INFLATION PERSISTENCE IN THE EURO AREA:
PRELIMINARY SUMMARY OF FINDINGS

Drafted by an IPN team composed of

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1. Introduction and main results

This report presents results from a research project developed by the European Central Bank and the 12 National Central Banks of the Eurosystem on the persistence of inflation in the euro area and its member countries. The analysis, conducted by a team called the Inflation Persistence Network (IPN), focuses on measuring and comparing patterns of price setting and inflation persistence in the euro area. For this purpose researchers have used data on individual goods prices and also data at the area-wide, national and sectoral levels. This paper summarises the results obtained so far and proposes tentative interpretations for the findings, relevant for macroeconomic modelling and for monetary policy. Since the project is expected to extend into 2005, the major aim of circulating a paper at this stage is to stimulate discussion and feedback that can help the team in the final part of its work.

The decision to initiate a comprehensive research project on inflation persistence in the euro area was taken in 2002; the reasons to do so can shed some light on the purposes the project is intended to achieve. Earlier Eurosystem research on the transmission of monetary policy[1] had uncovered, among others, two main findings. First, an unexpected monetary policy change has a short-lived effect on euro area real output, which peaks around 4-6 quarters after the shock and then dissipates relatively quickly. By contrast, the aggregate price level in the economy is affected more gradually but permanently. In this respect the euro area behaves similarly to the US[2]. Second, the size and the lags of the responses differ between the two economies. In particular, the response of prices tends to be more gradual in the euro area, and possibly also the size of the ultimate price response is lower, for any given change in output. An interpretation of this evidence is that the inflation process in the euro area is subject to a higher degree of rigidity, possibly due to a less competitive environment, more extensive price regulation or other formal or informal constraints on price setters. This interpretation is indirectly confirmed by analyses of the

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[1] Summarised in Angeloni, Kashyap and Mojon (2003).

[2] See, for example, Christiano, Eichenbaum and Evans (1999).

degree of product market regulation and competition conducted by the OECD[3], that clearly point to the existence of a less efficient price-setting mechanism in most European countries, relative to the US.

While these elements amount to a plausible line of reasoning, only an in-depth study of price setting, at both producer and retail level, based on all available statistical information, could provide adequate answers to the above questions on the degree and the nature of inflation persistence, that are of key importance for a proper conduct of monetary policy. This consideration led to the decision to launch the IPN. Shortly after its creation, the group concluded that the statistical information in the public domain or otherwise available to central banks – mainly aggregated national or sectoral price indices – was not sufficient for a proper analysis of the micro-pricing behaviour of producers and retailers, and decided to undertake a systematic effort to extend the statistical basis for the study.

As a result, the analysis of the IPN described in this report and by a set of accompanying papers[4] uses four main data sources. The first consists of data sets on individual records on consumer prices, for each country, covering the majority or even totality (depending on the country) of the data underlying the construction of the national consumer price indexes. These datasets, released by the national statistical offices on a confidential basis for the purpose of this study, permit the most detailed analysis of consumer price behaviour ever undertaken in Europe. The second source of data consists of individual prices underlying the compilation of producer price indices. The producer price datasets available to the IPN are less complete than those on consumer prices, but still unprecedented in their extent and coverage. Additionally, for several countries, qualitative data on producer prices from regular business surveys has been analysed. Third, the IPN launched a series of one-time surveys with individual companies, with comparable questionnaires in each country, in order to inquire about the price setting strategies followed by firms and their underlying motivations. The surveys follow in structure the classic study of Blinder et al. (1998), in order to facilitate comparability with the US and with other countries (UK, Sweden) where surveys of the same kind have been conducted. Finally, the IPN analysed time series data on aggregate price indices; this analysis is more standard in the literature, but nonetheless essential, since these data are used routinely to formulate monetary policy and monitor its performance.

With this large set of statistical information at its disposal, the research strategy of the IPN is broadly as follows. Micro-price data are used to derive a rich set of stylised facts on how individual prices are actually set, e.g. in terms of frequency, sign and size of adjustments, sectoral and national differences, evolution over time and synchronisation across firms, just to name a few. The determinants of these patterns are also analysed (e.g., macroeconomic conditions, or timing of other technical factors). Fitting these facts considerably narrows the range of admissible models of price setting behaviour. The survey evidence provides further heuristic power, confirming the data evidence or helping identify theories that are observationally equivalent. Finally, time series are used to check that the micro-data consistent models have implications in terms of inflation persistence (the key focus of the investigation) that match

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[3]   See Nicoletti, Scarpetta and Boylaud (1999).

[4]   For a complete list of papers, see appendix 4.

the aggregate data. Once the appropriate model to describe the data is identified, the reasons why that particular model is actually followed can be analysed, and the monetary policy implications explored.

As we noted at the outset, the research is still ongoing. The IPN does not yet have all the answers it hopes to eventually obtain. In particular, the last steps of confronting micro-data consistent models with aggregate inflation behaviour and drawing the policy implications still need to be further explored. But the results obtained so far already allow a much better understanding of price setting and inflation dynamics in the euro area than was available at the start. Some facts, among those we consider established, can be listed here.

1. Prices in the euro area economy change on average once every year. The existence of frictions that prevent most nominal prices from adjusting all the time is confirmed.

2. Average consumer price durations in the euro area (between 4 and 5 quarters) are significantly higher than in the US, where on average a retail price change occurs every 2 quarters.

3. When price adjustments occur, they tend to be quite large: the absolute magnitude (whether positive or negative) is around 8-10 percent in the retail sector and about 5 percent in the producer sector. Therefore, prices of individual goods are typically not changed around average or past inflation.

4. Price increases and price decreases are almost equally frequent and sizeable, in all countries. This contradicts the idea that pervasive downward price rigidity is the norm. The service sector is a notable exception, for which small price increases are common and decreases are very rare.

5. There is clear evidence of large sectoral differences in frequency, sign and size of price adjustments. Cross-sectoral rankings are strikingly similar across economies. In decreasing order of price flexibility we rank: energy and unprocessed food; processed food; non energy industry; services. There is some evidence (to be investigated further) that the cross-sectoral rankings of price rigidity on one hand, and of inflation persistence on the other, match with one another.

6. The frequency, size and sign of price changes depend on macroeconomic conditions (such as the inflation rate), sectoral conditions (such as the degree of competition), time factors (like seasonality) and specific shocks (such as VAT changes, the euro changeover, etc.)

7. Surveys indicate that explicit or implicit pricing contracts and strategic interactions among competing firms are the main sources of price stickiness for producer prices. Price adjustment ("menu") costs and information processing costs do not play an important role. The surveys also indicate that price reviews are more frequent (once every four to five months) than price changes (once every year).

8. Survey evidence suggests asymmetries in the adjustment of prices in response to cost versus market factors. In particular, prices respond more strongly to cost increases rather than decreases, while they respond more to a fall in demand than to a rise.

9. Measures of the degree of inflation persistence increase with the level of aggregation. Individual or highly disaggregated price series are, on average, much less persistent than aggregate ones. The most persistent sectors (typically, services) drive the persistence of nation-wide indices.

10. Empirical estimates of inflation persistence fall considerably when statistically significant occasional shifts in the mean level of inflation are accounted for. This may be interpreted as showing that high inflation persistence, as apparent in the data, largely disappears when controlling for the monetary policy regime.

The structure of the paper is as follows. In section 2 we discuss the definition of inflation persistence, in particularly distinguishing between the two key notions of "intrinsic" and "extrinsic" inflation persistence (i.e. of inflation per se, as opposed to that of its proximate determinants). We do so by using an illustrative simple model where inflation responds to real marginal costs and to expectations about the inflation process itself. In section 3 we look at the main stylised facts concerning inflation dynamics, as they emerge from aggregate and sectoral time series analyses. In section 4 we introduce the micro data evidence, for consumer and producer prices, and cross-check it with the survey results. In section 5 we tentatively confront some of the standard micro-founded macro models with the findings from the macro and the micro analyses. Eventually, this will allow us to restrict the admissible models of pricing behaviour to a narrower class that we regard as consistent with our overall body of evidence. Finally, in section 6 we conclude by highlighting the avenues we plan to follow in the rest of the research, including completing the micro and macro analysis and exploring the implications for monetary policy.

2.   Sources of inflation persistence

As discussed in the introduction, 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. In the present section we discuss the various factors that may lie behind such a slow adjustment of inflation.

In order to illustrate some of the issues involved, we make use of a simple macro-economic model which is described in Appendix 1. Its simplicity notwithstanding, the model incorporates in a stylised fashion the key building blocks found in larger more realistic models. To analyse the sources of the sluggish inflation response, it is useful to consider the structural inflation equation (sometimes called a hybrid New Keynesian Phillips curve) which is embedded in this model.

(1) $\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t(\pi_{t+1}) - \lambda \hat{\mu}_t + \xi_t$

where π_t denotes the inflation rate at time t; $E_t(\pi_{t+1})$ is the expectation conditional on time-*t* information of inflation at time *t+1*, $\hat{\mu}_t$ is the deviation of actual from desired mark-up and ξ_t is an exogenous mark-up shock. Broadly speaking four sources of inflation persistence can be distinguished, corresponding to each of the right-hand-side terms in the equation above: (i) persistence in the mark-up

gap, which will mirror, ceteris paribus, persistent fluctuations in the output gap ("extrinsic persistence"), (ii) dependence on past inflation due to the price-setting mechanism ("intrinsic persistence"), (iii) persistence due to the formation of inflation expectations ("expectations-based persistence") and (iv) persistence in the stochastic error term ("error term persistence").

In the remainder of this section, we will separately discuss each of those determinants. Nevertheless, it should be emphasized that these sources of persistence may be difficult to distinguish, in theory as well as empirically, since they interact in general equilibrium, and their relative importance will also very much depend on the monetary policy regime and the policy reaction function. For example, as shown below in the hybrid Phillips curve a more aggressive response to inflation, will typically reduce the persistence of the inflation response to various shocks.

2.1   Extrinsic Persistence

With flexible prices and model-consistent expectations, inflation simply reflects the rate of money growth relative to real potential output growth and equilibrium changes in velocity. In such an environment, the money growth rule will determine the extent to which the persistence in the real variables such as potential output growth carries over into inflation persistence. In that context equation (1) is no longer useful to understand the dynamics of equilibrium prices and inflation. Firms would always be able to keep their mark-up at their desired level, so that the mark-up gap would be zero.

In the presence of nominal rigidities in price setting, a key source of inflation and its variations over time lies in the extent to which average price mark-ups in the economy deviate from their desired levels, now or in the future, for only in that case firms adjusting prices today will want to choose a price different from the average price. The larger is the mark-up gap (current and anticipated) and the greater the fraction of firms adjusting prices at any given time, the larger will be change in the aggregate price level. In that case the persistence in the average mark-up gap will contribute to determine the persistence of inflation.

But the mark-up gap is an endogenous variable itself, so we need to understand the factors behind its persistence. The simple illustrative model laid out in Appendix 1 can be used to understand those factors. Consider, for illustrative purposes, a particular case of the model with no intrinsic persistence ($\gamma_b = 0$). For simplicity we also set $\pi_t^* = 0$ for all t. Then, under rational expectations, equilibrium inflation satisfies:

$$\pi_t = \Lambda_r d_t + \Lambda_u u_t$$

where $d_t = r_t^* - z_t$ denotes the interest rate gap and is a measure for demand shocks, $\Lambda_r \equiv \dfrac{\sigma\kappa}{1 + \sigma\kappa\phi - \rho_r\lambda_f}$ and $\Lambda_u \equiv \dfrac{1}{1 + \sigma\kappa\phi - \rho_u\lambda_f}$.

Thus, we see that inflation ends up inheriting the persistence of both the cost-push and demand shocks. Notice also that by increasing the strength of its response to inflation (i.e., by raising ϕ_π) the central bank will succeed in lowering inflation volatility, but not its persistence. In the above environment, the only way for monetary policy to dampen inflation persistence is by speeding up the convergence of the interest

rate to the natural rate, thus reducing the persistence of the interest rate gap. But even if the latter were to be eliminated or reduced considerably, the persistence of cost-push shocks (which we take to be exogenous here) would provide a lower bound to that persistence.

It is also important to realize that, under the assumptions made here, the degree of price stickiness does not affect the persistence of inflation, but only its volatility (through its influence on κ, which is inversely related to price stickiness). In particular, more stickiness will be positively associated with smaller fluctuations in inflation in the case of demand shocks, but larger fluctuations in response to cost-push shocks (since it takes a larger output gap change to dampen the effects of the cost-push shock on inflation).[5] In more general set-ups, the degree of nominal price stickiness will affect the degree of reduced-form inflation persistence as, for example, discussed in Wolman (1999).

In summary, due to the presence of nominal price stickiness, inflation inherits the persistence of its proximate determinants such as the real marginal cost or the output gap. This type of inflation persistence is sometimes called *extrinsic inflation persistence*.

2.2   Intrinsic Persistence

In terms of the hybrid New Keynesian Phillips curve discussed above, the basic Calvo pricing assumption results in a purely forward-looking specification ($\gamma_b = 0$). A higher average duration of price contracts will reduce the sensitivity of inflation to changes in current and future marginal cost, but it can not explain why lagged inflation enters this equation.

Various authors have introduced additional frictions related to indexation or rule-of-thumb behaviour (e.g. Smets and Wouters, 2003 and Gali and Gertler, 1999) to rationalise a lagged inflation term in the hybrid New-Keynesian Phillips curve above. Let us assume for simplicity the absence of any extrinsic persistence. In terms of our simple model this is accomplished by setting $\rho_u = \rho_r = 0$. Once again we assume a zero inflation target and rational expectations.

Under those assumptions equilibrium inflation is now given by

$$\pi_t = \rho_\pi \pi_{t-1} + b_u \varepsilon_t^u + b_r \varepsilon_t^r$$

where $\rho_\pi = \dfrac{1 + \kappa\sigma\phi - \sqrt{(1 + \kappa\sigma\phi)^2 - 4\gamma_b\gamma_f}}{2\gamma_f}$.

Inflation persistence not only depends on the persistence of the shocks (which is absent in our example), but also exhibits what is often called *intrinsic inflation persistence*. The higher the coefficient γ_b, the higher the degree of intrinsic inflation persistence. For instance, in the hybrid model of Galí and Gertler (1999) in which a fraction of firms set prices in a backward-looking fashion, an increase in that fraction

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[5]   Note that various real rigidities such as variable capital utilisation or endogenous countercyclical movements in the mark-up due to, for example, a kinked demand curve, will also have the tendency to affect the elasticity of inflation with respect to the output gap. See, for example, Dotsey and King (2001) and Eichenbaum and Fischer (2004). However, as is the case for nominal rigidities, these frictions will affect the volatility, but not the persistence of inflation.

raises γ_b and lowers γ_f, thus raising inflation persistence unambiguously. Similarly, in the Smets and Wouters (2003) model with partial backward-looking indexation, the coefficient γ_b will depend on the degree of indexation. In this case, an increase in the degree of price stickiness or a fall in κ will also increase the degree of inflation persistence as long as both γ_b and γ_f are strictly positive.

2.3   Expectations-based persistence

Most theories of inflation dynamics accord a significant role to inflation expectations in the determination of inflation. As shown in the discussion above, under the assumption of rational expectations, inflation expectations by themselves will not contribute to the persistence of the inflation process. However, relatively small deviations from the assumption of perfect information can change this result dramatically. Here it suffices to recall two examples.

First, imperfect information about which shocks (e.g. temporary versus permanent) are affecting the economy may lead to more persistent and gradual responses of inflation to shocks. For example, Erceg and Levin (2004) show how learning can explain the gradual disinflation process during the Volker era in an otherwise purely forward looking model. Similarly, when private agents have imperfect information about whether a given disturbance to inflation is due to a temporary shock or a permanent shift in the inflation target, inflation expectations may adjust following a purely temporary shock making the inflation response more persistent.

Recent empirical research (e.g. Adam and Padula, 2003) suggests that once direct measures of inflation expectations are used, the coefficient on lagged inflation in an equation like (1) does indeed fall quite dramatically and in many cases becomes insignificant. This suggests that the persistence of inflation expectations may be higher than warranted by the behaviour of inflation itself under the assumption of rational expectations and complete information. Some further evidence along those lines will be discussed in section 3.

Second, when private agents use relatively simple recursive learning algorithms to form inflation expectations in the presence of model uncertainty, Orphanides and Williams (2002) show that in particular activist central banks that care a lot about stabilising the output gap may slow down the learning process of agents trying to forecast inflation and may thereby increase the persistence of the inflation process. In this case, the monetary policy regime will affect the formation of inflation expectations and may affect inflation persistence through this channel. Generally speaking, a credible policy regime focused on price stability will reduce the persistence of inflation. For example, Gaspar, Smets and Vestin (2004) find a clear mapping between the monetary policy regime and the distribution of a persistence parameter in the perceived law of motion for inflation.

2.4   A note on heterogeneity, aggregation and inflation persistence

Most micro-founded inflation models, including variants of the New-Keynesian Phillips curve discussed above, are derived on the basis of a representative agent framework, where firms are ex ante identical. An important task of the IPN is to document the degree of heterogeneity in price setting at the micro level

and to derive the implications for aggregate inflation persistence. Both sections 3 and 4 will report our evidence regarding heterogeneity across countries and sectors.

In general terms, the aggregation of prices that are subject to different degrees of stickiness may well introduce higher order dependence in the aggregate price index as shown, for example, by Granger (1980). In such a case, it may be quite difficult to empirically distinguish between intrinsic and extrinsic inflation persistence solely on the basis of aggregate inflation data.

3.   Evidence from aggregate and sectoral data

This section summarises the stylised facts regarding inflation persistence in the euro area. It is based on a series of studies written in the context of the IPN that have investigated the degree of inflation persistence at the sectoral and macro level. Section 3.1 presents the evidence of based on aggregate euro area inflation data. It reviews various reduced-form measures of inflation persistence. The results of naïve reduced-form estimates for the overall degree of inflation persistence are reported in section 3.1.2 and confronted with estimates that account for changes in the mean of inflation in section 3.1.3. Subsequently, heterogeneity of inflation persistence across countries and sectors is analysed in section 3.2, along with the role of aggregation.

3.1   Aggregate euro area analysis

3.1.1   Measures of inflation persistence

In order to analyse the degree to which inflation is persistent, it is important to choose a measure according to which persistence can be categorised. Most of the recent literature on inflation persistence has used univariate time-series models to calculate various measures of inflation persistence.[6] Those measures include the sum of autoregressive coefficients, the largest autoregressive root, the half-life of innovations, etc. Each of those statistics gives an idea of how fast inflation returns back to its mean following an innovation. In addition, measures based on frequency-domain methods such as the spectral density at frequency zero (e.g. Benati, 2002) have been used. Various authors have also used multivariate methodologies (e.g. VARs) to calculate the timing of the peak effects of inflation to various non-structural innovations.[7]

Of these possible measures, the most common approach adopted in the papers referenced below is based on the sum of autoregressive coefficients, following Andrews and Chen (1994). Based on a univariate autoregressive process of the type

$$\pi_t = \mu + \sum_{j=1}^{K} \alpha_j \pi_{t-j} + \varepsilon_t$$

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[6]   See, e.g., Cogley and Sargent (2001), Pivetta and Reis (2002), Levin and Piger (2004).

[7]   See, e.g., Batini and Nelson (2001); Batini (2002).

the sum of the autoregressive coefficients is given as $\rho = \sum_{j=1}^{K} \alpha_j$. Another alternative, that has also been employed in some studies reported below is non-parametric and relies on the idea that there is a close relationship between persistence and mean reversion.[8] The estimator for the unconditional probability of a process not to cross its mean in period t is given by

$$\hat{\gamma} = 1 - n/T$$

where n stands for the number of times the series crosses its mean during a time interval with $T+1$ observations. An extensive discussion of the advantages and disadvantages of several measures of persistence is provided in Robalo Marques (2004). In the subsequent sections, we will report mainly results obtained with the sum of autoregressive coefficients, ρ, but will mention if alternative measures yield different results.

For several reasons, it might be desirable to expand such a simple univariate model, however. The reduced-form models measure the *overall degree of inflation persistence*, which will depend on the sources of inflation persistence discussed in Section 2 above, including the relative incidence of various types of shocks, and the degree of stability of the monetary policy regime. Hence, in order to distinguish extrinsic from intrinsic inflation persistence, it is useful to calculate the lagged inflation dependence controlling for past and current developments in marginal costs and/or other proximate driving variables.

In this context, it is also important to disentangle inflation persistence arising from monetary policy itself. In the medium to long run, inflation is primarily determined by monetary policy. Persistent changes in the central bank's monetary policy strategy that have a bearing on its medium-term inflation objective will therefore lead to persistent changes in inflation. This type of inflation persistence is, however, not part of the definition mentioned above. Instead, the definition refers to the tendency of actual inflation to adjust only sluggishly to the new steady-state inflation rate following a change in the monetary policy regime. Thus, to yield reduced-form estimates that correspond reasonably well to the broad definition given above, either the sample period should correspond to a reasonably stable policy regime, or the estimation methodology should explicitly account for shifts in the inflation objective. From an empirical perspective, distinguishing persistent shifts in the long-run inflation objective from persistent deviations of inflation from its long-run value may, however, not be very easy. We will see below that those estimates do indeed depend quite importantly on assumptions made regarding time variation in the mean.

3.1.2   Naïve reduced-form estimates

Table 3.1 reports the findings of various studies on inflation persistence in the euro area and the United States, that analyse a relatively long time-span without controlling for potential changes in the mean of inflation. We show estimates of ρ, which measure the overall degree of inflation persistence in the data. Studies that can reject the null of a unit root in inflation are marked by bold parameters. It is apparent that most studies, be they on the euro area or on the United States, cannot reject the hypothesis of a unit root

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[8]   This estimator is developed and discussed extensively in Robalo Marques (2004) and Dias and Robalo Marques (2004).

in inflation, which is consistent with the general view that inflation behaves in a highly persistent fashion. However, it is important to understand in more detail where the persistence arises – if indeed inflation behaved like a random walk in response to shocks, this would imply that monetary policy did not succeed in stabilising it around a stable target. Alternatively, the results could be affected by the long sample periods that generally cover several monetary policy regimes, and as such might not be representative for the current regime. We will turn to this issue in the next section, where we report the results of studies that allow for a break in the mean of inflation in an attempt to model differences in monetary policy regimes, or alternatively are estimated over shorter time samples.

3.1.3   Accounting for structural breaks

Another set of results is reported in table 3.2 – although they are at times taken from the same studies, the numbers reported in those tables are generally considerably lower than those reported above. In most cases, the null of a unit root in inflation can be rejected. The main difference between tables 3.1 and 3.2 lies either in the length of the time sample that underlies the analysis, or in the treatment of the mean of inflation. Allowing for a break in the mean of inflation, or a time-varying mean, is capable of reducing the degree of inflation persistence considerably to a point where it can be judged as moderate. Again, this conclusion holds in a similar fashion for both the euro area and the United States.

The studies reported in table 3.2 generally condition their analysis on a break in the mean of inflation after testing for the existence of such breaks, which is in most cases accepted statistically. There is therefore substantial statistical evidence that breaks in the mean of inflation have occurred in the recent past, and that the measures of inflation persistence depend on whether or not such a break is included in the statistical model. In order to assess the results reported above, it is crucial to take a stand on whether or not our measure of inflation persistence should be derived conditional on such breaks.

From a purely statistical perspective, it has been shown that a failure to account for such breaks could yield spuriously high estimates of the degree of persistence (Perron, 1990). The mean could even be modelled as entirely time-varying. Persistence measures are generally found to depend strongly on the assumptions regarding the process for the mean. The more time variation is assumed for the mean, the lower the estimates of persistence.[9] On the other hand, O'Reilly and Whelan (2004) argue that highly persistent processes can easily lead a time series away from its overall mean for considerable amounts of time, such that the existence of true breaks is difficult to detect. They find that tests based on asymptotic distributions overstate the evidence for such a break in their sample, such that a careful econometric treatment of the break tests is called for.

Beyond the purely statistical point of view, there are economic arguments why one would want to condition on breaks in the mean of inflation for our purposes. Given our working definition of inflation persistence as the tendency of inflation to converge slowly (or sluggishly) toward the long-run value implied by the monetary policy regime in place, it is crucial to have a thorough understanding of what the

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[9]   Robalo Marques (2004); Dossche and Everaert (2004); Cecchetti and Debelle (2004).

long-run value of inflation actually is empirically. With the start of EMU, a regime change has occurred in the euro area, such that it is important to identify inflation persistence under the new, current, regime, which is possibly characterised by a different mean of inflation than the period before EMU.

3.1.4   What drives the break in mean?

Although most papers reported above find evidence for a break in the mean of inflation, the reasons for the occurrence of such breaks is not clear in many cases. If monetary policy was the driving force, we would expect to see the break occurring in a similar fashion for most sectoral inflation series. This is not the case in several instances, however, as break dates are sometimes distributed widely, like for example for the various aggregate inflation series reported in Gadzinski and Orlandi (2004). The time series properties of inflation can potentially change for other reasons than monetary policy. For instance, a methodological change in the measurement of prices, like the inclusion of sales, can affect the stability of the univariate autoregressive model.[10]

In other cases, it is evident, however, that breaks in the mean of inflation are a result of changes to monetary policy. Bilke (2004) makes a convincing case that the breaks in French inflation are indeed driven by monetary policy. The break dates detected for overall inflation as well as a large number of sectoral subindices cluster around a few months in the mid-1980s, closely linked to the times when French monetary policy tightened considerably and started its "franc fort" policy, and shortly after wage and price freezes in 1982. This result is confirmed in Corvoisier and Mojon (2004). Their analysis of a large number of OECD countries finds mainly three "waves" of breaks in the mean of inflation: the first in the late 1960s or early 1970s, the second in the mid 1980s, and the third in the early 1990s. They find evidence that these waves are associated mainly with breaks in the mean of nominal rather than real variables, which they take as evidence that all three waves are related to monetary policy. They report an interesting difference of the breaks in the 1980s and 1990s: in the first instance, real interest rates increase, while in the 1990s, they decline. Accordingly, they argue that the increase in real rates in the 1980s may have led to disinflation, whereas the disinflation in the 1990s seems to have been more credible, and thus more compatible with low real interest rates.

3.2   Heterogeneity across countries and sectors

3.2.1   Country-specific estimates

How does the evidence on the euro area compare with the one on the euro area countries? The answer to this question is given in table 3.3, which reports the results available at the country level. Given the findings reported above, the table includes only studies that allow for a change in the mean of inflation, or are estimated over a relatively short time sample. The results point to a considerable degree of

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[10]   See Lünnemann and Mathä (2004a).

heterogeneity across countries – however, there is also a wide range of estimates across studies, and it is very difficult to find a common pattern.[11]

In various cases, the studies disagree considerably on the country rankings. For example, Gadzinski and Orlandi (2004) find Germany to be the country with the *least* persistent inflation, whereas Levin and Piger (2004) have it down as the *most* persistent country (although from a smaller subset of countries). In few cases, a similar pattern emerges. For example, the Netherlands are always either in the intermediate range, or at the lower end of the estimates.

Regardless of the country ranking, it is interesting to note that for the vast majority of cases, the null of a unit root in inflation can be easily rejected. Furthermore, the level of persistence is generally moderate, and lower than at the euro area level.

3.2.2   Sector-specific estimates

Going down one more level of aggregation, it is possible to analyse the extent to which inflation is persistent in the different sectors of the economy. We summarise the evidence of the IPN in two tables, tables 3.4 and 3.5. The first one, obtained in Lünnemann and Mathä (2004a), contains a sectoral analysis for all euro area countries. As mentioned above, the inclusion of sales prices into the compilation of the HICP affects the measured degree of inflation persistence substantially, leading to very low estimates of ρ even at the country level. The sectoral analysis will help us understand which sectors affect these results most strongly. As a matter of fact, all countries have sectors for which a negative ρ is found. Clothing and footwear is the sector that has by far the most cases of negative ρ, which makes sense, as this sector is indeed characterised by end-of-season sales. It turns out that there are only very few sectors for which the hypothesis of a unit root cannot be rejected. Looking at the 20 most persistent subindices, we find that the services sector is represented most often, followed by furnishings and household equipments.

The second table, table 3.5, reports the results of Altissimo et al. (2004) and Bilke (2004). These are based on a considerably longer time span, ranging from 1985 to 2003 and 1973 to 2004, respectively, and as such are less affected by the change in methodology. There is clear evidence for considerable heterogeneity across sectors. In most cases non-processed food and energy are little persistent on the one hand, and services and industrial goods are highly persistent on the other. Altissimo et al. furthermore find that the differences across sectors are larger than those across countries.

The differences in inflation persistence across sectors most likely reflect in parts different price setting practices that depend on the various market structures in which firms operate. A potentially large difference in price setting practices can be expected if prices are not market-determined, but administered, which in itself might be an outcome of particular market structures or other relevant factors. This issue

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[11]   Lünnemann and Mathä (2004a) illustrate that the introduction of sales prices into the compilation of the HICP may have a substantial impact on the measured degree of inflation persistence, which leads to a large number of negative estimates for ρ in their study.

has been analysed in Lünnemann and Mathä (2004b). The first complication that arises in this respect is to find a measure of administered prices, as there is no readily available index.[12] Various issues complicate the construction of such an index. First, there is a large variety of administrative measures. Second, some measures apply only at the regional or local level, or depend on characteristics of the consumer. A possible way forward is therefore to identify the subindices that are considered heavily influenced by administered price setting. In many instances, however, this implies aggregating administered prices as well as market-determined ones, a caveat that needs to be borne in mind when analysing results obtained at the subindex level.

Although changes in administered prices can have a sizeable impact on the *level* of inflation,[13] this does not necessarily imply that they also affect inflation *persistence*. A first indication for this is given in Dexter et al. (2004), who show for the US that regulated prices are on average slower to respond to changes in cost and demand conditions. Lünnemann and Mathä find that prices in their administered subindices, which account for around 9% of the euro area HICP basket, change less frequently and by larger amounts than market-determined ones. However, they report that the inclusion of subindices with administered prices does not affect the persistence of euro area aggregate inflation in any significant fashion. This is in line with some indirect evidence in Altissimo et al. (2004) for an aggregate of France, Germany and Italy, although not necessarily with their evidence at the country level. They compare estimates of ρ for actual aggregate inflation and for an aggregate that is constructed without the inclusion of series that are adjusted step-wise, a behaviour typically found for administered prices. Although the constructed aggregate is somewhat less persistent than overall inflation in France and Italy, this is not the case for Germany and the aggregate of the three countries.

3.2.3   Aggregation effects

The papers mentioned above typically find a higher level of persistence for aggregated inflation series compared to a simple average of the more disaggregated ones. For the US, the persistence of aggregate inflation is higher than the one of its subindices. In the euro area, the aggregate is more persistent than the country series, which in turn are more persistent than the sectoral subindices themselves.[14] To give an example, Bilke (2004) finds an estimate of ρ for French CPI inflation of 0.76 (see table 3.3), whereas the corresponding estimates for non-processed food, processed food, industrial goods, energy and services are 0.15, 0.34, 0.72, 0.28 and 0.44, respectively (see table 3.5). These examples illustrate how the time series properties of inflation can be subjected to an aggregation effect (a phenomenon first noted by Granger, 1980[15]).

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[12] See also ECB (2003, 2004).

[13] This has been shown, e.g. ,in ECB (2003, 2004).

[14] For the US, see Clark (2003); for the euro area, Gadzinski and Orlandi (2004) and Lünnemann and Mathä (2004a).

[15] Conversely, if micro series are lumpy, aggregation can actually <u>eliminate</u> a bias that would arise when estimating with elementary data, a point made by Caballero and Engel (2003).

As argued in Altissimo, Mojon and Zaffaroni (2004), aggregation of subindices to an aggregate series has mainly two effects on the time series properties that are relevant in our context. First, idiosyncratic shocks to the subindices will tend to wash out if there is a sufficiently large number of series that are aggregated, such that the autoregressive model of the aggregate will be dominated by the common shocks. Second, the persistence of the aggregate series depends on the distribution of the persistence parameters of the subindices, where the more persistent series receive a relatively larger weight (Chambers, 1998). As a result, persistence can be magnified through aggregation. Their estimates show that both effects are present. Around 30% of the variance of sectoral inflation rates is explained by one common factor, with the bulk of the remainder being driven by sector-specific idiosyncratic shocks. Furthermore, there is a magnification effect through a relatively larger weight of the more persistent subindices.

4. Evidence from micro data

This section brings together the results of the empirical analyses conducted at the micro level. The evidence comes from two main types of data sources, described in detail in appendix 2. The first type of data consists of direct information on individual prices at the consumer and the producer level. Dhyne et al. (2004) and Vermeulen et al. (2004) provide a synthesis of the national studies of respectively consumer prices and producer prices. Using these micro data, these studies compute frequencies of price changes and implied measures of price duration. Moreover, they analyse how these frequencies are affected by the type of product, the type of outlet, the time span elapsed since the last price change and a variety of other variables including proxies of macro-economic or sectoral conditions, indirect tax changes, seasonal factors, etc. The size and the sign of price changes are also analyzed, as well as the issue whether price changes occur in a synchronized or in a staggered fashion.

The second source of evidence consists of one-time surveys, conducted specifically for this project, on pricing policies followed by firms. Surveys have the comparative advantage that they can document, in qualitative terms, the underlying rationale of the observed pricing patterns. We refer to Fabiani et al. (2004) for a synthesis of the survey results and to the national studies underlying this synthesis for more details. The usefulness of bringing together these different types of information in this section consists in potential synergies among the different angles from which different data look at the same (or closely related) phenomena.

The rest of this section is structured around three sets of questions that deal respectively with the patterns of price adjustment (Section 4.1), the issue of state and time dependence (Section 4.2) and the sources of nominal and real rigidities in price setting (Section 4.3).[16]

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[16] The full list of questions that were used to guide the meta-analysis and their links to the various price-setting theories are presented in appendix 3.

4.1   Patterns of price adjustment

What is the typical pattern of price changes (in terms of frequency, size and persistence of price changes) at the individual and sectoral level? Do pricing patterns vary substantially across countries and/or sectors (due to factors such as economic/financial structure, degree of competition, etc.)? In particular, do consumer prices and producer prices exhibit different patterns of adjustment? Do pricing patterns (frequency, size and persistence of price changes) vary with the sign of such changes (increase, decrease)? Are there indications that prices (or a significant fraction of them) are fully flexible?

The different data sources consistently confirm that most prices tend to change relatively infrequently in the euro area. The existence of frictions that prevent nominal prices from adjusting continuously is therefore confirmed. The finding that prices tend to be sticky in the short run is important, as it is a prerequisite for discussing inflation persistence along the lines of equation (1) in section 2 above. Moreover, Fabiani et al. (2004) provide ample evidence of the fact that the firms participating in the surveys operate in an environment which clearly deviates from a situation of perfect competition: prices tend to be set as mark-ups over marginal costs; many firms have some kind of long-term relationship with their customers; and price discrimination and pricing-to-market is a widespread practice. Overall, the assumption of imperfect competition underlying New-Keynesian models - which is a prerequisite for price stickiness to be a short-run equilibrium phenomenon - is verified.

For consumer prices, Dhyne et al. (2004) find that on average in a particular month only 15% of the recorded prices change. The implied average duration of a price spell ranges from 4 to 5 quarters. This is significantly higher than for consumer prices in the US. According to Bils and Klenow (2004) (BK, hereafter), on average about 26 % of the prices recorded in the BLS database change in a particular month. The corresponding estimates of average price duration for the US is around 2 quarters, less than half of that in the euro area. Based on a longer historical sample, Klenow and Kryvtsov (2004) report an even higher frequency of price changes of 29% in the US. Overall, these differences between the euro area and the US are relatively well in line with the estimates of price duration based on aggregate inflation data in Galí et al. (2003).

An important issue concerns the effect of temporary price rebates or sales on estimated average price durations in the retail sector. Evidence from Baudry et al (2004) and Baumgartner et al (2004) for France and Austria respectively and the results of a pooled regression in Dhyne et al. (2004) suggest that excluding rebates does not lower price adjustment frequencies dramatically, although the impact on measured price durations can be more pronounced. According to these estimates, including sales prices increases the frequency of price adjustment by approximately 3 percentage points at the level of the individual country. The treatment of end of season sales is, however, very heterogeneous across euro area countries.[17] Taking into account the weights of the countries in which sales are recorded, sales are likely

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[17]   Sales are included in Austria, Finland, France, Italy, Luxembourg, the Netherlands and Portugal, whereas they are not in the databases for the other countries.

to affect the aggregate frequency of price changes in the euro area probably by no more than 1 percentage point. According to Klenow and Kryvtsov (2004), the impact of temporary price rebates is somewhat more pronounced in the US, as the frequency of price changes drops from 29.3% for all prices to 23.3 % for regular prices. Conceptually, it is not very clear whether temporary price rebates should be excluded from the calculation of frequencies or not. After all, one could argue that discounts are a form of price flexibility and they can be used by retailers to optimally respond to market conditions.[18]

Regarding differences in the frequency of price changes across countries, it turns out that differences in the composition of the consumption basket and differences in the statistical treatment of sales can explain a substantial fraction of those cross-country differences. However, even after controlling for these factors as well as for other variables such as the mean and the standard deviation of sectoral inflation rates in the countries concerned, Dhyne et al. (2004) find significant cross-country differences. One factor that could explain this is the structure of the retail sector, as several national studies find that super- and hypermarkets adjust prices more frequently than small shops.[19] However, the indicator that Dhyne et al. (2004) use to control for this phenomenon proves to be insignificant, although this could be due to the lack of good data for several countries.

Overall, heterogeneity across products and sectors is far more pronounced than heterogeneity across countries (Table 4.1). Moreover, the ranking of products and sectors in terms of the degree of price stickines is very similar in each of the countries analysed. Energy and unprocessed food prices change more frequently (on average 78 and 28 percent per month), while services prices are modified much more infrequently (5.6 percent per month). A similar pattern of sectoral heterogeneity was also found for producer prices in Vermeulen et al. (2004). Prices of energy products change most frequently. Food and intermediate goods occupy an intermediate position and prices of capital goods change least frequently. Obviously, PPI data do not cover the services sector.

At this point the reasons behind the sectoral pattern of the frequency of price changes are unclear (possible suspects are the degree of market competition, the characteristics of the production chain, the variance of sectoral shocks and differences in price adjustment costs). However, it is interesting to note that BK report similar cross-sectoral patterns in the US. Also in the US services prices change less frequently, particularly if transportation items which presumably contain a significant energy component are excluded. As in the euro area, non-durable and raw goods prices change more often. This robust pattern could mean that intrinsic features of the production or distribution processes play a key role in the price setting mechanism. In some cases this is rather obvious: for example, seasonal and climatic factors are a key driver of price changes in the fresh food sector (fruits and vegetables), where observed price durations tend to be very low.

Another interesting question refers to whether the frequency of price changes is different in the producer sector compared to the retail sector. The surveys presented in Fabiani et al. (2004) suggest that about 50

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[18] See Rotemberg (2004) for a pricing theory that can explain the existence of temporary price rebates.

[19] Beaudry et al. (2004), Veronese et al. (2004), Jonker et al. (2004) and Dias, Dias and Neves (2004).

percent of the firms in the 9 countries considered adjust prices once a year or less frequently. This is quite comparable with the average price durations for consumer prices reported above. The survey results are relatively homogenous across countries. Moreover, similar sectoral patterns in the frequency of price adjustments emerge as for consumer prices: for example, services prices adjust less often, while prices in trade and food sectors tend to adjust more frequently. For several countries (Spain, Italy, Luxembourg and the Netherlands) the survey results do indicate that firms producing directly for the retail sector adjust prices more often. The Portuguese (Dias, Dias and Neves, 2004), Spanish (Álvarez et al., 2004b) and Italian (Sabatini et al, 2004) research teams were able to directly compare the frequency of price changes for a subset of product categories which are common to the CPI and the PPI. Only in the Portuguese case it was found that consumer prices tend to adjust more frequently than producer prices. In Italy and Spain the opposite holds. In sum, the euro area data do not suggest that the frequency of price adjustments in the retail sector is much higher than the one for producers.

As to the size of the price changes, both Dhyne et al. (2004) and Vermeulen et al. (2004) typically find that prices adjust by a large amount compared to the prevailing rate of aggregate inflation. As discussed in Golosov and Lucas (2003), this suggests that firm or sector specific developments are important factors in price setting. For the CPI, prices tend to increase on average by 9.7 percent and to decrease on average by 12.3 percent. This finding is consistent with the results of Bils and Klenow (2003) for the US. The size of the price changes is less pronounced in the producer sector. On the basis of the available evidence for three countries (Italy, Spain and Portugal), the absolute size of both price increases and price decreases is about 5 percent. Only a fraction of the difference in size between consumer and producer prices can be attributed to the end of season sales that affect the CPI of some countries. An important area for future research will be to examine the link between the size of the changes and their frequency.

Finally, it is interesting to examine whether there is any evidence of asymmetries. First, retail price data suggest that price decreases are not uncommon and almost as frequent as price increases. Moreover as discussed above, when prices decrease, the size of the decrease tends to be somewhat larger than that of an increase. The frequency of decreases depends however on the sector: for services it is lowest. The latter result may be due to the fact that the share of labor costs in the services sector is particularly important. Overall, there are, however, no strong indications that specific downward rigidities are at work in product markets.

This does not mean, however, that there are no asymmetries at all. In Fabiani et al. (2004) it is shown that there exist consistent asymmetries in the motivations driving price changes across euro area countries. For price increases, cost push factors (mainly labor costs and the cost of raw materials) are more important as driving factor than other determinants, such as competitors' prices and changes in demand. For price decreases, the opposite holds: competitors' prices and variations in demand play are a more prominent role as an incentive to decrease prices than cost factors.

4.2   State and time dependence

How stable are the price adjustment patterns? Do they differ over time and how? Does the pattern of price changes (frequency, size and persistence) vary with macroeconomic conditions, such as the level of aggregate inflation or the state of the business cycle? To what extent do these patterns reflect the incidence of firm-specific or sector-specific factors, such as shifts in cost or demand? Do pricing patterns (frequency, size and persistence of price changes) depend on the length of the time period in which the price has remained constant and how?

Turning first to the effects of macro-economic conditions, there appears to be only weak evidence that the aggregate frequency of price adjustment (at the retail or producer price level) evolves over time in close relation to macroeconomic conditions. For a few countries, the dependence of price adjustment frequencies on aggregate inflation or on aggregate wage dynamics was tested explicitly. For consumer prices this turned out to be significant in Spain and Italy[20] for inflation and in the Netherlands[21] for wages. For Belgium, France and Portugal, national studies put forward in a less formal way some relationship between the aggregate frequency of price adjustment and aggregate (or core) inflation.[22] The more limited evidence available on producer prices (for Germany[23]) confirms that pricing practices are remarkably stable through time - though Germany is probably not an ideal testing ground for investigating the effect of large changes in the inflation regime. A much stronger feature of the data is that the probabilities of price changes are greatly affected by identifiable events that occur at specific points in time, such as the euro cash changeover or changes in VAT rates. This evidence is robust across countries and extends to several sectors. For producer prices in Germany, Stahl (2004) finds that the frequency to adjust prices is affected at the time wages are negotiated.

Conversely, as we saw, the price adjustment frequencies and hazard functions (which plot the probability of a price change as a function of the time that is elapsed without a price change) do change significantly and systematically across sectors, and to some extent across countries as well. The pooled regression analysis in Dhyne et al. (2004) shows that sectoral differences in the frequency of price adjustment are to some extent related to factors such as the mean (in absolute value) and the standard deviation of the sectoral inflation rates. Also in the national studies there is more and stronger evidence that the probability to observe a price change in a given product category depends significantly on the product-specific inflation rate and its variation over time.[24] This indicates that the role of sector-specific factors is important. Moreover, the survey evidence summarized in Fabiani et al (2004) shows that firms facing strong competitive pressures tend to adjust their prices more frequently, highlighting the link between the

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[20]   Álvarez and Hernando (2004) and Veronese et al. (2004).

[21]   Jonker et al. (2004).

[22]   Aucremanne and Dhyne (2004a and 2004b), Beaudry et al. (2004), Dias, Dias and Neves (2004) and Dias, Robalo Marques and Santos Silva (2004).

[23]   Stahl (2004).

[24]   See Álvarez and Hernando (2004), Aucremanne and Dhyne (2004b), Baumgartner et al. (2004), Dias, Robalo Marques and Santos Silva (2004), Fougère et al. (2004) and Veronese et al. (2004).

degree of nominal price rigidity and the degree of competition. Moreover, the observed high frequency of both positive and negative price changes and the fact that price changes are large in absolute value compared to the level of aggregate inflation further suggest that sectoral or idiosyncratic factors at the firm level are important.

The survey responses summarized in Fabiani et al. (2004) support the existence of both state-dependent and time-dependent price review practices. While less than 40 percent of the firms review their prices on a mainly time dependent basis, around half of the firms follow both time and state dependent rules. Interestingly, in several national studies it is found that the price reviewing process is predominantly time-dependent under normal conditions, but can shift towards state-dependency if sufficient important shocks occur. Among the "states" relevant for triggering price changes, there is a certain prevalence of answers mentioning changes in costs, while changes in demand do not seem so important, particularly for price increases. Provided that cost factors are more driven by sectoral or idiosyncratic shocks at the firm level (including wages), this evidence also points to a predominant relevance of this type of shocks, as opposed to macro shocks, in determining the frequency of price changes.

As to the firms that apply a time-dependent price reviewing process, Fabiani et al. (2004) report that the median review frequency is once a year and this frequency is compatible with the seasonality in the frequency of price changes, which was found both for consumer prices (Dhyne et al., 2004) and for producer prices (Vermeulen et al., 2004).

How does this evidence compare with estimates of hazard functions? All the available results typically show that unconditional *aggregate* hazard functions are downward sloping with peaks at specific horizons, particularly at multiples of 12 months. Similar hazard functions were found by Klenow and Kryvtsov (2004) for the US. At first sight, this evidence seems at odds with most of the theoretical pricing rules used in macro models, which suggest that the hazard function should either be flat or increasing.[25] However, as demonstrated analytically by Álvarez et al. (2004a), heterogeneity in price setting with aggregation can account for the downward-sloping feature. In particular, Álvarez et al. (2004a) show that a parsimonious combination of different time-dependent pricing rules fits the Spanish data quite well. Specifically, the combination of three different types of random price-setting firms (Calvo firms) (highly flexible, intermediate and sticky) and so-called annual Calvo price setters is successful in reproducing the empirical aggregate hazard functions, both for consumer prices and for producer prices.

Somewhat contrasting with this purely time-dependent representation of the downward-sloping unconditional hazard functions are the econometric estimations in Aucremanne and Dhyne (2004b), Baumgartner et al. (2004), Fougère et al. (2004) and Dias, Robalo Marques and Santos Silva (2004). These studies find that, once heterogeneity is taken into account, the probability to observe a price change

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[25]   Burriel et al. (2004) show that time-dependent pricing rules typically produce constant hazards (as in the case of Calvo (1983)), or constant hazards with truncation at a specific horizon - i.e. at this horizon the conditional probability to observe a price equals one - (truncated Calvo). Taylor contracts are a special case of truncated Calvo, showing only the truncation at the length of the Taylor contract (and a flat zero hazard for shorter durations). State dependent pricing rules produce upward sloping hazard functions, at least in steady state and with positive inflation (Dotsey, King and Wolman (1999), hereafter DKW).

is an increasing function of accumulated (sector-specific) inflation since the last price change. As is shown in Aucremanne and Dhyne (2004b), this finding implies increasing hazards in case of a constant, positive inflation rate, as is, for example, predicted by the state-dependent pricing model of Dotsey, King and Wolman (1999). They also show that this effect is further enhanced when concentrating on the impact of positive inflation on the probability to observe a price increase, a situation which is closest to the one modeled in Dotsey, King and Wolman (1999). Moreover, Dias, Robalo Marques and Santos Silva (2004) reject the hypothesis of uniform staggering, which underlies some time-dependent rules, such as for instance Calvo and Taylor.

Overall, the exact extent to which state-dependent and time-dependent pricing is applied is unclear at this stage of the research project and further research should address this issue. The available results tend to find more state-dependency with respect to sectoral or idiosyncratic factors than with respect to aggregate factors. This result accords quite well with Golosov and Lucas (2003), according to which (i) the level of general inflation begins to affect the frequency of price changes only at very high levels of inflation and (ii) the pattern of price movements is dominated by firm-level idiosyncratic shocks at a low level of inflation (such as that prevailing in the US and the euro area in the sample periods).

4.3   Sources of nominal and real rigidities

To what extent do price rigidities or adjustment costs seem inherent to the act of changing prices per se? To what extent do price rigidities seem to relate to the cost of calculating the correct price and deciding upon it? How important are automatic indexation schemes? To what extent do price rigidities seem to relate to the perceived reaction of customers or competing firms? How important is psychological pricing?

The answers to these questions rely mainly on the survey evidence presented in the summary paper by Fabiani et al. (2004) and in the underlying analyses at the national level. As stressed in Appendix 2, surveys were able to address the price reviewing and the price changing stage separately. From this, it appears that firms are relatively sticky at both stages. In most countries, the modal number of price reviews lies in the range of less than four times a year, while most of the firms tend to change their prices only once a year. Comparing the frequency of price reviews with the frequency of price changes, it is clear that prices are changed less frequently than they are reviewed. These results do not appear consistent with theories that identify the bulk of the costs firms bear when adjusting prices in the collection and processing of information. In fact, when firms are asked directly whether there are any explicit and direct costs connected with (i) gathering and analyzing the information necessary for price reviews and/or (ii) changing the price per se (something that could be related to the existence of specific pecuniary menu costs), the large majority of firms tends to answer that both information gathering costs and direct menu costs play little or no role at all. The latter results are broadly similar to those obtained in comparable surveys for the US (Blinder et al (1998)), for the UK (Hall et al. (2000)) and Sweden (Apel et al. (2001)).

While direct menu costs did not appear to be particularly important as a source of stickiness for nominal prices, Fabiani et al. (2004) shows that the majority of firms in all countries ranked the existence of either

implicit or explicit contracts very high as a factor that hampers price adjustment. This evidence is consistent with the fact that most of the firms in the surveyed sample have some sort of long-term relationship with their customers.

In nearly all cases, the reaction of competitors (or, more generally, strategic market considerations) also plays an important role. In particular, the surveys provide evidence in favor of so-called "co-ordination failures". Synchronized time-dependent rules could in this event act as a co-ordination mechanism. Although this is compatible with the evidence on seasonality in the frequencies of price adjustment, Dhyne et al. (2004) also show that prices are, to a large extent, changed in a non-synchronized or staggered way, even at the level of relatively homogeneously defined CPI product categories within the same country. Non-synchronized or staggered price setting is an important assumption underlying macro models and is a prerequisite to produce what Taylor (1999) described as "neighborhood effects between price setters, so that one firm pays close attention to the price decision of the next firm and the most recent firm, thereby linking the price decision of one firm to another and causing the persistence effect". The theory of "co-ordination failures" also embeds features of the kinked demand curve and some surveys have tested this source of rigidity in real prices explicitly and found supporting evidence. Fabiani et al. (2004) also found that so-called cost-based pricing is an important factor underlying the observed degree of price stickiness, and that real rigidities magnify the impact of nominal rigidities.

More competition seems to lead to less stickiness, which confirms the relevance of monopolistically competitive factors. Per se, more competition leads to a greater reluctance to change real or relative prices and could therefore be a source of real rigidity. However, having more competition leads also to lower mark-ups and leaves firms less room for not adjusting their prices when costs change. Hence, price stickiness is less likely to be a short-run equilibrium phenomenon. It is very unlikely that staggered pricing can be an equilibrium in highly competitive markets and consequently the concern about real prices leads in the limit to a situation where all prices change continuously and simultaneously.

There is ample evidence of attractive pricing in the retail sector; prices ending in 0, 5 and 9 are indeed very frequently used for CPI goods. However, the use of pricing thresholds does not seem to be an important source of price stickiness, as is discussed both in Dhyne et al. (2004) and in Fabiani et al. (2004).

Some surveys (Belgium, Italy, Luxembourg, Portugal and Austria)[26] explicitly address which type of information is used in the price reviewing process. However, as this question was not part of the "minimum common sample", it was addressed in a rather heterogeneous way and therefore results are difficult to compare. Nonetheless, it is interesting to note that, while it was found that the pricing process is predominantly forward looking, these studies also find evidence of deviations from a purely forward looking price reviewing process. In particular, the Belgian, Luxembourg and Portuguese teams find that price reviews are sometimes based on so-called rules of thumb, such as indexation on past CPI inflation. These types of deviations from purely forward looking pricing could lead to a so-called hybrid New-

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[26] See Aucremanne and Druant (2004), Fabiani, Gattulli and Sabbatini (2004), Martins (2004), Kwapil et al. (2004).

Keynesian Phillips curve, as described in section 2 and be an additional source of sluggishness in the inflationary process.

5. Implications for structural models

Micro-founded macro models of inflation provide a framework for interpreting the stylised facts about observed inflation persistence. For example, they are important tools for disentangling the various sources of inflation persistence discussed in Section 2. In view of the Lucas critique, a micro-founded approach is also required to analyse the monetary policy implications of inflation dynamics. Such analysis is essential in comparing the performance of alternative monetary policy regimes and in making reasonable predictions about the effects of a change in regime. In this section, we proceed to interpret the evidence presented in Sections 3 and 4 in terms of such models. In particular, section 5.1 considers the extent to which standard macro models can explain the macro evidence on inflation persistence. Section 5.2 then compares those models in terms of their ability to match the key features of the micro evidence.

5.1 Consistency with the macro evidence

The standard micro-founded macro models of inflation determination (Calvo, 1983, Taylor, 1999 or Rotemberg, 1982) have often been criticised for not being able to deliver enough aggregate inflation persistence (See, for example, Fuhrer and Moore, 1995 and Mankiw, 2001)). As discussed in section 2, the purely forward-looking Calvo model implies that inflation adopts the persistence properties of its proximate determinants. However, there is no independent role for lagged inflation. Similarly, as discussed in Whelan (2004), the standard Taylor-contracting model implies that inflation will depend negatively on past inflation, once the impact of the current and expected evolution of its determinants is taken into account. These features contrast with empirical findings that inflation often depends on lagged inflation even after controlling for current and past developments in marginal costs (See e.g. Corvoisier and Mojon, 2004 and Whelan, 2004). While these deficiencies can be overcome by ad hoc adjustments to those models such as the inclusion of automatic indexation (Christiano et al, 2004) or simple rule-of-thumb behaviour (Gali and Gertler, 1999), the micro-foundations of such adjustments are questionable as we will discuss below in Section 5.2.

In this section we review the ability of the standard models to generate enough inflation persistence in light of the evidence gathered in Section 3. The bulk of the evidence in Section 3 points to a reasonably low degree of reduced-form inflation persistence, once occasional shifts in the mean of inflation, which are most likely the result of shifts in the monetary policy regime, are accounted for. Within a stable monetary policy regime, the null of a unit root in inflation is generally rejected. While the estimates of the degree of persistence vary considerably, most shocks to inflation do not appear to have very persistent effects.

This finding also seems to be born out by structural estimates of the degree of intrinsic inflation persistence. Using various structural macroeconomic models for the euro area and its member countries, Berben et al. (2004) find very little evidence for persistent inflation responses to structural shocks – with

the exception of fiscal shocks. The sources of persistence in their models are mainly related to labour markets.

Table 5.1 reports estimates for the parameter γ_b in structural inflation equations of the type $\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \{\pi_{t+1}\} - \lambda \hat{\mu}_t + \xi_t$ discussed in Section 2. All studies find that there is a significant role for backward-lookingness, and thus for intrinsic inflation persistence. In some papers, the euro area compares favourably with the US, as the degree of intrinsic persistence is found to be somewhat lower. However, interestingly, and in line with the reduced-form evidence, also structural models find that the degree of intrinsic persistence drops when estimated over more recent samples or over stable monetary policy regimes. For example, for the US Gali and Gertler (1999) find that the weight on the backward-looking component becomes insignificant when the post-Volker sample period is considered. Similarly, Coenen and Wieland (2004) and Coenen and Levin (2004) find that a standard Taylor contracting model fits German inflation data, which are characterised by a relatively stable monetary policy regime, quite well. Finally, in the context of a larger DSGE model with many real and nominal frictions, de Walque, Smets and Wouters (2004) find that an inflation model without indexation or a backward-looking component fits the euro area and US data better than one with indexation, when allowing for a time-varying inflation target.[27]

As discussed in Section 2, an important additional channel through which monetary policy can affect the properties of inflation dynamics is by steering the inflation expectations of economic agents. Erceg and Levin (2004) show that inflation persistence increases when private agents have limited information about the central bank's objectives. In such a setting, the agents will try to disentangle persistent shifts in the inflation objective from transitory disturbances, and will manage to do so more quickly, the more transparent and credible the central bank. Empirically, it has been found that central bank transparency can indeed facilitate the anchoring of long-run inflation expectations, and reduce the degree of inflation persistence.[28] In a related fashion, Kozicki and Tinsley (2002) suggest that shifts in the long-run inflation expectations have contributed significantly to inflation persistence in the US and Canada.

A direct test of the importance of inflation expectations for the dynamics of inflation can be conducted in the framework of a New Keynesian Phillips curve. Whereas most studies assume rational expectations, some model the inflation process through direct measures of inflation forecasts obtained, e.g., from the Survey of Professional Forecasters for the US and from the OECD for the euro area.[29] These studies find that the role for explicit backward-looking inflation behaviour (and thus inflation persistence) is significantly reduced, if one allows for bounded rationality in expectations. Consistent with this overall picture, Paloviita (2004) finds that inflation has become more forward-looking in the recent years, and that it has been more forward-looking in the low-inflation countries of the euro area prior to the inception of EMU. The endogeneity of the persistence in the inflation expectations formation process to monetary

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[27] See also Paloviita (2004).

[28] E.g., Ravenna (2002) or Levin, Natalucci and Piger (2004).

[29] E.g., Roberts (1995, 1997); Adam and Padula (2003); Paloviita (2004).

policy behaviour is also highlighted in the work of Orphanides and Williams (2002), Gaspar and Smets (2002) and Gaspar, Smets and Vestin (2004).

Overall, this evidence suggests that standard micro-founded models can explain the relatively low observed inflation persistence in stable monetary policy regimes. However, as for example discussed in Coenen and Levin (2004), the macro evidence can not distinguish between the various micro-foundations. In other words, many of the standard micro-founded macro models of inflation are observationally equivalent (See, for example, Trabandt, 2004). As suggested by the Lucas critique, those micro foundations do, however, matter for policy analysis. In the next section, we therefore use the micro evidence in a first attempt to try to distinguish between the various theories.

5.2   Consistency with the micro evidence

Burriel et al (2004) provides a catalogue of some of the most common micro-founded macro models of inflation and derives the implied micro distributions of price changes in those models. These models include the models of quadratic and polynomial price adjustment costs as in Rotemberg (1982) and Kozicki and Tinsley (2002), various variants of the Calvo (1983) model with and without indexation and with and without rule-of-thumb price setters, the truncated Calvo model, various variants of the Taylor contracting model and the sticky information model of Mankiw and Reis (2002). The catalogue does not include the models of consumer resistance and fair pricing developed by Rotemberg (2002, 2004). Neither does it include the state-dependent convex menu cost models that are difficult to analyse in a general equilibrium framework or the state-dependent pricing models by Dotsey, King and Wolman (1999).

In this section, we confront the micro-foundations of those models with some of the micro-based stylised facts listed in the previous sections and draw a number of tentative conclusions. However, before doing so, it is worth noting that the models listed above are necessarily only rough approximations of the true behaviour of aggregate inflation that will be the result of price setting by a large number of firms typically in a heterogeneous set of circumstances. In particular, the most popular listed macro models are based on a number of simplifying assumptions that allow closed-form aggregation into macro-economic inflation equations. These assumptions include monopolistic competition as in Dixit and Stiglitz (1977) and the absence of ex-ante heterogeneity. It is clear that as a literal description of the micro behaviour, none of those models will pass the test. An important question for future research will be to see which micro features are important to capture and which ones are not for the macro-economic and policy analysis.

5.2.1   Lumpy versus continuous price adjustments

One clear and consistent finding across micro data sets is that in aggregate cross-sections of price quotes a large majority of firms typically keep their nominal prices unchanged for some time. This finding is inconsistent with theories of price setting that imply that firms typically change their prices continuously and in small amounts. This nominal rigidity is also inconsistent with widespread indexation. In the catalogue list mentioned above this finding provides evidence against the theories of non-convex price

adjustment costs (Rotemberg, 1982), the Calvo models with indexation either to steady-state inflation or past inflation (Yun, 1996 and Christiano et al, 2004) and the sticky information model of Mankiw and Reis (2002). In particular in an environment with positive aggregate inflation, each of those models implies that firms change their prices all the time. They can therefore not explain the large critical mass at zero that distributions of price changes show.

5.2.2   Rule of thumb behaviour and sticky information

One advantage of the rule-of-thumb Calvo model proposed by Gali and Gertler (1999) is that it is consistent with the observation that prices only change infrequently. At the same time, it delivers an observationally equivalent reduced-form inflation equation as the Calvo model with indexation to past inflation which does suffer from this problem. Similarly, Trabandt (2004) shows that this model has very similar implications as the sticky-information model of Mankiw and Reis (2002). What is the evidence on rule-of-thumb behaviour?

At this point, the evidence is rather mixed. First, there is very little indication that at the micro level price changes are concentrated around average or past inflation. Automatic indexation of prices or analogous rule-of-thumb behaviour would imply that price changes would cluster around those values. Instead, the average change (whether positive or negative) is typically much larger. However, a systematic study of whether there is a critical mass at the past inflation rate in the distribution of price changes has not explicitly been performed. Second, the survey evidence suggests that firms do not perceive the costs of collecting and processing information as one of the main reasons for price stickiness. On the other hand, as discussed above, those surveys that inquired about the degree of forward-lookingness of firms price-setting, did find some evidence of rule-of-thumb behaviour such as indexation to past CPI inflation. Finally, a robust finding across surveys is that firms seem to review their pricing decisions more frequently than that they adjust their prices. This again suggests that sticky information theories may not be the most important.

5.2.3   Time dependent pricing models: Calvo versus Taylor

In common with all time-dependent pricing models, both the Calvo and the Taylor model predict that the average frequency of price changes is constant over time. However, both models imply very different individual price trajectories and levels of synchronisation of price changes across price-setters. In the basic Taylor-contracting model, the length of time in between price changes is constant and there is possibly a relatively high degree of synchronisation of price changes depending on the degree of staggering. In contrast, price changes arrive randomly in the Calvo set-up.

The micro evidence regarding these features is again somewhat mixed. The micro price records based on the CPI suggest that the synchronisation of price changes across price setters does not seem to be large at the product level, even within the same country – see, for example, Dhyne et al. (2004). A random look at selected individual price records also suggests that the time in between price changes varies considerably. However, in all cases, hazard functions of price spells are also characterised by local modes at durations of 12 and 24 months indicating that a fraction of firms could apply yearly pricing rules. The survey based

evidence appears to be somewhat more favourable for the Taylor contracting model. Quite a large fraction of firms replies that its prices are reviewed in a time-dependent fashion, which in this case could be interpreted as during fixed time periods during the year. Also in this case, this behaviour corresponds to clear peaks in the hazard rates of a number of sectors at the 6 and 12 month horizons. Overall, it appears, however, that the micro data are more consistent with the Calvo model than the Taylor model. This may not be so surprising when one considers that when Taylor (1980) presented his overlapping contract model he had mostly the labour market in mind.

5.2.4   Sectoral heterogeneity, declining hazard rates and Calvo-mixture models

A robust finding across the various micro studies is that the unconditional hazard functions of price changes are decreasing in the duration of price spells. This contradicts the predictions of the various Calvo and Taylor contracting models that the hazard rates should either be constant or approach one as the duration of the price spell increases. However, Alvarez et al (2004a) show that a mixture of pure Calvo (1983) price-setting models with different probabilities of price adjustment, corresponding to flexible, intermediate and sticky price setters, may provide a good and relatively parsimonious approximation of the declining hazard functions. This is due to a composition effect: as time elapses the share of less flexible firms decreases thereby reducing the average frequency of price adjustment. Similarly, as discussed in Section 4, a number of micro studies show that the hazard functions do become flatter when one controls for heterogeneity.

In sum, a Calvo-mixture model can account for a number of the micro stylised facts: (i) the largely random nature of price adjustments; (ii) the common finding of declining unconditional hazard rates; and (iii), importantly, the robust finding that the frequency of price changes differs in a systematic way across sectors. In addition, explicitly accounting for a certain degree of heterogeneity in price setting may help in explaining the degree of persistence at the macro level. As discussed in Carvalho (2004) and Dixon and Kara (2004), the aggregation effect will be important in particular when the degree of strategic complementarity in price setting between the sectors is high.

Of course, the Calvo model still relies on the fact that ex-ante all firms within the same monopolistic sector are identical. It can, therefore, not account for the large price adjustments (both positive and negative) that are observed at the micro level both in the consumer and producers sectors. These large positive and negative price changes suggest the presence of large idiosyncratic shocks (see Golosov and Lucas, 2003). Large idiosyncratic shocks can also explain why firms appear to change their prices randomly. However, Danziger (1999) develops a general equilibrium model with Ss price setting rules and both idiosyncratic and aggregate shocks, in which the large positive and negative idiosyncratic shocks wash out in the aggregate and what remains is the response to aggregate shocks. Moreover, he shows that under particular assumptions the probability of a price change depends on the steady state inflation rate, but is constant over time in response to aggregate shocks. The probability also depends on sector-specific characteristics such as the variance of the idiosyncratic shocks and the sectoral inflation rate. Under such conditions, the Calvo model may indeed be a good approximation of the macro dynamics of inflation.

5.2.5 State versus time dependent price setting

The argument made in the last section assumes that idiosyncratic shocks are dominating the aggregate shocks in the decision of price-setters when to change prices. Of course, it may be the case that firms also respond to sufficiently large aggregate changes in current and expected marginal costs, etc. In that case, one would expect a bunching of price adjustments when such aggregate shocks occur and a comovement between the aggregate economy and the frequency of price changes.

As in Bils and Klenow (2004), the IPN micro evidence has uncovered quite a bit of variation in the frequency of price adjustments over time. However, clear cyclical patterns have not been detected. Moreover, for the US Klenow and Kryvtsov (2004) calibrate a state-dependent price setting model as in Dotsey, King and Wolman (1999) to match the extent of time variation in the average frequencies (between 15 and 35%) and show that the macro-economic relevance of this type of state dependence is limited. The impulse responses of various shocks in such a model are very similar to those of a standard Calvo model with fixed probabilities of price adjustment. In future research, it would be useful to perform similar exercises for euro area data.

Of course, the IPN has also uncovered other forms of state dependence in price setting. For example, Dhyne et al (2004) show that the frequency of price changes in the CPI price records depends on the sectoral level of inflation and changes in VAT. Similarly, the survey evidence shows a relatively close correlation between the frequency of price changes and the degree of competition. All these findings can be interpreted as evidence in favour of a state-dependent model such as that of Dotsey, King and Wolman (1999). However, whether it is important to include such features of state dependence will largely be an empirical question and will also depend on the questions one wants to answer. Overall, it appears that for the analysis of a monetary policy in a stable, low inflation regime, the assumption of a Calvo model with constant probabilities of adjusting prices is a reasonable approximation.[30]

5.2.6 The role of customer markets, coordination failures and fair pricing

There is quite a bit of evidence that customer markets play an important role in price setting. For example, the frequency of price changes in large supermarkets is much higher than in corner shops where customer relationships are probably firmer. Similarly, explicit and implicit contracts as perceived as being the most important reason for price stickiness in the producer sector, where long-term relationships are relatively important (Fabiani et al, 2004).

Another finding from the survey papers is that coordination failures are an important factor behind price rigidities. This may explain why in those samples time dependence may be relatively more important than in the retail sector

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[30] For a defense of the partial adjustment model even when there are idiosyncratic shocks, see King and Thomas (2003).

Finally, the evidence on asymmetries in the way prices increase or decrease in response to changes in costs and demand suggest that theories based on fair pricing as developed by Rotemberg (2004) may be important.

Overall, most micro-founded macro models of inflation have used the model of monopolistic competition of Dixit and Stiglitz as the model of the underlying market structure. The various pieces of evidence presented above suggest that more complicated market structures may well be important. One question for macro modellers is how to take these considerations into account, while at the same time retaining tractability at the macro level.

6.   Directions for future research

The IPN currently plans to continue its work for another year. In this concluding section we briefly outline the current thinking within the IPN about the next research steps to be undertaken. The section is divided in three parts: the first focuses on the completion of the micro data analyses; the second concerns the implications for macro models; and the third relates to deriving the policy implications.

6.1   Completing and expanding the micro analysis

At the micro and disaggregated level there are three main directions for future analysis.

First, it is important to deepen our understanding of what factors explain the observed sectoral differences in price setting. One major shortcoming of the analysis done so far is that, because of data restrictions, there is very little evidence at the micro level on the volatility and persistence of the proximate driving variables of prices such as marginal costs. When considering differences in price setting at the micro level, it is therefore difficult to distinguish between the hypothesis that these differences are driven by nominal rigidities or by differences in the driving variables. For example, it may be the case that those sectors that change their prices very frequently are subject to similar nominal rigidities as other more sticky sectors, but face more volatile marginal costs. A first set of complementary analyses could focus on trying to shed more light on this issue in a number of ways. First, it is relatively straightforward to do some simple analysis on the existing statistics to examine whether those sectors that change their prices frequently also change their prices by a smaller size. This is what one may expect if the main source of differences in average frequency of price changes are nominal rigidities. Such a relationship may be absent if the main source is differences in the processes driving marginal costs. Second, a more ambitious approach is to relate the sectoral differences in price setting to other sectoral features such as the market structure (e.g. the degree of competition) and the structure of the factor markets. This may in particular be feasible for the micro producer price data which can be linked to data at the sectoral level regarding output and cost developments and market structure. Such an analysis will also be important to determine to what extent ignoring features of state dependence may be permissible.

A second avenue for future research concerns the analysis of whether there is stickiness in price changes, as well as in price levels at the micro level. The statistics collected in the IPN so far concern mostly the

frequency of price changes and the size of price changes conditional on a change happening. So far, no statistics have been calculated regarding the persistence of price changes. For example, what is the probability that the next price change is positive given that the previous one was positive? Statistics capturing the mean reversion in price changes such as the probability of a process not to cross its mean in a given period could also be calculated for micro data. Such an analysis of persistence in price changes would allow us to check whether there is a correspondence between the results at the micro level and the findings of differences in inflation persistence at the disaggregated sectoral level.

More generally, in order to get a better handle on the aggregation issue, it would be useful to extend the analysis in Bilke (2004) and Altissimo et al (2004) to other countries and investigate the relation between price stickiness (from the micro data) and inflation persistence (from aggregated indices) more systematically. Finally, a more thorough analysis of the distribution of price changes at the micro level could be usefully performed. Most of the evidence reported above refers to the average or median size of positive and negative price changes, not to the full distribution. Such analysis could give useful information on a number of issues. First, as argued in Ball and Mankiw (1995) the presence of menu costs and positive aggregate inflation typically implies that the distribution of price changes is skewed.[31] It would be interesting to see whether this is indeed the case. Second, the distribution of price changes may provide information about the presence of indexation or other forms of rule-of-thumb behaviour. For example, a local mode at the aggregate inflation rate may suggest that a number of sectors appear to follow a relatively simple pricing rule based on the aggregate inflation rate.

6.2 Macro analysis

As is clear from the discussion in Section 5, there is also a need to expand the macro analysis of the micro findings.

First of all, some IPN studies suggest that a combination of Calvo-type sectors with different probabilities of adjusting prices can match quite well important features of the micro data such as the declining hazard rates and the robust finding of heterogeneity across sectors. One obvious avenue for future research is to investigate whether such a model calibrated to micro data can also fit the observed inflation persistence at the macro level. In particular, does such a model do much better than the simple Calvo model in generating persistence of impulse responses following a variety of shocks. Is the better performance sufficient to justify the increased complexity? Can such a multi-sector model explain the presence of intrinsic inflation persistence in a single Calvo model? In this context, it would also be very useful to redo the simulation study of Golosov and Lucas (2003) which explicitly allows for idiosyncratic shocks. The question would be whether allowing for sectors with different degrees of price rigidities and calibrating the model to the euro area findings would overturn their results that the macro-economic consequences of the nominal rigidities are limited.

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[31] Aucremanne et al. (2002), for instance, find indeed that the more lasting part of the skewness in the distribution of sectoral CPI price changes in Belgium is indeed positively related to the aggregate inflation rate. This type of analyses has not yet been conducted at the level of individual price changes.

A second finding of the micro studies is the presence of state dependence at the firm, sectoral and macro level. It would be useful to analyse to what extent explicitly incorporating these features in macro models is important from a macro perspective. Obviously, the answer to this question will depend on the type of question asked. For example, it is likely to be less important for the analysis of monetary policy in a stable low inflation policy regime. Two pieces of analysis could be useful. First, estimates of the dependence of price setting on the degree of competition and the average inflation rate could be used to calibrate state-dependent pricing models such as the one proposed by Dotsey, King and Wolman (1999). Second, an analysis as in Klenow and Kryvtsov (2004) could be performed to investigate whether the observed variation in the frequency of price changes over time is economically important at the macro level.

Finally, results from the surveys suggest that firms typically review their prices more often than they change them. Consistent with some of the other answers, this suggests that costs of processing informations are less important than costs of changing prices. Nevertheless, it may be that firms specialise their information systems towards gathering info regarding their own cost structure and markets and pay less attention to macro-economic developments. In this context, the test recently performed by Bils, Klenow and Kryvtsov (2004) for the US that aims at analysing the response of relative sectoral prices to a monetary policy shock is a useful one. Their results suggest indeed that flexible price firms do not adjust more rapidly than more rigid sectors to aggregate shocks.

6.3   Exploring the policy implications

Finally, the IPN plans to undertake the analysis of the policy implications as a last step in its research. The reason is rather obvious: the policy implications are likely to depend critically on the exact nature of the findings and on their interpretation. For example, one straightforward way to conduct this analysis, which would be consistent with the discussion in section 5, would be to use the empirical findings to improve the specification and the estimation or calibration of existing macro-models, and then to analyse the policy implications within these models.

Although at this stage it is too early to draw any policy implications, there seem to be various areas where the IPN results may lead to significant implications for both monetary and non-monetary policies. First, the bulk of the micro evidence points to significant stickiness in price setting in the euro area. Price stickiness appears to be very unevenly distributed across economic sectors, but on average to be quite stronger in the euro area than in the US. This can explain (or contribute to explain) the relatively sluggish transmission of monetary policy to prices we alluded to in the introduction, which in turn may affect the appropriate horizon of monetary policy. However, in order to interpret this degree of stickiness as coming from inefficiencies in the euro area pricing mechanisms, the IPN will need to sharpen its analysis of what drives the inter-sectoral and international differences in price flexibility, linking these patterns to determinants such as the degree of competitiveness of the production and distribution sectors, the

regulatory and price-setting action of the government, etc.[32] Other policy implications may derive from the heterogeneity in the degree of price stickiness across sectors.[33] Also in this case, uncovering the determinants of price stickiness and the reasons why such strong sectoral differences exist will be important.

The evidence collected by the IPN in favour of significant "intrinsic" inflation persistence seems at the moment to be weaker than that supporting the existence of price level stickiness. The implications of intrinsic persistence for monetary policy rules have been analysed by Erceg, Henderson and Levin (2000) and more recently, within a euro area model, by Angeloni, Coenen and Smets (2003) and Coenen (2004). This analysis will have to be reassessed in the light those findings.

Finally, time series estimates seem to provide direct and indirect confirmation that inflation regimes, possibly linked to expectations and to monetary policy, matter in determining the persistence of the inflation process. There is evidence of relatively low inflation persistence when occasional shifts in the mean of inflation are allowed for, suggesting that high inflation persistence is partly associated with unstable monetary policy regimes.

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[32]   One open question in this context is whether the adoption of the euro has stimulated cross-border competition and affected price setting practices.

[33]   See, for example, Benigno (2004), which suggests that a central bank adopting an aggregate inflation objective may need to pay more attention to sectors where prices are comparatively sticky. This conclusion would not apply, however, if stickiness is not given, but endogenous to policy.

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Appendix 1: A simple illustrative model

In order to help us convey and illustrate some of the issues involved in Section 2, in this box we lay out a simple macroeconomic model.[34]

At risk of oversimplifying, we can view most of the models in that literature as being made up of four building blocks. Next we describe and present stylised representations of each of those blocks.

A first block relates the evolution of inflation to its past values (possibly as a result of some backward-looking behaviour in price setting decisions), as well as to the gap between newly optimised prices and the average level of prices. That gap depends, in turn, on (i) the expected path of future inflation (since firms optimising prices today will seek to offset some of the erosion on their relative price caused by inflation in the period of time until they re-optimise prices again), and (ii) the deviation of the average markup in the economy from the desired markup (so that, on average over the anticipated life of the newly set price, the markup is roughly equal to the optimal one). The previous factors can be represented in a stylised manner by means of the following difference equation:

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \{\pi_{t+1}\} - \lambda \hat{\mu}_t + \xi_t$$

where $\pi_t = \Delta p_t$ is the rate of inflation rate and $\hat{\mu}_t = \mu_t - \overline{\mu}_t$ is the deviation of the economy's average price mark-up from its frictionless or desired level. Parameter γ_b is related to the degree of backward-lookingness of price-setting decisions.[35]

A second block of the model links the mark-up gap to a measure of economic activity. Let $x_t \equiv y_t - y_t^*$ denote the gap between output and its natural level, where the latter, denoted here by y_t^*, is defined as the equilibrium level of output in the absence of any frictions (nominal or real). For simplicity, we assume that the output gap is expressed in deviations from its mean or steady state level.

Without loss of generality we postulate the following relationship:

$$x_t = -\alpha \hat{\mu}_t + v_t$$

where v_t can be thought of as an index of the variations in the size of frictions other than sticky prices (e.g., wage mark-ups, desired price mark-ups, etc)

Combining () and () yields an equation often referred to as the hybrid New Keynesian Phillips curve

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[34]   The past decade has witnessed the development of a large literature on the implications of alternative monetary policy arrangements for the performance of an economy and the welfare of its citizens. A key feature of that literature has been the use of dynamic general equilibrium models with optimizing households and firms. In those models it is generally assumed that prices and wages are set in imperfectly competitive markets, with some constraints imposed on the frequency of their adjustment.

[35]   See, e.g., Galí and Gertler (1999) or Smets and Wouters (2003)

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \{\pi_{t+1}\} + \kappa x_t + u_t$$

where $u_t = \alpha^{-1} v_t + \xi_t$ is often referred to as a cost-push shock. That cost-push shock assumed to follow an AR(1) process with coefficients ρ_u

A third building block of the model relates the output gap to the (ex-ante) real interest rate. For our purposes we just postulate use a simple linear contemporaneous relationship (we abstract thus from more complicated dynamics):

$$x_t = -\sigma \left(i_t - E_t \{\pi_{t+1}\} - r_t^* \right)$$

where r_t^* is the natural real rate, defined here as the equilibrium real rate in the absence of any frictions.

Finally, a fourth building block describes how the interest rate is set by the central bank. An example of such a rule, which suffices for our purposes is

$$i_t = E_t \pi_{t+1} + \phi(\pi_t - \pi_t^*) + z_t$$

where π_t^* is the inflation target and z_t represents variations in interest rates beyond those warranted by deviations of inflation from target. We assume that the "intercept" of the interest rule evolves over time according to the following partial adjustment model:

$$z_t = r_t^* + \rho_r (z_{t-1} - r_{t-1}^*) - \zeta_r \varepsilon_t^r$$

Notice that in this context ρ_r represents the persistence of exogenous variations in the interest rate (un-backed by a corresponding change in the natural rate), as well as the persistence of the deviations of the interest rate from the natural rate in response to exogenous variations in the latter (notice that the two are equivalent). In what follows we refer to those shocks as demand shocks, independently of their source (since they are observationally equivalent in our framework..

Appendix 2: Description of the micro-data sets

This section describes the databases underlying the results of the empirical analyses conducted at the micro level. The evidence comes from two main types of data sources. The first type of data consists of direct information on individual prices at the consumer and the producer level. The second source of evidence consists in one-time surveys, conducted specifically for this project, on pricing policies followed by firms.

Individual prices at the consumer and producer level

The first type of data consists of direct information on individual prices at the consumer and the producer level. Here we highlight only the most important features of these databases, as well as their strengths and weaknesses for an analysis of the issues the IPN is interested in. For more details, we refer to Dhyne et al. (2004) and Vermeulen et al. (2004) where a synthesis of the analyses for respectively consumer prices and producer prices is presented, as well as to the individual papers underlying these syntheses.

Table: Coverage of the micro data sources

	Consumer prices	Producer prices			Ad hoc surveys
		of which:	Quantitative PPI data	Qualitative data from business cycle surveys	
Austria	Yes				Yes
Belgium	Yes	Yes		Yes	Yes
Finland	Yes				
France	Yes	Yes		Yes	Yes
Germany	Yes	Yes		Yes	Yes
Greece					
Ireland					
Italy	Yes	Yes	Yes		Yes
Luxembourg	Yes				Yes
Netherlands	Yes				Yes
Portugal	Yes	Yes	Yes		Yes
Spain	Yes	Yes	Yes		Yes
Coverage of the euro area in terms of GDP weights	97%	85%	30%	54%	94%

Specifically for **consumer prices**, it was possible for research teams in the National Central Banks of the Eurosystem to obtain from the national statistical offices large sets of elementary databases underlying the construction of the national consumer price indices. IPN research teams have now access to these data in 10 euro area countries (Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain), covering 97 % of euro area GDP. Before the creation of the IPN in 2003, this type of data was only available, to a limited extent and for specific purposes only, in Belgium, the Netherlands and Portugal. Data were typically made available on a bilateral basis between the respective national statistical offices on one hand and the national IPN teams in the NCBs of the corresponding countries on the other. Each of these data releases was subject to specific restrictions, a common feature being the fact that, due to confidentiality constraints, databases can only be accessed by the specific national team. This made it impossible to pool the national data sources and to conduct an analysis directly at the level of the euro area. However, via the interaction between the different national teams within the IPN, it became possible to draw a picture on price-setting in an economic and monetary union as vast as the euro area.

The CPI databases are typically large, unbalanced panels of price quotes at the very micro level, i.e. the price of a particular product sold in a given outlet. This means that these databases have two types of cross-sectional dimension, as well as a temporal dimension.

First of all, they cover a wide range of different product categories and therefore allow a much broader analysis of price-setting practices than what has been done in most of the pre-IPN studies, such as for instance Cecchetti (1986), Lach and Tsiddon (1992,1996). The nature and the scope of these databases is only comparable to the BLS data underlying the US CPI, which were recently used in Bills and Klenow (2004), Klenow and Kryvtsov (2004) and Golosov and Lucas (2003), and the data used by Konieczny and Skrzypacz (2004) for Poland. Product coverage varies, however, across countries. While 7 national research teams have at their disposal detailed price quotes for product categories which cover at least 65 p.c. of the consumption basket of their country (Austria, Belgium, Finland, France, Luxembourg, Portugal and Spain), a "minimum common sample" of 50 product categories was obtained for 3 other countries (Germany, Italy and the Netherlands). This common sample was defined in the IPN, with the aim to allow comparison of results, even for the countries where only a limited set of data could be released or processed. This wide coverage allows analyzing the extent to which pricing patterns are heterogeneous across product categories.

Besides this inter-market dimension, cross-sections also dispose of a rich intra-market dimension, as, for a given product category, each month a large number of individual prices is recorded in different outlets. Exploiting this dimension of the data is very interesting, as it mimics to some extent the situation of monopolistic competition underlying the macro models. There is, however, an important caveat in this respect. While in theoretical models firms are homogenous except for their timing of price adjustment, there are several other sources of heterogeneity in the micro price data. First of all, even in relatively homogenously defined product categories (e.g. "beer in a shop"), it can well be the case that somewhat different individual products are followed, e.g. of different brands. Moreover, it is possible that the scope

of price adjustment costs differs between firms. Finally, heterogeneity can be related to differences in the exposure to shocks, including idiosyncratic shocks at the firm level. In many cases, this heterogeneity is unobserved in the sense that the content of the databases is essentially limited to a single variable - the price of an individual product -, besides codes that allow for identification of the product concerned. This makes it also impossible to say whether the observed degree of price stickiness is due to the existence of price adjustment costs (nominal rigidities) or to the fact that the frictionless price has not changed at all or only marginally (as a result of so-called real rigidities). It is also impossible to check whether a newly set price is set in a fully optimizing and forward looking way or, alternatively, is the result of a simpler price review which exploits only a limited set of information or applies a rule of thumb.

The time dimension of the CPI databases varies a lot across the different countries. It is well developed - i.e. databases start at the end of the 1980's or the beginning of the 1990's - in Belgium, Portugal, Spain and France. Italy and Austria occupy an intermediate position, as databases start in 1996. For Finland, Germany, the Netherlands and Luxembourg shorter time spans are covered, starting in 1997, 1998 or 1999. Even these shorter time spans compare relatively favorably with the period used in Bils and Klenow (2004), i.e. 1995-1997. Having a longer time span is particularly relevant when one wants to examine whether pricing patterns vary over time and with macroeconomic conditions.

For **producer prices**, national research teams were able to gather comparable statistical information on the *micro data underlying the national producer price indices* for a few countries only (Portugal, Spain and Italy). For others, the National Statistical Institutes either could not release the data or are still in the process of releasing them. These databases are, to a large extent, comparable to those described above for consumer prices. As far as the number of product categories is concerned, also these databases cover either a wide variety or a "minimum common sample", defined in the IPN. Interestingly, databases on the CPI and the PPI contain a subset of product categories which is common to both, so that results can be compared. As far as the intra-market dimension is concerned, it is far less developed for the PPI than for the CPI, as the statistical information is typically obtained with production units, as opposed to outlets in the case of consumer prices. Although the time dimension of the databases is generally less developed than for CPI prices, available time spans still range from 5 to 8 years. The same caveats and drawbacks as those mentioned for consumer prices apply to these PPI databases.

In some cases (Belgium, France and Germany), a second type of data on producer prices is available to the national IPN teams. These data relate to the *monthly business cycle surveys*; the available information at the plant level corresponds to qualitative answers to questions referring to the price changes during the month under review and anticipations of price changes in the coming months. While having only qualitative information on the sign of price changes (up, down or unchanged) can be seen as a major drawback compared to the quantitative databases described above, this type of analysis is promising, though, as it allows to link the pricing behavior of the firm to other (qualitatively measured) variables in the same survey, such as variations in demand, order position, etc. …, as is done for instance in Stahl (2004). There are only few examples of studies where firms' price-setting practices are analyzed on the basis of this type of data (see for instance Buckle and Carlson, 2000).

The countries where at least one of the two data sources on producer prices at the micro level is available represent approximately 85 % of euro area GDP.

Using these micro data on consumer and producer prices, the IPN country teams computed frequencies of price changes, and implied measures of price duration. They also conducted preliminary analyses of how these frequencies are affected by the type of product, type of outlet, the time span elapsed since the last price change and a variety of other variables including proxies of macro-economic or sectoral conditions, indirect tax changes, seasonal factors, etc. The size and the sign of price changes were also analyzed, as well as the issue whether price changes occur in a synchronized or in a staggered fashion. At the current juncture, there are more results available concerning the distribution of the frequency of price changes than concerning the distribution of the size of the changes and more work was done for consumer prices than for producer prices. A minimum set of mainly descriptive statistics was computed on the basis of a harmonized methodology by all the national teams participating in this part of the project, while several teams conducted further research with the aim to exploit the comparative advantages of each national database. Even in the latter case, many convergent patterns were discovered across countries, notwithstanding differences in the methodologies used. This suggests that results are relatively robust.

Ad hoc surveys on pricing behavior of firms in the euro area

The second type of data comes from one-time surveys, conducted specifically for this project, on pricing policies followed by firms. The survey design was inspired on the classic study by Blinder et al. (1998) for the US and subsequent work of Hall et al. (2000) for the UK and Apel et al. (2001) for Sweden. In this sub-section we just highlight the most important features of these surveys, as well as their strengths and weaknesses. For more details, we refer to Fabiani et al. (2004) where a synthesis of the survey analyses is presented, as well as to the individual papers underlying this synthesis.

Surveys were conducted in nine countries (Austria, Belgium, France, Germany, Italy, Luxembourg, the Netherlands, Portugal and Spain), covering 94 % of euro area GDP. A decentralized approach was followed, in the sense that surveys were conducted by each NCB at the national level. This allowed to take advantage of the existing knowledge in these NCBs on survey and sample design and/or to adapt the list of questions, the exact wording and the technical aspects of the survey to national specificities. Yet, a sufficiently high degree of comparability across countries was achieved by means of intensive exchange of views and thorough coordination at the different stages of the project. In particular, a "minimum common sample" of questions was addressed in each survey and analyzed subsequently on a fairly comparable basis.

The number of respondents to the surveys ranged from 333 in Italy to 2,000 in Belgium. Overall, more than 10,000 enterprises in the euro area participated in the survey. All the national surveys cover the manufacturing sector. Trade and other services are relatively well covered in terms of number of countries, respectively 5 and 7. However, as these sectors are not covered in the two largest economies of the euro area (Germany and France), the GDP weights of the countries covering these sectors amount to approximately 40% only. Coverage of the construction sector is very incomplete, both in terms of number

of countries (and corresponding GDP weights) and in terms of the number of individual firms in the samples.

The aim of the surveys was to collect mainly qualitative information which could complement the results obtained on the basis of the databases outlined in the previous sub-section. Relative to these databases, ad hoc surveys have the comparative advantage that they can document, in qualitative terms, the underlying rationale of the observed pricing patterns.

In particular, surveys can provide insight as to the relative importance of nominal versus real rigidities, whereas it was emphasized above that the CPI and PPI databases do not allow to say whether the observed degree of price stickiness is due to the existence of price adjustment costs or to the fact that the frictionless price has not changed at all or only marginally so. Moreover, surveys can address the two stages in the price adjustment process - i.e. the price reviewing stage and the price changing stage - separately and test whether pricing frictions predominantly relate to one of these stages or to both. CPI and PPI databases evidently provide only information as to the final outcome of the price adjustment process, i.e. *after* the price changing stage. Finally, while CPI and PPI databases do not allow checking whether a newly set price is set in a fully optimising way, surveys can address this issue, by asking firms directly which type of information they use when prices are reviewed.

Surveys have as major drawback that the information they provide is mainly qualitative, implying that it is sometimes difficult to grasp the precise importance of a given statement. Moreover they typically relate to current or recent price-setting practices and do not allow us to address the question whether pricing patterns change over time. Finally, they are typically subjective and therefore results could be misleading to a certain extent. It is in this respect however reassuring that the nine national surveys reveal the existence of important common patterns. As a consequence, the results obtained do not appear to depend significantly on the way the survey was conducted, the number of questions addressed, the precise wording and the language of the questions, as well as the ordering of the questions and/or options within a particular question. Results therefore appear to be relatively robust.

Appendix 3: Questions for the meta-analysis

The original list of 10 Questions is given in table 1. A few comments on each of them follow.

Q1 and Q2 are self-explanatory. They provide a general description of the data and start informing about some key features of the typical pattern of price changes and whether those patterns differ over time and across countries. Changes in these patterns could, for example, provide a hint as to whether monetary policy and inflation regimes matter for the frequency or for other patterns of price adjustment, or more generally whether state-dependent pricing is present. Differences across countries, sectors and over time can be observed and tested. One-time surveys on pricing policies presumably can offer little to answer the question whether pricing patters differ over time, but can inform on what the reasons may be for firms and retailers to follow certain price adjustment patterns.

Q3 and Q4 deal directly with the issue of time and state dependency. Q3 can help in distinguishing between different pricing models, insofar as they have different implications for the shape of the hazard function. For instance, in the case of the Calvo model, which is the most commonly used in macro analysis, the hazard rate is constant as the frequency of re-pricing does not depend on the length of the time period in which the price has remained unchanged, whereas other price setting models imply different types of dependence. The second question focuses on state dependent pricing, where price adjustments depend on economic conditions and addresses moreover the issue of what relevant "states" affect pricing. A specific case, of particular importance for monetary policy, is when pricing is affected by inflationary expectations, or more generally by the monetary and inflation regime. The answer to these questions should come mostly from micro data, but also survey evidence can be used. Micro distributions of price changes could show spikes around zero or around aggregate inflation rates or past price changes. One obvious hypothesis of interest is whether the decline in inflation and inflationary expectations that has taken place in euro area countries over the last 15-20 years has reduced the relevance of past inflation rates on pricing behavior.

Q5 provides evidence on whether price or inflation rigidity differs across sectors. To the extent that market structure differs, such evidence may give an indication that market structures are indeed important. Micro data can provide evidence of sector-specific pricing behavior that can be matched with macro and sectoral time series. Q6 addresses the issue of asymmetries between positive and negative price changes. Asymmetries of this type can, at the macro level, generate different trade-offs between restrictive and expansionary monetary policies and would have implications for the optimal rate of steady state inflation. Again, both micro and survey evidence could be useful.

Q7 to Q10 go back to basic principles. The first aims at establishing whether at least part of the economy can be approximated by the paradigm of frictionless pricing. Though most of the literature tends to reject pure price flexibility as a good empirical assumption (see, recently, Golosov and Lucas 2003), there may be nonetheless economic sectors where such assumption is accurate. This could have important

implications for the conduct of monetary policy and for the relevant definition of the price index which monetary authorities want to stabilize. Questions Q8-Q10 refer to three specific models that have been proposed to explain price rigidities. The first (Q8) is the classic menu cost model (which can be fixed, as in Akerlof, Dickens and Perry, 2000; variable, as in Rotemberg, 1982 and Kozicki and Tinsley, 2002; or random, as in Dotsey, King and Wolman, 1999). Since the existence of "pure" menu costs is difficult to identify from simple price observations, survey information can be of significant help here. Q9 and Q10 should allow discriminate theories based on sticky information (Q9), of the type of Mankiw and Reis (2002), or "customer anger" (Q10), as in Rotemberg (2002). Again, the survey information seems very promising here, but the data evidence used to answer Q3 to Q6 should also provide hints.

TABLE 1: Ten questions for the meta-analysis

Q1: What is the typical pattern of price changes (in terms of frequency, size and persistence of price changes) at the individual and sectoral level?

Q2: How stable are these patterns? Do they differ over time and across countries and how?

Q3: Do pricing patterns (frequency, size and persistence of price changes) depend on the length of the time period in which the price has remained constant and how?

Q4: Does the pattern of price changes (frequency, size and persistence) vary with macroeconomic conditions, such as the level of aggregate inflation or the state of the business cycle? To what extent do these patterns reflect the incidence of firm-specific or sector-specific factors, such as shifts in cost or demand?

Q5: Do pricing patterns vary substantially across countries and/or sectors (due to factors such as economic/financial structure, degree of competition, etc.)? In particular, do consumer prices and producer prices exhibit different patterns of adjustment?

Q6: Do pricing patterns (frequency, size and persistence of price changes) vary with the sign of such changes (increase, decrease)?

Q7: Are there indications that prices (or a significant fraction of them) are fully flexible?

Q8: To what extent do price rigidities or adjustment costs seem inherent to the act of changing prices per se?

Q9: To what extent do price rigidities seem to relate to the cost of calculating the correct price and deciding upon it? How important are automatic indexation schemes?

Q10: To what extent do price rigidities seem to relate to the perceived reaction of customers or competing firms? How important is psychological pricing?

Appendix 4: Papers of the Inflation Persistence Network[36]

F. Altissimo, B. Mojon and P. Zaffaroni (2004). "Fast micro and slow macro: can aggregation explain the persistence of inflation?"

L. Álvarez, P. Burriel and I. Hernando (2004a). "Do decreasing hazard functions of price durations make any sense?"

L. Álvarez, P. Burriel, I. Hernando (2004a). "Price setting behaviour in Spain: evidence from micro PPI data"

L. Álvarez, I. Hernando (2004). "Price setting behaviour in Spain. Stylised facts using consumer price micro data"

L. Aucremanne and E. Dhyne (2004). "How frequently do prices change? Evidence based on the micro data underlying the Belgian CPI"

L. Aucremanne and E. Dhyne (2004). "Time-dependent versus state-dependent pricing: a panel data approach to the determinants of Belgian consumer price changes"

L. Aucremanne and M. Druant (2004). "Price setting behaviour in Belgium: what can be learned from an ad hoc survey?"

L. Baudry, H. Le Bihan, P. Sevestre and S. Tarrieu (2004). "Price rigidity. Evidence from the French CPI micro-data"

J. Baumgartner, E. Glatzer, F. Rumler, A. Stiglbauer (2004). "How frequently do consumer prices change in Austria? Evidence from micro CPI data"

R.-P. Berben, R. Mestre, T. Mitrakos, J. Morgan and N. Zonzilos (2004). "Inflation persistence in structural macroeconomic models"

L. Bilke (2004). "Break in the mean and persistence of inflation: a sectoral analysis of French CPI"

G. Coenen and A. Levin (2004). "Identifying the influences of nominal and real rigidities in aggregate price setting behavior"

S. Corvoisier and B. Mojon (2004). "Breaks in the mean of inflation: how they happen and what to do with them"

G. de Walque, F. Smets and R. Wouters (2004). "Price setting in general equilibrium: alternative specifications"

E. Dhyne, L. Álvarez, H. Le Bihan, G. Veronese, D. Dias, J. Hoffmann, N. Jonker, P. Lünnemann, F. Rumler and J. Vilmunen (2004): "Price setting in the euro area: Some stylised facts from Individual Consumer Price Data"

D. Dias and C. Robalo Marques (2004). "Using mean reversion as a measure of persistence"

D. Dias, C. Robalo Marques, J. Santos Silva (2004). "Time or state dependent price setting rules? Evidence from Portuguese micro data"

M. Dias, D. Dias and P. Neves (2004). "Stylised features of price setting behaviour in Portugal: 1992-2001"

M. Dossche and G. Everaert (2004). "Measuring inflation persistence: a structural time series approach"

S. Fabiani, M. Druant, I. Hernando, C. Kwapil, B. Landau, C. Loupias, F. Martins, T. Mathä, R. Sabbatini, H. Stahl and A. Stockman (2004): "The Pricing Behaviour of Firms in the Euro Area: New Survey Evidence"

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Table 3.1: Naïve estimates of inflation persistence

Source	ρ	Sample	Comment
Euro Area			
Altissimo, Mojon and Zaffaroni (2004)	0.93	1985:I-2004:I	CPI (test not available)
Batini (2002)	**0.74**	1984:III-2002:II	HICP
Gadzinski and Orlandi (2004)	[1.02;1.04]	1970:II-2003:III	GDP deflator, CPI, HICP and core inflation
O'Reilly and Whelan (2004)	0.96	1970:I-2002:IV	GDP deflator and HICP
Robalo Marques (2004)	0.85	1984:I-2002:IV	CPI
United States			
Gadzinski and Orlandi (2004)	[0.92;1.03]	1970:II-2003:III	GDP deflator, CPI, PCE and core inflation
Levin and Piger (2004)	[**0.65**;1.02]	1984:I-2003:IV	Bayesian estimates for GDP deflator, CPI and PCE inflation, and core inflation
Robalo Marques (2004)	**0.66, 0.81**	1982:I-2002:IV	CPI, GDP deflator

Note: Parameters in bold are able to reject the unit root hypothesis.

Table 3.2: Estimates of inflation persistence with time-variations in the mean of inflation or over short samples

Source	ρ	Sample	Comment
Euro Area			
Dossche and Everaert (2004)	**0.4**	1971:II-2003:IV	GDP deflator. Allowing for a time-varying inflation target
Gadzinski and Orlandi (2004)	[**0.60**;0.90]	1984:I-2003:III	GDP deflator, CPI, HICP and core inflation
Lünnemann and Mathä (2004a)	**0.40**	1995:1-2000:12	HICP inflation (drops to -0.53 after the inclusion of sales in 2001:I)
Robalo Marques (2004)	**0.34**	1986:II-2002:IV	HP-filtered CPI (persistence drops significantly when allowing for more time variation in the mean, e.g. 13-quarter centered MA)
United States			
Dossche and Everaert (2004)	**0.58**	1971:II-2003:IV	GDP deflator. Allowing for a time-varying inflation target.
Gadzinski and Orlandi (2004)	[**0.52**;0.80]		GDP deflator, CPI, PCE and core inflation
Levin and Piger (2004)	[**0.37**;0.89]	1984-2003	GDP deflator, CPI and PCE inflation and core inflation
Robalo Marques (2004)	**0.27, 0.28**	1983:I-2002:IV	GDP deflator, CPI inflation

Note: Parameters in bold are able to reject the unit root hypothesis.

Table 3.3: Estimates of inflation persistence for the euro area countries

	BE	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	FI
Bilke (2004)					**0.76**							
Cecchetti and Debelle (2004)	**-0.11**	**-0.34**		**0.23**	**0.25**		**0.45**	**-0.62**	**-0.02**	**0.33**	**0.45**	**0.30**
Gadzinski and Orlandi (2004)	**0.01**	**0.13**	**0.63**	0.91	0.60	**0.14**	0.63	**0.32**	**0.34**	0.73	0.58	0.84
Hondroyiannis and Lazaretou (2004)				0.78								
Levin and Piger (2004)		**0.78**			**0.74**		**0.73**		**0.55**			
Lünnemann and Mathä (2004a)	**-0.33**	**-0.16**	**0.51**	**-0.50**	0.49	**0.38**	**0.23**	**-0.17**	**0.28**	0.43	**0.31**	**0.07**

Notes: All numbers refer to HICP inflation, unless indicated otherwise. Parameters in bold are able to reject the unit root hypothesis.

Bilke: sample period: 1973:1-2004:1. CPI inflation. Conditional on a break in the mean of inflation in 1985:5.

Cecchetti and Debelle (2004): Data starts in 1990. Conditional one one break in the mean of inflation. Persistence is lower if more breaks are allowed for, and higher for models without a break. No test for unit root available.

Gadzinski and Orlandi: 1984:I-2003:III. Conditional on breaks in the mean of inflation. Results with the half-life indicator reduce persistence considerably in FR & IT, and increase it in NL.

Hondroyiannis and Lazaretou: 1991:I-2003:II. CPI inflation. The persistence parameter appears somewhat lower towards the end of this sample and in a random coefficient model.

Levin and Piger: 1984-2003. CPI inflation. Bayesian estimates. Results with classical estimates rank the Netherlands as the second most persistent country. No country changes position relative to the US.

Lünnemann and Mathä: 1995:1-2003:12. Results are affected by the inclusion of sales, and change considerably when using the mean reversion coefficient γ.

Table 3.4: Estimates of sectoral inflation persistence

		Weight in %	BE	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	FI	EA
cp01	Food & non-alcoholic beverages	15.81	**-0.14**	**0.41**	**-0.19**	**0.49**	**0.14**	**0.36**	**0.65**	**0.70**	**0.18**	**0.18**	**0.36**	**0.32**	**0.46**
cp02	Alcoholic beverages, tobacco & narcotics	3.83	**0.31**	**-0.12**	**-0.54**	**-0.04**	1.07	0.38	**-0.04**	**0.10**	**-0.03**	**0.30**	**0.30**	0.08	**0.16**
cp03	Clothing & footwear	7.71	**0.94**	0.38	0.60	**-0.96**	**-0.89**	**-0.03**	**-0.90**	0.00	**-0.02**	-0.13	-0.01	**-1.86**	**-0.99**
cp04	Housing, water, electricity, gas & other fuels	15.19	**0.03**	**0.15**	**-0.65**	**-0.13**	**0.00**	0.37	**0.36**	**0.13**	**-0.11**	0.60	**0.25**	**-0.07**	**0.20**
cp05	Furnishings & household equipments	8.03	**0.49**	0.47	**0.48**	0.44	**0.37**	0.75	**0.59**	**-0.68**	0.61	**0.24**	**0.23**	**0.20**	0.65
cp06	Health	3.94	**0.15**	**0.54**	**0.38**	**0.29**	**0.46**	**0.38**	**0.34**	**0.08**	**0.27**	**0.20**	**0.32**	**-0.23**	**0.49**
cp07	Transportation	15.08	**0.13**	**-0.06**	**0.00**	**-0.01**	**0.02**	**0.08**	**0.25**	**-0.03**	**0.08**	**0.01**	**-0.19**	**-0.01**	**0.04**
cp08	Communications	2.73	**0.33**	**0.43**	0.56	**0.46**	**-0.03**	**0.29**	**0.36**	**0.18**	**0.28**	**0.25**	**0.48**	**0.05**	**0.43**
cp09	Recreation & culture	9.84	**-0.11**	**-0.58**	**0.19**	**-0.40**	**0.10**	**0.50**	**0.48**	**0.38**	**0.14**	**-0.53**	**0.04**	**0.68**	**0.19**
cp10	Education	0.96		**0.21**	0.72	**0.31**	0.89	**0.21**	**-0.11**		**0.02**	**0.00**	**0.10**	**0.21**	**0.59**
cp11	Restaurants & hotels	9.18	**-0.46**	**-0.36**	**0.28**	**0.13**	**0.38**	**0.22**	**0.22**	**0.71**	**0.27**	**-0.32**	**-0.06**	**-0.30**	**0.61**
cp12	Miscellaneous goods & services	7.70	**0.18**	**0.37**	**0.54**	**0.31**	0.84	**0.20**	**0.28**	**0.18**	0.75	**0.57**	**0.41**	0.58	0.77

Source: Lünnemann and Mathä (2004a). Parameters in bold are able to reject the unit root hypothesis.

Table 3.5: Estimates of sectoral inflation persistence in France, Germany, Italy and the euro area

	France		Germany	Italy	Euro Area
	AMZ	Bilke	AMZ	AMZ	AMZ
Non-processed food	0.63	0.15	0.25	0.45	0.55
Energy	0.44	0.28	0.47	0.41	0.44
Processed food	0.34	0.34	0.60	0.69	0.61
Services	0.51	0.44	0.60	0.49	0.53
Industrial goods	0.68	0.72	0.65	0.70	0.68

Source: AMZ = Altissimo et al. (2004); Bilke (2004). AMZ report means of persistence of finer subindices;
Bilke reports direct measures of persistence at the respective sectoral level.

Table 4.1: Frequency of price change by product type[1]

	Unprocessed food	Processed food	Energy (oil products)	Non energy industrial goods	Services	Total [2] country weights	Total [3] Euro area weights
Austria (AT)	37.5	15.5	72.3	8.4	7.1	15.4	17.1
Belgium (BE)	31.5	19.1	81.6	5.9	3.0	17.6	15.6
Germany (DE)	25.2	8.9	91.4	5.4	4.3	13.5	15.0
Spain (ES)[4]	50.9	17.7	n.a.	6.1	4.6	13.3	11.5
Finland (FI)	52.7	12.8	89.3	18.1	11.6	20.3	-
France (FR)	24.7	20.3	76.9	18.0	7.4	20.9	20.4
Italy (IT)	19.3	9.4	61.6	5.8	4.6	10.0	12.0
Luxembourg (LU)[5]	54.6	10.5	73.9	14.5	4.8	23.0	19.2
Netherlands (NL)	30.8	17.3	72.6	14.2	7.9	16.2	19.0
Portugal (PT)	55.3	24.5	15.9	14.3	13.6	21.1	18.7
Euro area	**28.3**	**13.7**	**78.0**	**9.2**	**5.6**	**15.1**	**15.8**
US	47.7	27.1	74.1	22.4	15.0	24.8	-

Sources: Dhyne et al. (2004)

(1) Figures presented in this table are computed on the basis of the 50 product sample, with the only exception of Finland for which figures based on the entire CPI are presented. Figures based on a larger coverage of the CPI for each individual country, when available, are presented in their respective national paper mentioned in Table 1

(2) The total is calculated using country specific weights for each item.

(3) The total is calculated using common euro area weights for each sub-index. No figures are provided for Finland because of lack of comparability of the sample of products used in this country.

(4) In the Spanish database no energy products are included, which biases downwards the aggregate frequency

(5) Figures for Luxembourg are still preliminary.

Table 5.1: Estimates of inflation persistence in structural models

	BE	DE	GR	ES	FR	IE	IT	LU	NL	AT	PT	FI	EA	US
Angeloni and Ehrmann (2004)													0.46	
Benigno and Lopez-Salido (2002)		0.09;0.04		0.50	0.30;0.31		0.52;0.55		0.37;0.35					
Galí, Gertler and Lopez-Salido (2001)													0.04;0.27	0.35;0.36
Jondeau and Le Bihan (2004)		0.15;0.57			0.35;0.74		0.52;0.41						0.26;0.26	0.26;0.53
Paloviita (2004)													0.44;0.64	
Rumler (2004)	0.46	0.43	0.42	0.45	0.40		0.67		0.30	0.54		0.45	0.49;0.72	
Sondergaard (2004)				0.10	0.28		0.37							

Notes: Angeloni and Ehrmann: 1998:I-2003:II. HICP. Obtained in a country-panel estimate which imposes homogeneity of this parameter across countries.

Benigno and Lopez-Salido: 1970:I-1997:I. GDP deflator.

Galí, Gertler and Lopez-Salido: 1970:I-1998:II. Estimates suggest that forward-looking behaviour is dominant.

Jondeau and Le Bihan: 1970:I-1999:IV. GDP deflator. First coefficients refer to a model with real unit labout costs, the second to a model with the output gap.

Paloviita: 1977-2003. Numbers in the table show minimum and maximum obtained in various regressions. Forward-looking behaviour more important in recent years and for low-inflation countries of the euro area.

Rumler: 1970:I-1998:IV. GDP deflator.

Sondergaard: 1979:II-2001:III. Based on an implicit price deflator.