sectoral and regional information to better interprete shocks and forecast inflation and to design appropriate policy responses.

8. *Euro Area versus U.S.A.: Different Price Stickiness – Different Monetary Policy?*

It is a commonly held view that over the past decade U.S. monetary policy has been more "activist" than the euro area's monetary policy. In the first place, one should not exaggerate such differences. Estimated Taylor rules for the euro area and the U.S.A., arrive at highly ambiguous results. Second, to the extent that there are such differences, the above findings and arguments can be useful to understand their rationale. The higher price stickiness in the euro area as compared to the U.S.A. implies that inflation responds less to changes in real marginal cost and in the output gap. Taking the example of cost push shocks, which were very prominent over past years, this has two consequences. On the one hand, food and oil price increases should have less of an impact on euro area inflation than on U.S. inflation. According to the above line of arguments, the higher price rigidity should allow the Eurosystem to "see through" temporary increases in inflation beyond the definition of price stability. This conclusion from theory is indeed mirrored both in the Eurosystem's medium-term oriented monetary policy strategy and in its actual monetary policy so far. On the other hand, the higher price rigidity implies that deviations from the inflation objective, once they happen, are more costly to control in the euro area. Thus, the Eurosystem should put greater weight on maintaining price stability vis-à-vis output stabilisation. The Maastricht Treaty's clear primacy of price stability as opposed to the multiple objective mandate of the U.S. Fed reflects this prescription.

3. Benchmarking Austria

A major benefit from the joint and coordinated research effort of the IPN is that (to a large degree) comparable data on price setting were compiled and made accessible. Out of the many "benchmarking" exercises one could undertake between Austria and other euro area countries, four issues which seem particularly interesting are highlighted here.

1. Inflation Persistence in Austria is Comparatively High

While estimates for inflation persistence from various studies differ widely (which illustrates the point about inflation persistence uncertainty made above), all studies have in common that Austria ranges among the three countries with the highest inflation persistence (table 1). The reasons for this higher persistence are unclear at this stage; possible explanations might be fewer price shocks or smaller price effects of given shocks. Whatever the reasons for the higher inflation persistence in Austria are, monetary and incomes policies aiming at containing inflation seem to be particularly called for in Austria. The wage moderation pursued over recent years fits this recommendation well.

Table 1: Estimated Inflation Persistence in Euro Area Countries

Country	NKPC – γ	Reduced form – ρ		
	Rumler	Gadzinski & Orlandi	Cecchetti & Debelle	Lünnemann & Mathä
BE	0.46	**0.32**	**–0.11**	**–0.33**
DE	0.43	0.82	**–0.34**	**–0.16**
GR	0.42	0.82		**0.51**
ES	0.45	0.93	**0.23**	**–0.50**
FR	0.40	0.54	**0.25**	0.49
IE		0.79		**0.38**
IT	0.67	**0.58**	**0.45**	**0.23**
LU		**0.47**	**–0.62**	**–0.17**
NL	0.30	**0.44**	**–0.02**	**0.28**
AT	0.54	1.03	**0.33**	0.43
PT		**0.49**	**0.45**	**0.31**
FI	0.45	**0.47**	**0.30**	**0.07**
Euro Area	0.49			

Rumler: inflation persistence is the parameter γ in the backward-looking term of a New Keynesian Phillips Curve; period covered: 1970:I-1998:IV. In all other estimates the parameter ρ serves as measure for reduced-form estimates of inflation persistence; figures for ρ in bold indicate that it is possible to reject statistically that ρ=1. Periods covered: Gadzinski & Orlandi (2004) 1984:I-2003:III; Cecchetti & Debelle (2005): data starts in 1990. Lünnemann & Mathä (2004): 1995-2003:12.

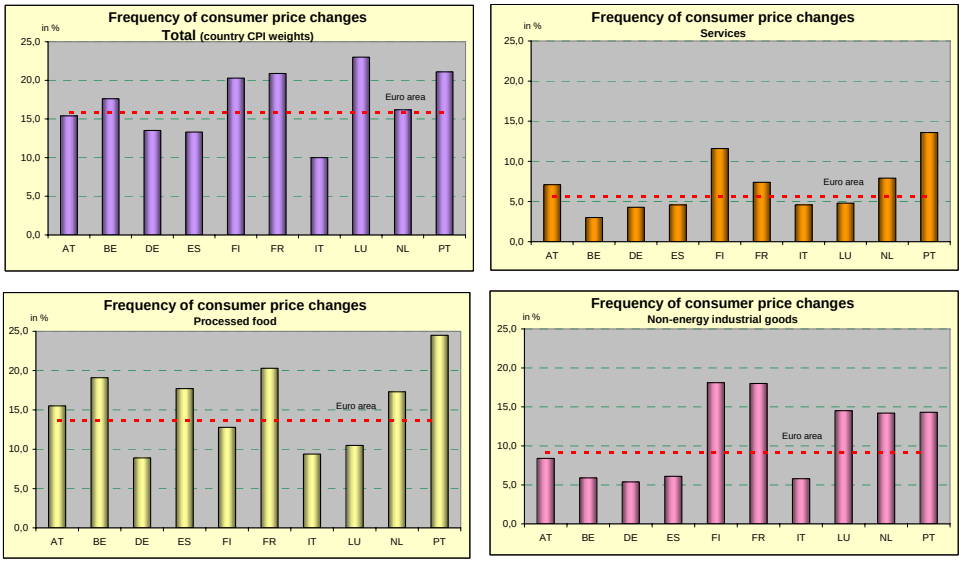
Source: Rumler (in this volume), Gadzinski et al. (2004), Cecchetti et al. (2005), Lünnemann et al. (2004).

2. Price Flexibility in Austria is Intermediate

The frequency of consumer price changes varies considerably across euro area countries (chart 1). Austria is very close to the euro area averages in terms of price flexibility of the total CPI. Prices for processed food and for services are changed slightly more frequently in Austria than in the euro area on average, while those for non-energy industrial goods are adjusted slightly less frequently. As in most other euro area countries, service prices are by far the most rigid, which may reflect, inter alia, the continued weaker exposure to (domestic and foreign) competition.

This intermediate price flexibility may be seen to be somewhat at odds with the high degree of inflation persistence described above. A tentative explanation might be that while individual prices are rather flexible, aggregate inflation moves rather little, reflecting the long-standing track record of a stability oriented monetary policy regime pursued under the hard currency policy (see, e.g. Gnan, (2005)).

Chart 1: Frequency of Consumer Price Changes in Euro Area Countries



Source: Dhyne et al. (2005).

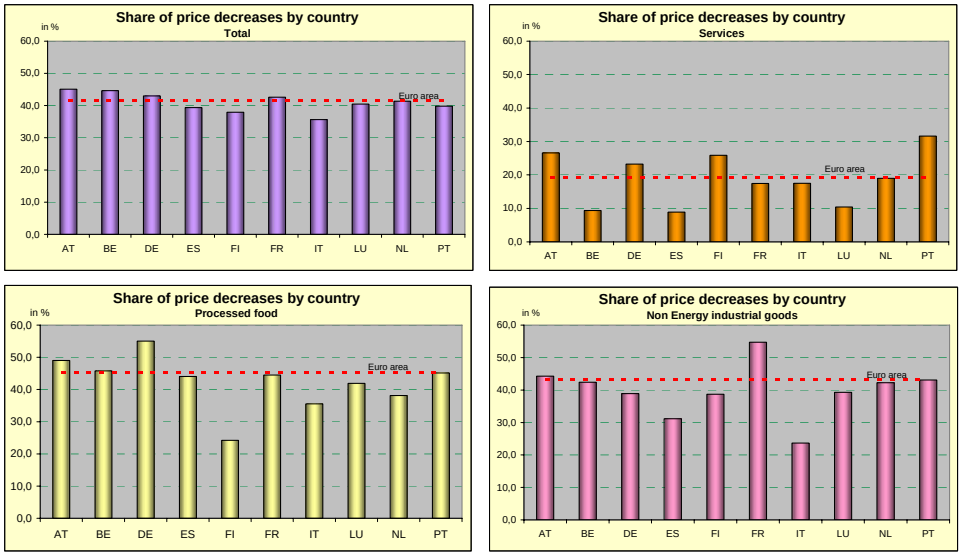
3. Price Decreases in Austria Are More Frequent than in Other Euro Area Countries.

Interestingly, price cuts make up a larger share of total price changes in Austria than on average in the euro area (chart 2). The difference is most pronounced for services prices, where Austria ranges second, after Portugal, in terms of the share of price cuts in total price changes, and seven percentage points or one third above

the euro area average. This result is surprising and at odds with general public perceptions about service price inflation, particularly in the wake of the changeover to euro banknotes and coins. The result should be treated with caution, since it conceals strong heteregoneity of price developments within the service sector. Tentative explanations are seasonal price effects in tourism.

Also for processed food and non-energy industrial goods Austria ranks second, after Germany and France, respectively, although the difference to the euro area average is less pronounced in these sectors. Findings by Fabiani et al. (2005) suggest that price cuts are more strongly motivated in Austria by competitors' prices or by situations of falling demand for firms with a high export share.

Chart 2: Share of Price Decreases in Euro Area Countries



Source: Dhyne et al. (2005).

4. Austrian Firms Have Pricing Motives Similar to the Average of Other Euro Area Countries

Surveys conducted at euro area firms reveal a very high similarity of the motives for pricing decisions of firms across euro area countries (table 2). While results for Austria are rather similar to the euro area average, some minor divergencies from the average might be noted. Implicit contracts (i.e. long-established customer relations) and explicit contracts appear to be slightly more important in Austria. By contrast, temporary shocks were seen as less important than by other euro area firms.

Table 2: Importance of Theories Explaining Price Stickiness (Mean Scores)

	BE	DE	ES	FR	IT	LU	NL	***AT***	PT	***Euro area*** *(1)*	U.S.	SW	GB	CA (2)
Implicit contracts	2.5		2.6	2.2		2.7	2.7	***3.0***	3.1	***2.7***	4	1	5	2/7
Explicit contracts	2.4	2.4	2.3	2.7	2.6	2.8	2.5	***3.0***	2.6	***2.6***	5	3	1	3
Cost-based pricing	2.4			2.5		2.7		***2.6***	2.7	***2.6***	2	2	2	1
Coordination failure	2.2.	2.2	2.4	3.0	2.6	2.1	2.2	***2.3***	2.8	***2.4***	1	4	3	5/8
Judging quality by price	1.9		1.8			2.2	2.4	***1.9***	2.3	***2.1***	12		10	
Temporary shocks	1.8	1.9	1.8	2.1	2.0	1.7	2.4	***1.5***	2.5	***2.0***				
Change non-price factors	1.7		1.3			1.9	1.9	***1.7***		***1.7***	3		8	4
Menu costs	1.5	1.4	1.4	1.4	1.6	1.8	1.7	***1.5***	1.9	***1.6***	6	11	11	10
Costly information	1.6		1.3			1.8		***1.6***	1.7	***1.6***		13		10
Pricing thresholds	1.7		1.5	1.6	1.4	1.8	1.8	***1.3***	1.8	***1.6***	8	7	4	

Notes: (1) Unweighted average of countries' scores. Columns 11 to 14 report the ranking of the theories in Blinder et al. (1998), Apel et al. (2005), Hall et al. (1997) and Amirault et al. (2004), respectively. - (2) In the column for Canada, two figures are reported for the implicit contracts and coordination failure theories, because in the Canadian questionnaire there are two different statements related to these theories.

Source: Fabiani et al. (2005).

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Contributors

Karl Aiginger, born in 1948, has been the director of the Austrian Institute of Economic Research (WIFO) since March 2005. He is a professor of economics at the University of Linz and he held a position of a visiting professor at Stanford University (1982 and 2002); the Massachusetts Institute of Technology (MIT, 1991); and the University of California Los Angeles (UCLA, 1997). He has contributed to the Austrian Advisory Council for Economic and Social Affairs and the Reform Dialogue of the Austrian Government. He has been a lead manager and contributor to the European Competitiveness Reprots since 1998. He is the editor of the Journal of Industry, Competition and Trade (JICT, jointly with André Sapir). Key areas of research include industrial economics, industrial policy and competitiveness.

Josef Baumgartner, born 1964, is an economist at the Austrian Institute of Economic Research (WIFO) in Vienna, Austria. He was a lecturer at the Department of Economics at the University of Linz (Austria), and assistant professor at the Department of Economics at the Technical University Vienna. He studied economics and econometrics at the University of Linz , the Institute for Advanced Studies in Vienna and the Vienna University of Economics and Business Administration. His major research interests are macroeconomics, applied econometrics, business cycle and inflation analysis and forecasting. He participated in the "Eurosystem Inflation Persistence Network (IPN)" on behalf of the Oesterreichische Nationalbank.

Günther K. Chaloupek, was born on June 5, 1947 in Lower Austria. He received his doctorate degree from the University of Vienna in 1969 and his M.A. (economics) from the University of Kansas, Lawrence, Ks., U.S.A. Since 1971, he has been the director of the Economic Research Department of the Austrian Chamber of Labour. In addition, he is a member of the Advisory Council for Economic and Social Affairs; vice president of the Government Debt Committee. Günther K. Chaloupek has published numerous articles (in German and in English) in journals and contributions to books in the field of history of economic theory.

Jesús Crespo Cuaresma is an assistant professor in the Department of Economics at the University of Vienna, and holds a Ph.D. in economics from the University of Vienna. His research interests are in the field of time series analysis and macroeconometrics. He has published on these topics in international journals and books.

Ernst Glatzer (born in 1969) studied technical physics at the Vienna University of Technology and Economics at the Vienna University of Economics and Business Administration where he also received his Ph.D. in economics (2002). He held the position of an assistant professor at the Department of Statistics at the Vienna University of Economics and Business Administration from 1998 to 2000 and joined the Oesterreichische Nationalbank in 2000.

Ernest Gnan was born in Vienna in 1964. He received his Ph.D. in economics at the University of Economics and Business Administration, Vienna, in 1989. In 1987, he started out his professional career as an investment fund manager and joined the Oesterreichische Nationalbank as an economist in 1988. In 1992, he moved to the European Commission in Brussels and in 1994 to the European Monetary Institute in Frankfurt. In 1998, Ernest Gnan became Deputy Head of the Oesterreichische Nationalbank's Foreign Research Division and in 1999 Head of the Bank's Economic Analysis Division. He is a member of the European Central Bank's Monetary Policy Committee and a member of the Austrian Government Debt Committee. Ernest Gnan has been giving numerous lectures on issues related to macroeconomics, monetary union and European integration. Since 1999, he has been adjunct professor at Webster University Vienna, and since 2005 lecturer at the University of Vienna. His numerous publications cover macroeconomics; economic growth, monetary policy, economic, institutional and legal aspects of European Monetary Union, exchange rate policy, the European Monetary System, the ERM 2 and the international monetary system, the institutional status of central banks and the Austrian capital market.

Clemens Eder (born in 1979) studied International Business at the Vienna University of Economics and Business Administration and at ESADE Barcelona and graduated from the CEMS Master's in International Management program. Currently, he is working in the Economic Policy Department of the Austrian Federal Economic Chamber.

Johannes Hoffmann (born in 1960) studied economics at the University of Cologne where he also earned his doctorate degree in 1988. Before joining the Economics Department of the Deutsche Bundesbank in 1994, he worked as a research assistant at the Institute for Economic Policy and at the Institute for Economic Theory at the University of Cologne. He served as an advisor to the OECD and to the German Federal Statistical Office, and he was a lecturer at the College for Banking Studies in Frankfurt, the Institute for Journalism in Cologne and the Martin-Luther-University Halle-Wittenberg. He is presently holding the position of a Senior Economist in the Macroeconomic Analysis and Projections Division of the Deutsche Bundesbank, and he is leading a group of economists, which analyses price, wage and labour market developments in Germany and in the euro area. His main research interests are the measurement and the analysis of price developments on factor, product and housing markets.

Harald Kaszanits, born in 1963, studied law at the University of Salzburg. He joined the Austrian Federal Economic Chamber (WKO) in 2000 and has been the head of WKO's Economic Policy Department since 2004. His special field of interest is labor and social economics, on which he has published numerous articles and commentaries. He is also an editor for the Austrian specialist journals "Zeitschrift für Arbeits- und Sozialrecht" and "Wirtschaftspolitische Blätter".

Erich Kirchler is a professor for applied psychology at the University of Vienna, Faculty of Psychology. He studied Psychology and Anthropology at the University of Vienna, graduated 1979, and was in the following employed as an assistant professor and associate professor at the University of Linz. He was visiting professor at various universities in Europe, U.S.A. and Australia, received calls for professorship at the Universities of Nuremberg and Cologne, Germany, and received the honour to be president of the International Association for Research of Economic Psychology and the Austrian Association for Psychology. His research areas are economic psychology in general and financial decisions in the private household (money management, expenditures, saving and credit use) and tax behaviour in particular. He has published several books in work and organizational psychology and economic psychology and over 150 scientific articles, mainly in applied psychological, social psychological and economic journals and edited books.

Markus Knell studied economics, sociology and philosophy at the University of Vienna, the Institute for Advanced Studies and the University of Zurich where he also received his Ph.D. in economics (2000). In the same year he joined the Oesterreichische Nationalbank where he works as a researcher in the Economic Studies Division. His main fields of interest and research include monetary policy, labour markets and pensions systems.

Jerzy D. Konieczny holds a M.A. in economics from the Warsaw University (1979) and a Ph.D. from the University of Western Ontario (1987). He started his professional career with appointments as a research assistant and lecturer at the Universities of Toronto and Western Ontario, and as an assistant professor at the Wilfrid Laurier University (Canada). Among many appointments as a visiting professor, he was engaged as a postdoctoral fellow at Tel-Aviv University (1989) and as a visiting fellow at Harvard University (1990). Since 1995, Jerzy D. Konieczny has been holding the position of an associate professor at the Wilfrid Laurier University. His research interests focus on macroeconomics and monetary theory, which is documented in numerous publications in refereed journals.

Claudia Kwapil, born in 1972, holds two master degrees in economics, one from the University of Vienna and the other from the London School of Economics and Political Science. Currently, she is doing her Ph.D. in economics at the University of Economics and Business Administration in Vienna. Since 1999, she has been

working as an economist in the Economic Analysis Division of the Oesterreichische Nationalbank, where her main field of activity is related to monetary policy. In particular, her research interests are monetary policy rules, the monetary policy transmission mechanism and inflation in general.

Thomas Y. Mathä studied in Freiburg, Norwich and Stockholm. He holds a M.A. and a Ph.D. in economics from the University of East Anglia, U.K. After several consultancy appointments with the European Investment Bank, he joined the Monetary, Economics and Statistics Department of the Banque centrale du Luxembourg. His fields of interests include international and monetary economics.

Fabio Rumler works as an economist in the Economic Analysis Division of the Oesterreichische Nationalbank. He is specialized in the fields of inflation and monetary policy. Additionally, he gives presentations at scientific seminars and conferences and holds a position as a lecturer at the Vienna University of Economics and Business Administration. Before becoming a central banker, he was an assistant professor at the Institute of Economics at the Vienna University of Economics and Business Administration, Department of Fiscal and Monetary Policy with Professor Nowotny. He started his career with a University Degree in trade and commerce at the Vienna University of Economics and Business Administration and continued with a post-graduate program in economics at the Institute for Advanced Studies in Vienna. Furthermore, he obtained a Ph.D. in economics at the Vienna University of Economics and Business Administration. His publications concentrate on the fields of inflation and monetary theory and policy.

Johann Scharler works as an economist at the Oesterreichische Nationalbank where he is mainly involved in macroeconomic modelling. His research interests include international economics, monetary theory and policy. He has published numerous papers in these fields. Besides his duties at the Oesterreichische Nationalbank, he teaches macroeconomics at the University of Vienna. He obtained an M.A. in economics from the University of Vienna, a post-graduate degree from the Institute for Advanced Studies in Vienna and a Ph.D. from the Simon Fraser University in Vancouver.

Alfred Stiglbauer is an economist in the Economic Analysis Division of the Oesterreichische Nationalbank (OeNB). His research interests focus mainly on labor economics, structural labor market issues and applied microeconometrics. He earned a master and a doctorate degree from the Johannes Kepler University of Linz (Austria), where he held the positition of an assistant professor at the Department of Economics before joining the OeNB in 2001.

Helmut Stix is a research economist at the Oesterreichische Nationalbank. He studied economics at the University of Vienna, the University of California San Diego and the Institute for Advanced Studies, Vienna. He holds a Ph.D. in

economics from the University of Vienna. He has published in the field of monetary economics, in particular exchange rate economics, money demand and payment innovations.

Martin Zagler is an associate professor of Economics at the Vienna University of Economics and Business Administration (on leave) and currently Jean Monnet Fellow at the Robert Schuman Center (Florence). He studied in Linz, Aix-en-Provence, Vienna and Florence and in addition, he was a visiting researcher at Harvard University, the European University Institute and University College London. His research interests are economic growth theory, public finance and labour markets. He has published in learned journals and is the author of Growth and Employment in Europe (Palgrave/Macmillan) and Endogenous Growth, Economic Policy and Market Failures, (Macmillan and St. Martin's Press).

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