Money, Prices and the Transition to EMU [*]

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1. Introduction

Under the responsibility of the European Monetary Institute (EMI), numerous complex issues have been negotiated in order to enable the European System of Central Banks (ESCB) to run the single monetary policy effectively and efficiently from the very first day of the third stage of the Economic and Monetary Union (Giovannini 1993, Monticelli and Viñals 1993). According to the agreed time schedule, the third stage will start on the 1st of January 1999. At that date, the currencies of the participating countries will be irrevocably fixed as a prelude to the introduction of the euro by 2002 at the latest. The primary objective of the ESCB had already been settled in its statute which states that the central goal of the ESCB is the achievement and maintenance of price stability.

The strategic and tactical question how to formulate and execute the future common monetary policy is left open in the statute of the ESCB, though. On the basis of current central bank practices and taking into account theoretical considerations, the EMI has recently in-

vestigated the possible monetary strategies for the ESCB (see European Monetary Institute 1997). In principle, the ESCB can choose between real or nominal interest rate objectives (Barro 1989), nominal income targets (Garganas 1993), exchange rate targets, money (Issing 1992) and/or other indicators as information variables (Friedman 1994).

This article contributes to these actual discussions by investigating whether monetary aggregates can play a useful role in the monetary policy decision process in the second or the third stage of EMU. To this end, we use an extended version of the standard P*-model developed by Hallman, Porter and Small (henceforth HPS, 1989 and 1991). The initial P*-concept has drawn renewed attention to the quantity theory of money and triggered a huge body of empirical research.[1] Indeed, in the 1980s doubts have arisen about the existence of stable relationships between money, prices and output, which prompted several countries to abandon or downgrade the practice of monetary targeting (see Goodhart 1989). In the original P*-framework, the equilibrium price level (P^*) is assumed to change proportionally with the money stock, provided that real output and the velocity of money are at their long-run equilibrium levels. Deviations between the actual and equilibrium price level – the price gap – are supposed to be eliminated through adjustment of the actual price level. Then, the price gap conveys information with respect to the short-run dynamics of inflation.

However, the standard P*-model is based on a closed-economy perspective, thereby neglecting the potential impact of increased international economic and financial integration on the domestic relationship between money and prices. Especially for small countries participating in a fixed exchange rate system like the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS), this assumption appears unrealistic. In the EMS, non-anchor countries have increasingly oriented monetary policy towards the objective of exchange rate stability. This policy choice has facilitated cross-country

convergence in prices, but has also resulted in a loss of monetary autonomy. Consequently, monetary aggregates have become primarily demand-determined and virtually uncontrollable for the monetary authorities in question. For Germany as the anchor country of the ERM, it is also likely that its inflation rate is increasingly affected by monetary conditions abroad.[2] First, almost complete inflation convergence within a so-called core-group of EMS countries may have eroded Germany's unique position as the single guardian of price stability to some extent. Second, although monetary policy is still the responsibility of national monetary authorities in the current second stage of EMU, increasing importance is attached to policy coordination. Consequently, German inflation may have become more sensitive to ERM-wide monetary conditions over the years. If true, the Bundesbank should consider to place more weight on monetary developments in other ERM countries in its policy decisions. At the same time, this might fit into an adequate preparation for the third stage of EMU, when money growth as well as inflation need to be analyzed on a European-wide scale.

To shed more light on this issue, we examine to what extent inflation behaviour in five founding members of the ERM – Belgium, France, Germany, Italy and the Netherlands – can be ascribed to either domestic or European monetary conditions, respectively, over the period 1973.I-1994.IV. For each country, we first calculate aggregate money, real output and prices in the other four countries as a group. Subsequently, we compute a domestic and an external 'European' price gap. The latter reflects the average monetary conditions in the other four countries. We include both gaps in domestic inflation regressions to analyze their respective importance for the path of inflation. Different subperiod results are reported to investigate potential changes in cross-country relations over time.

This article is structured as follows. In Section 2, we briefly discuss the conventional P*-approach and the open-economy extension to include cross-country monetary spill-over effects. Section 3 outlines the Multi State Kalman Filter method which is used to compute

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[1] HPS (1989 and 1991) apply the P*-approach to the United States. Extensions to other countries are reported in Bank of Japan (1990), Deutsche Bundesbank (1992), Hoeller and Poret (1991), Kole and Leahy (1991) and Reimers and Tödter (1994) among others. Generally speaking, the results of these studies are encouraging. Moreover, the P*-concept has been the theoretical foundation of monetary policy in Germany for several years now, see Issing (1992).

[2] Examples of studies devoted to the German leadership hypothesis are De Grauwe (1989), Artis and Nachane (1990), Herz and Röger (1992) and Koedijk and Kool (1992).

the equilibrium variables. In Section 4 we present and discuss our empirical results, while Section 5 summarizes the main findings.

2. Theoretical underpinnings

2.1. *The P*- methodology*

The P*-approach – developed by HPS (1989 and 1991) – combines the quantity theory of money with the notion of lagged price adjustment. Hence, it is assumed that causality within the system runs from money to prices.[3] The basic idea is that a gap between the actual and equilibrium price level causes actual prices and inflation to adjust in the direction of the equilibrium price P^*, thereby eliminating the gap over time. The starting point of the P*-model is Fisher's well-known equation of exchange identity:[4]

$$P = M(V/Y) \qquad (1)$$

where P denotes the price level, M the domestic money stock, Y real output and V the income velocity of money. No testable hypothesis can be derived from equation (1), since it simply pins down actual velocity for given values of P, M and Y. HPS hypothesize the following long-run equilibrium version of equation (1):

$$P^* = M(V^*/Y^*) \qquad (2)$$

$$GAP^d = (p - p^*) = (v - v^*) - (y - y)^* \qquad (3)$$

where P^* is the equilibrium price level to which actual prices converge in the long run, and V^* and Y^* are equilibrium levels of the income velocity of money and real output, respectively. Assuming that V^* and Y^* can be determined independently, and that both are independent of the money stock, equation (2) shows that the equilibrium price level moves proportionally with the stock of money. To derive

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[3] Hall and Milne (1994) challenge this assumption. They stress that equation (1) holds true by identity and can be consistent with an entirely different casual ordering: inflation could originate from a different process and money could adjust subsequently to accommodate a higher price level.

[4] Humphrey (1989) gives a review of the precursors of this approach and shows that a variant of the approach can be traced back to David Hume.

an expression for the gap between the actual and equilibrium price level, equation (1) is divided by (2), yielding the domestic price gap (GAP^d). Expressed in natural logarithms, this gap is defined as:[5]

$$GAP^d = (p - p^*) = (v - v^*) - (y - y^*)$$

The price gap $(p - p^*)$ consists of the difference between the velocity gap $(v - v^*)$ and the output gap $(y - y^*)$ and is expected to give an indication of the direction of future price movements. Analogous to other P*-studies, we model the adjustment process as a constrained 'error-correction model':

$$\Delta\pi_t = \alpha_0 + \alpha_1 (p - p^*)_{t-1} + \sum_{j=1}^{n} \beta_j \Delta p_{t-j} + \varepsilon_t \qquad (4)$$

where the inflation lags are introduced to account for short-run dynamics and ε_t is the random error term. The P*-model hypothesizes that the price gap is zero in equilibrium. Under the null hypothesis, α_1 is negative. This implies that inflationary pressures can originate either from overutilization of existing capacities $(y > y^*)$ or from higher-than-usual money holdings $(v < v^*)$. In econometric terms, the above error-correction framework requires the actual and equilibrium price level to be co-integrated. Nonstationarity of inflation (Δp) may lead to econometric problems in estimating equation (4). To overcome these potential problems, equation (4) can be rewritten without loss of generality as:

$$\Delta\pi_t = \alpha_0 + \alpha_1 (p - p^*)_{t-1} + \sum_{j=1}^{n} \delta_j \Delta\alpha_0 \pi_{t-j} + \delta_0 \pi_{t-1} + \varepsilon_t \qquad (5)$$

where π denotes inflation. If inflation is stationary, δ_0 is (significantly) negative, otherwise, δ_0 in equation (5) has a theoretical value of zero and may be omitted. In Subsection 2.2, we extend equation (5) to allow for possible cross-country spill-over effects.

2.2. *An open economy P*-framework*

According to the monetary approach to the balance of payments, countries with fixed exchange rates should have equal inflation rates and price levels, where the overall price level is determined by

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[5] Lower-case letters in general stand for natural logarithms, i.e. $p = \ln(P)$. The superscript d indicates that the gap is domestically determined.

the aggregate money growth across countries.[6] In a more general version, permanent real exchange rate shifts may be taken into account as well. Adjustment mechanisms to eliminate price and inflation differentials across countries may work both through goods and asset markets.[7] In the P*-approach, these channels are all subsumed in the European price gap.

To derive a European aggregate price gap, we assume that European equivalents of equations (1) and (2) can be formulated.[8] Then, the following equations result:

$$P_{eur} = M_{eur} (V_{eur}/Y_{eur}) \tag{6}$$

and

$$P^*_{eur} = M_{eur} (V^*_{eur}/Y^*_{eur}) \tag{7}$$

where M_{eur}, P_{eur}, Y_{eur} and V_{eur} are European money, price, output and velocity aggregates, respectively. When the equilibrium European price level as determined by equation (7) is known, the equilibrium price level in each of the participating countries follows from the exchange rate constraint:

$$P^{n*} = EP^*_{eur}/ER^* \tag{8}$$

where P^{n*} is the newly defined equilibrium price level, E is the nominal exchange rate, equal to the number of domestic currency units per unit of foreign currency in which the European aggregates are expressed, and ER^* is the corresponding equilibrium real exchange rate.

Analogous to the domestic price gap in equation (3) that is based on the domestic equilibrium price level in equation (2), a 'European' price gap corresponding to equation (8) can be derived as:

$$GAP^f = [p - (p^*_{eur} + e - er^*)]. \tag{9}$$

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[6] See Kool and Tatom (1994). McKinnon (1982) makes a similar argument for countries under flexible exchange rates with a high degree of currency substitution.

[7] An often proposed transmission channel is currency substitution. The empirical evidence on its importance is mixed, though. Lane and Poloz (1992) conclude that currency substitution plays a significant role in the demand for money of ERM-countries. See Giovannini and Turtelboom (1992) for a review of the literature.

[8] This presupposes the existence of a stable aggregated European money demand. Bekx and Tullio (1989), Kremers and Lane (1990), Artis, Blanden-Hovell and Zhang (1993), Monticelli and Strauss-Kahn (1991), and Fase and Winder (1993) provide empirical support for this assumption. Arnold (1994) asserts that these findings are a mere statistical artifact.

According to equation (9), downward pressure on domestic inflation arises whenever the actual domestic price level exceeds the European equilibrium price level (corrected for permanent real exchange rate changes). The amount of pressure this gap actually exerts on current domestic inflation and on the speed of adjustment toward equilibrium depends on the extent of arbitrage in goods and capital markets, and the degree to which the economies are integrated.

In a sense, the domestic price gap from equation (3) and the European price gap from equation (9) compete for influence on actual domestic inflation dynamics. One extreme would be that the European price completely dominates the domestic one regarding the impact on national inflation rates. Obviously, this is most likely to occur in the case of small open economies with perfect capital mobility, where domestic monetary policy is almost completely ineffective. In the other extreme case, the domestic gap would be the major driving force of inflation. Then, the country is totally independent of ERM-wide monetary developments. Germany appears the most likely candidate for this scenario. Of course, intermediate positions are possible as well, when both gaps exercise a significant impact on inflation. Moreover, we hypothesize that the increased economic and financial integration witnessed in the past decade in Europe has led to a shift in the relative importance of domestic and European monetary conditions for detecting future price trends in individual countries in favour of the latter variable. These hypotheses are tested in Subsection 4.2 using a generalization of equation (5), where both gaps are included in the inflation regression:

$$\Delta\pi_t = \alpha_0 + \alpha_1 GAP^d_{t-1} + \alpha_2 GAP^f_{t-1} + \sum_{j=1}^{n-1} \delta_j \Delta\pi_{t-j} + \delta_0 \pi_{t-1} \tag{10}$$

In the actual empirical analysis, European money, output and prices are not computed by aggregating across all five countries (Belgium, France, Germany, Italy and the Netherlands). Instead, country-specific European aggregates are constructed that exclude data for the country under consideration. For the Netherlands, for example, European aggregates comprise data for Belgium, France, Italy and Germany only. This way, potential multicollinearity problems due to the possible existence of correlation between GAP^d and GAP^f, when the latter gap measure would also contain domestic data of the country in question, are avoided. This is especially relevant for Germany –

and to a lesser extent France and Italy –, which would have a relatively large weight in a European aggregate for all countries together.

In the aggregation procedure, we follow Bekx and Tullio (1989) and Artis, Blanden-Hovell and Zhang (1993) and take base-period exchange rates to convert domestic variables into a common currency. This is similar in spirit to Bayoumi and Kenen (1993) who sum the weighted rates of change of economic variables across countries.[9]

3. The Multi State Kalman Filter method

Previous P*-studies have used various methods to determine the equilibrium time paths of the velocity of money (V^*) and potential real output (Y^*), respectively.[10] In this study, we employ the Multi State Kalman Filter (MSKF) method to generate the equilibrium time paths of both domestic and aggregate European velocity and real output and real exchange rates.[11]

We implement a univariate specification of the MSKF method to extract a permanent trend from a time-series of observations z_t. This stochastic trend is used as proxy for the long-run equilibrium time-path of the series under consideration. The method combines recursive estimation techniques and Bayesian learning processes. Recursive estimation mimics on-line decision making and thus corresponds closely to decision-dependent economic models. Bayesian learning allows for the flexibility to cope with the occurrence of structural changes.

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[9] Alternative aggregation procedures use either actual nominal exchange rates (see Monticelli and Strauss-Kahn 1991), or purchasing power exchange rates (see Kremers and Lane 1990). Unreported results show that European aggregates constructed with actual and PPP exchange rate are similar, due to the limited long-run real exchange rate movements between the countries considered. European aggregates constructed with 1985 benchmark exchange rate differ somewhat more. Unreported results show that a gap analysis based on current exchange rates yields qualitatively similar results to the one with benchmark exchange rates in this article.

[10] In Bank of Japan (1990), for instance, a simple linear time trend analysis is used, while HPS (1989 and 1991) and Ebrill and Fries (1991) apply structural models, and Hoeller and Poret (1991) and Kool and Tatom (1994) use the Hodrick-Prescott filter.

[11] For an in-depth discussion of the features of the Kalman Filter method, see Harvey (1991) and Kool (1989).

In the current application, three distinct types of shocks are assumed to hit the series z_t: transitory shocks, permanent shocks to the level, and permanent shocks to the growth rate. Each period, a new observation comes available, which one may use to revise one's estimates of the long-run trend growth rate and trend level of the series. To what extent the current shock is interpreted as transitory versus permanent depends on the relative frequency with which these shocks have occurred in the recent past. When a change in relative frequencies is perceived to have taken place, the Bayesian learning allows for updating and adjusting the extent to which new information is incorporated in the current trend estimates. Consequently, the speed and magnitude with which the estimated trend level and growth rate change can vary across time. The MSKF method is implemented in the following way:

$$z_t = \begin{pmatrix} 1 \\ 0 \end{pmatrix}' (\beta_{1t}, \beta_{2t}) + v_t, \tag{11}$$

where v_t is a serially independent white noise term with variance h_t/λ_t, β_{1t} is the permanent level of z_t, and β_{2t} the trend growth rate. The dynamics of β_t are described by a discounted relation between the posterior distribution for $(\beta_t|I_t)$ and the prior distribution for $(\beta_{t+1}|I_t)$. Let the posterior distribution at time t be

$$(\beta_t|I_t) \sim N (b_t, R_t|\lambda_t) \tag{12}$$

The prior distribution for the next period is:

$$(\beta_{t+1}|I_t) \sim N (Gb_t, R_{t+1}|\lambda_{t+1}) \tag{13}$$

with

$$(\beta_{t+1}|I_t) = A^{-1/2} GR_t G' A^{-1/2} \tag{14}$$

and

$$G = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}, \tag{15}$$

where G is the transition matrix linking β_{t+1} to β_t, and b_t is the estimate of β_t conditional on all information up to and including period t. This way, β_{2t} is assumed to follow a pure random walk, while β_{1t} is a random walk with stochastic drift β_{2t}. A is a diagonal discount matrix with elements smaller than or equal to one and larger than zero. The smaller a diagonal element A_{ii} of A, the larger the variability of

the corresponding β_t. R_t is the conditional covariance matrix of β_t. New sample information in period $t+1$ is combined with the prior distribution for period $t+1$ to arrive at a new posterior distribution conditional on all information up till and including period $t+1$.

Bayesian learning is incorporated through the use of six parallel prespecified forecasting models which all have the same functional form of equations (11)-(15). The models differ with respect to the diagonal elements A_{ii} of discount matrix A and the magnitude of the variance $h^{(i)}$. The precision level λ_t is equal across models and is recursively estimated from the data.

The overall forecast, $\hat{z}_{t+1}$, is a weighted average of the forecasts of the individual models. The weights depend on the relative performance of each of the individual models to forecast the dependent variable, and are updated over time by means of a Bayesian learning mechanism. This results in a flexible forecasting method.

Of the six parallel models, the first (benchmark) model assumes that the dependent variable z_t is mainly subject to transitory shocks, that is, the variance of v_t is large compared to the variance of the state variable β_t. In this model, forecasts errors are thus assumed to be predominantly transitory with little impact on the level and trend estimates. Unlike the first model, the second one supposes that prediction-errors generally arise due to permanent changes in the level of the dependent variable (β_{1t}). The variance of the v_t is now relatively small. The third model accounts for the occurrence of permanent shifts in the growth rate (β_{2t}). The remaining three models are outlier models which have characteristics corresponding to the first three models. The outlier models only take part in the estimation procedure when a tracking signal indicates a significant deterioration of the forecast performance of the three 'normal-sized-error' models. In the empirical analysis, the forecast variance of the outlier models is arbitrarily set at a factor 16 times as large as the forecast variance of the normal models. The discount factor for the benchmark model is set at 0.95 while the discount factor for the variance level is set at 0.975.[12]

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[12] A sensitivity analysis for different initializations of the MSKF shows that the results are robust.

4. Empirical results

4.1. *Data description*

We use seasonally adjusted quarterly data over the period 1973-1994. Harmonized M3 data that are roughly comparable across countries are obtained from the respective national central banks. All other data have been collected from the databank of the Bank for International Settlements. Income is measured as either GDP or GNP, depending on availability. Real income is in 1985 prices. For Belgium, quarterly real and nominal income series are obtained through interpolation using industrial production as an instrument. Prices are implicit GDP (or GNP) deflators.

TABLE 1

SUMMARY STATISTICS
(1973.I-1994.IV, percentages per quarter)

	Inflation				Output growth				Money growth			
	M	Std	Sk	K	M	Std	Sk	K	M	Std	Sk	K
Belgium	1.3	1.4	0.4	3.8	0.5	1.3	-0.1	3.9	2.1	1.2	0.1	2.7
France	1.7	1.1	0.3	2.0	0.6	0.6	-0.7	3.5	2.4	1.3	-0.5	4.8
Germany	0.9	0.6	0.7	4.2	0.6	1.1	0.6	2.9	1.8	0.8	0.5	2.9
Italy	2.8	1.5	0.3	2.0	0.7	0.9	-0.0	0.6	3.1	1.6	0.5	2.4
The Netherlands	1.0	1.1	0.2	3.3	0.5	1.7	0.3	8.7	2.0	1.0	0.1	2.9

Note: M = mean; Std = standard deviation; Sk = skewness; K = kurtosis.

Table 1 documents summary statistics for inflation, output and money growth for Belgium, France, Germany, Italy and the Netherlands. Inflation and monetary expansion have been highest in Italy over the total period and lowest in Germany on average. Of course, subperiods have somewhat different characteristics. In the mid-1970s and early 1980s, inflation rates were relatively high and showed considerable cross-country divergence. Since the mid-1980s, national inflation rates have converged to relatively low levels. Nowadays, most countries are close to what is generally considered a reasonable degree of price stability.

Tables 2 and 3 report results of standard Augmented Dickey-Fuller (ADF) tests for both the log levels and growth rates of prices, output, broad money and velocity for each country. The Tables contain the t-statistic on the coefficient of the lagged level of the endogenous variable and the preferred specification in parentheses. In general, nonstationarity of the logarithmic levels cannot be rejected. Exceptions are the log of M3 for Italy and the Italian and Dutch price level.[13] Consequently, computation of the equilibrium values of velocity and real output requires a method capable of handling stochastic trends.

TABLE 2

ADF UNIT ROOT RESULTS: LOG LEVELS
(1973.I-1994.IV)

Country	P	Y	M3	VM3
Belgium	−3.3 (t, 7)	−2.8 (t, 0)	−2.6 (t, 1)	−2.5 (t, 1)
France	0.6 (t, 1)	−2.8 (t, 2)	1.3 (t, 1)	−2.2 (t, 1)
Germany	−3.4 (t, 4)	−2.1 (t, 4)	−2.0 (t, 0)	−3.1 (t, 4)
Italy	−5.3 (c, 1)	−3.1 (t, 1)	−9.4 (c, 0)	−1.4 (c, 3)
The Netherlands	−7.1 (c, 0)	−3.1 (t, 0)	−2.4 (t, 3)	−1.6 (t, 2)

Note: P = GNP/GDP deflator; Y = real output; VM3 = velocity of M3.
The entries show the relevant statistic tests; the information in parentheses indicates the use of an intercept only, c, or a constant and a trend, t, followed by the number of lagged dependent variables included. The critical values at the 5% significance level are −3.56 and −2.96, with and without the inclusion of a trend, respectively.

Table 3 suggests that nonstationarity of inflation cannot be rejected at the 5% level for any country, except Italy. In the latter case, a relatively large number of lags of endogenous variable needs to be included in the regression. To avoid estimation problems due to non-stationarity of the dependent variable of the regression, we will use $\Delta \pi$ as the dependent variable in the gap-analysis for all countries.

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[13] The stationarity of the Dutch price level is inconsistent with the result for Dutch inflation in Table 3. This can probably be attributed to the low power of the test and is therefore disregarded.

TABLE 3

ADF UNIT ROOT RESULTS: GROWTH RATES
(1973.I-1994.IV)

Country	P	Y	M3	VM3
Belgium	−3.4 (t, 6)	−11.5 (c, 0)	−5.3 (c, 0)	−5.2 (c, 2)
France	−3.1 (t, 4)	−4.5 (c, 1)	−6.6 (t, 0)	−5.4 (c, 3)
Germany	−2.7 (t, 3)	−3.4 (c, 3)	−8.5 (c, 0)	−8.9 (c, 0)
Italy	−4.3 (t, 8)	−5.1 (c, 2)	−8.1 (t, 0)	−5.7 (c, 2)
The Netherlands	−2.8 (t, 4)	−11.6 (c, 0)	−3.1 (c, 1)	−9.1 (c, 2)

Note: see Table 2.

### 4.2. Characteristics of domestic and European price gaps

For each country, we construct a domestic equilibrium price level (P^*) and a corresponding domestic price gap (GAP^d) through equations (2) and (3), using the MSKF estimates of equilibrium velocity (V^*) and output (Y^*). Similarly, equations (8) and (9) are used to compute an equilibrium price level and price gap (GAP^f) based on external European monetary conditions, for each country separately.

Figure 1 displays both gaps for each country. Clearly, domestic and European price gaps are only imperfectly correlated, indicating either the existence of country-specific monetary and real shocks or at least a different timing of common shocks across countries. Over the whole period, the simple correlation coefficient between the domestic and European gap is −0.27 for France, −0.13 for Belgium, 0.03 for Germany, 0.13 for Italy and 0.38 for the Netherlands. For the period 1973-1989, which excludes German unification and the ERM currency crises, these correlation coefficients remain virtually unchanged, except for Germany. There, the correlation rises to 0.42.

In the early 1990s, sizeable price gaps emerge especially in Italy and Germany. For Italy, the European price gap indicates considerable external inflationary pressure after late 1992, due of course to the large depreciation of the lira in September 1992. In the case of Ger-

FIGURE 1

DOMESTIC AND EUROPEAN PRICE GAPS IN FIVE ERM COUNTRIES

Belgium

France

Germany

Italy

The Netherlands
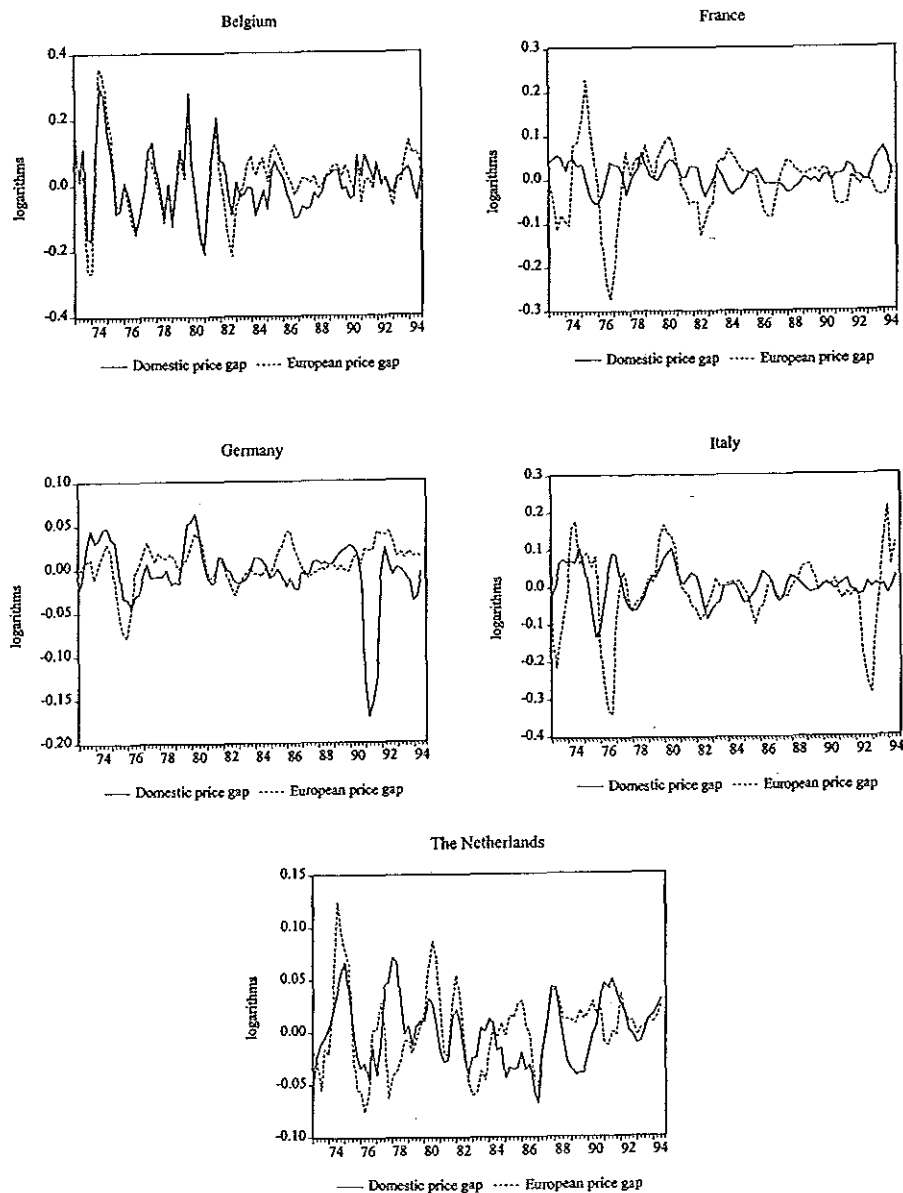
many, the large negative domestic price gap around 1991 may be explained by the occurrence of German monetary unification. This event led to an excess supply of money, with a corresponding fall in actual velocity (see von Hagen 1993), suggesting the need for a price level shift through temporarily higher inflation. This point was repeatedly made by the Bundesbank at the time. German unification appears to have exerted mild inflationary pressure on the other European countries as well, as measured by the negative European price gaps for these countries.

Theoretically, price gaps should be stationary variables, because an underlying equilibrating mechanism is assumed to eventually eliminate discrepancies between actual and equilibrium prices. Although Figure 1 already suggests that the constructed price gaps are all stationary and fluctuate around zero, Table 4 contains a more formal test of the stationarity of both domestic and European gaps. The results do indeed reject a unit root for every price gap. We, therefore, proceed and include the gap measures in country-specific inflation equations to assess the relative importance of domestic and European monetary conditions for domestic inflation over time.

TABLE 4

ADF UNIT ROOT RESULTS FOR DOMESTIC
AND EUROPEAN PRICE GAPS
(1973.I-1994.IV)

Country	Domestic price gap GAP^d	European price gap GAP^f
Belgium	−7.8 (n, 0)	−3.5 (n, 8)
France	−5.9 (n, 3)	−5.3 (n, 3)
Germany	−6.7 (n, 0)	−7.2 (n, 0)
Italy	−6.7 (n, 2)	−4.5 (n, 8)
The Netherlands	−7.3 (n, 0)	−7.6 (n, 1)

Note: The specification includes neither an intercept nor a trend, indicated by (n, .).
The 5% significance level is −1.92.

4.3. Testing the P*-model

We first estimate the standard closed-economy version of the P*-model as a benchmark case, using equation (5). In the initial specification, four lags of the dependent variable are included along with the domestic price gap and a constant. Following Ebrill and Fries (1991) and Reimers and Tödter (1994), we also add the change in energy prices as a proxy for temporarily inflationary supply shocks. Here, we realize that inflation may be driven by more factors in the short or medium term. To keep the analysis as transparent as possible, we have not included other variables, though. Subsequently, insignificant lagged dependent variables are dropped from the equation and the new specification is re-estimated. Table 5 documents the coefficients and corresponding t-values of the price gap and the supply variable, and a number of general statistic tests to assess the performance of the regression. To save space, the coefficients on the lagged dependent variable are omitted. After experimentation with different lags, price gaps for all periods and all countries have been uniformly included with a three-quarter lag in the subsequent analysis. No significant results were consistently found at other lags.

We report results for the whole sample period 1973-1994, as well as for the subperiods 1979-1994 and 1986-1994, to analyze potential changes in inflationary dynamics over time. For Belgium, France, Italy and the Netherlands, a similar pattern emerges: both the size and significance of the coefficient of the domestic price gap decrease when shorter and more recent subperiods are considered. While the price gap is significant over the whole period for each of these four countries, this ceases to be the case for Italy and the Netherlands after 1979, and for Belgium and France after 1986.

The results, thus, exemplify the theoretical notion that these four countries have lost their monetary autonomy by pegging their currencies to the Deutsche Mark. Germany's low inflation is automatically imported through the exchange rate constraint at the price of being forced to adopt the Bundesbank's monetary policy stance to ensure a smooth operation of the ERM. Not surprisingly, this worsens the relation between domestic money and price trends.

For Germany, on the contrary, a stable and significant coefficient links the domestic price gap to changes in inflation. To check

TABLE 5

Table 5

REGRESSION RESULTS WITH DOMESTIC PRICE GAPS

Sample	Domestic price gap	Energy prices	LDV	R²	SE	Q(8)	HET
Belgium							
73.1-94.4	-.207 (4.8")	–	123	.63	1.05	20.4"	14.9°
79.1-94.4	-.210 (3.3")	–	12	.67	.89	13.6°	21.4"
86.1-94.4	-.093 (1.6)	–	12	.56	.63	4.2	5.0
France							
73.1-94.4	-.178 (3.1")	.013 (3.2")	12	.32	.50	7.4	8.5
79.1-94.4	-.186 (2.0°)	1.02 (3.3")	123	.29	.46	8.9	10.5
86.1-94.4	.010 (0.2)	1.00 (4.2")	12	.60	.29	2.3	8.1
Germany							
73.1-94.4	-.129 (5.7")	.009 (3.5")	123	.62	.52	1.6	10.9
79.1-94.4	-.101 (3.6")	–	123	.64	.45	2.7	5.3
86.1-94.4	.116 (6.9")	–	12	.69	.40	9.9	3.6
Italy							
73.1-94.4	-.186 (3.4")	.023 (5.3")	123	.28	.80	5.6	9.2
79.1-94.4	-.035 (0.6)	0.20 (3.1")	1234	.30	.61	1.7	12.9
86.1-94.4	.119 (1.0)	0.16 (2.4")	12	.36	.59	7.2	8.5
The Netherlands							
73.1-94.4	-.236 (2.5")	.017 (2.5")	123	.39	.97	8.4	9.7
79.1-94.4	-.206 (1.5)	2.09 (3.8")	1234	.45	.90	2.9	22.7
86.1-94.4	.133 (1.2)	2.06 (3.8")	1234	.53	.67	8.5	26.2"

Note: The most general specification has the following format: $\Delta\pi = \alpha_0 + \sum_{i=1}^{4} \alpha_i \Delta\pi_{-i} + \alpha_5 \Delta ENPR_{-1} + \alpha_6 GAP^d_{-j}$.

The domestic price gaps are included with a lag of three quarters in all cases. Heteroscedasticity-consistent t-statistics are recorded behind the estimated coefficients. LDV denotes the significant lags of the dependent variable. For instance, 134 means that the first, third and fourth lags of the change in the inflation rate are significant and included. SE is the standard error of the regression multiplied by 100. Q(8) is the Box-Pierce statistic for serial correlation in the residuals. HET is White's statistic for heteroscedasticity and is distributed as χ^2. The symbols °, ' and " denote that the statistic test differs significantly from zero at the 10, 5 and 1% level, respectively.

whether the results for Germany are unduly influenced by German unification, we have included both a dummy that is one in 1991.I and zero elsewhere, and a dummy that is one in 1991.II and zero elsewhere in the German inflation regression. Under the assumption that the unification caused a long-run price level shift without influencing long-run inflation, we hypothesize an initial rise in inflation with a corresponding decline afterwards. If true, this would lead to a significant positive coefficient on the 1991.I-dummy and a significant negative coefficent of similar magnitude on the 1991.II-dummy. Our results support this hypothesis. For the period 1973-1994, for example, the 1991.I-dummy has a coefficient equal to 0.0075 with a t-value equal to 6.0, and the coefficient on the 1991.II dummy is –0.0062 with t-value 5.7. Their sum differs insignificantly from zero. The subperiod results are qualitatively similar.[14] The gap coefficients in Table 5 are for the specification including the dummy variables. The impact of the inclusion of the dummies on the gap coefficients is marginal. The German outcome at least suggests a higher degree of monetary autonomy for Germany than for the other countries considered, even over the most recent period.

Next, we extend our analysis to take into account possible cross-country interdependencies by using the open-economy version of the P*-model which comes down to estimating equation (10). In this setup, both the domestic price gap (GAP^d) and the European price gap (GAP^f) are included in the inflation models. Again, coefficients of the lagged dependent variables are unreported. The two German unification dummies defined above have again been added to the specification for Germany. Like before, the coefficients of these variables have opposite signs and are equal in absolute terms. The inclusion of the dummies has no impact on either of the price gap coefficients in Germany. To verify to what extent the significance of the European price gap in the inflation equations for Belgium, France, Italy and the Netherlands is due to the German unification, the same dummy variables are inserted in the inflation equations for these countries as well. In all instances, the dummy coefficients appear to be insignificant outside Germany.

[14] For the period 1986-1994, the decline in inflation appears to be spread out equally over 1991.II and 1991.III.

Table 6

TABLE 6

REGRESSION RESULTS WITH DOMESTIC AND EUROPEAN PRICE GAPS

Sample	Price gap		Energy prices	LDV	R²	SE	Q(8)	HET
	Domestic	European						
Belgium'								
73.1-94.4	-.133 (2.1')	-.074 (1.6)	—	123	.63	1.04	22.4"	14.0
79.1-94.4	-.129 (1.8°)	-.110 (1.8°)	—	12	.68	.88	12.8	20.4"
86.1-94.4	.033 (0.5)	-.290 (3.0")	—	12	.67	.54	62.	12.4
France								
73.1-94.4	-.141 (2.5')	-.046 (2.2')	.014 (4.0")	12	.30	.50	4.0	11.9
79.1-94.4	-.220 (2.4")	.061 (1.5)	.014 (4.1")	12	.30	.46	5.2	14.8
86.1-94.4	-.005 (0.1)	.037 (2.0')	.011 (4.5")	12	.60	.29	1.3	8.8
Germany								
73.1-94.4	-.124 (5.6")	-.094 (1.1)	.008 (3.4")	123	.63	.52	3.1	14.2
79.1-94.4	-.104 (3.4")	-.111 (1.1)	—	123	.64	.45	4.5	5.8
86.1-94.4	-.135 (9.1")	-.206 (2.4')	—	12	.71	.38	9.4	4.5
Italy								
73.1-94.4	-.187 (3.4")	-.008 (0.7)	.023 (5.3")	123	.27	.81	5.6	9.4
79.1-94.4	-.032 (0.6)	-.011 (0.7)	.021 (3.3")	1234	.29	.62	2.2	13.5
86.1-94.4	-.106 (0.9)	-.024 (1.8°)	.013 (1.8°)	123	.40	.57	3.6	16.7
The Netherlands								
73.1-94.4	-.222 (2.6')	-.057 (0.7)	.015 (2.1')	123	.39	.97	8.1	14.6
79.1-94.4	-.124 (1.0)	-.233 (1.9°)	.028 (3.8')	1234	.49	.87	4.3	19.6
86.1-94.4	-.139 (1.4)	-.241 (2.0')	.024 (3.5')	1234	.54	.68	11.3	21.8'

Note: The initial specification has the following format: $\Delta \pi = \alpha_0 + \sum_{i=1}^{4} \alpha_i \Delta \pi_{-i} + \alpha_5 \Delta ENPR_{-1} + \alpha_6 GAP_{-3}^d + \alpha_7 GAP_{-3}^f$.

The domestic price gaps are included with a lag of three quarters in all cases. Moreover, the European variables do not comprise data for the countries of which the inflation equation is estimated. Heteroscedasticity-consistent t-statistics are recorded behind the estimated coefficients. LDV denotes the significant lags of the dependent variable. For instance, 1 3 4 means that the first, third and fourth lags of the dependent variable are significant and included. SE is the standard error of the regression multiplied by 100. Q(8) is the Box-Pierce statistic for serial correlation in the residuals. HET is White's statistic for heteroscedasticity and is distributed as χ^2. The symbols °, ' and " denote that the statistic test differs significantly from zero at the ten, five and one percent level, respectively.

Table 6 shows the estimation results. In general, the coefficients on the domestic price gap are only marginally affected by the inclusion of the European price gap. For Belgium, France, Italy and the Netherlands, the evolution of the coefficients on the European price gap proves to be the mirror image of that of the domestic gap coefficients. Over the whole sample, the European price gap coefficient is insignificant, except for France. For all four countries, the size and significance of this coefficient increases with shorter and more recent samples, leading to a complete crowding-out of the domestic gap by the European gap over the 1986-1994 sample. Especially for the Belgium and the Netherlands, the magnitude of the European price gap coefficient gets quite large, −0.24 and −0.29 respectively, over the last subperiod. For France and Italy, the parameter size remains modest. This finding is in accordance with the intuitive idea that due to their relatively low economic weight, Belgium and the Netherlands are the prime candidates for losing monetary autonomy, which renders their inflation dynamics virtually completely dominated by European monetary conditions.

For Germany, we obtain somewhat different results. On the one hand, the domestic price gap remains significantly correlated with German inflation, despite the insertion of the European price gap. On the other hand, the European price gap has clearly informative value for the future course of German inflation in the period 1986-1994. Moreover, the magnitude of the European gap coefficient becomes larger than that of the domestic price gap and the inclusion of the former improves the explanatory power of Germany's inflation equation.[15] From this, we may first conclude that the anchor country Germany is increasingly subject to monetary spill-over effects from its immediate neighbours. Excess money growth in these countries leads to inflationary pressures in Germany, potentially requiring a compensating and sometimes more contractionary German monetary policy with corresponding real costs for Germany. Second, our results confirm the existence of an asymmetric monetary system in Europe and,

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[15] The results in Table 6 remain virtually unchanged when current exchange rates are used in aggregating instead of benchmark rates, with the exception of Germany. In the latter country, the European price gap remains insignificant after 1986. Unreported experiments show that this is due to Italy. If the European price gap for Germany is constructed with current exchange rates using data for Belgium, France and the Netherlands only, it again is significant after 1986.

consequently, of a weak version of the German leadership hypothesis. Germany is the only country where a strong and stable link is found between the domestic price gap and changes in inflation. Although the European price gap exerts a significant impact after 1986, it only adds a few percentages to the explanatory power of the regression. Third, our results point to an increased importance of aggregate European monetary developments for the future time path of inflation in individual countries, and as such stress the need for closer coordination of monetary policies in Europe.

5. Summary and conclusion

In this article, we formulate and subsequently estimate an extended open-economy version of the standard P*-model to investigate the potential impact of cross-country monetary spill-over effects on inflation in five founding members of the European Monetary System. We compare the results with a standard closed-economy version of the P*-model. More specifically, we examine the impact of domestic and ERM-wide monetary conditions – measured by price gaps – on national inflation rates in Belgium, France, Germany, Italy and the Netherlands over the period 1973-1994. In line with earlier P*-studies, we abstain from other variables that may affect inflation and assume the causality runs from money to prices. To analyze changes in the importance of international spill-over effects over time, the inflation equations are also estimated over the subperiods 1979-1994 and 1986-1994.

In the analysis, European aggregates are calculated with benchmark exchange rates against the German mark. Stochastic equilibrium time paths of velocity, real output and real exchange rates have been computed through the Multi State Kalman Filter method that allows for Bayesian learning and on-line decision making. The method distinguishes between transitory level shocks, permanent level shocks and temporary shocks to the growth rate of a series and extracts a stochastic trend based on this distinction.

The empirical results show that the explanatory power of domestic price gaps has deteriorated gradually since the establishment of

the ERM for the four non-anchor countries, and has become statistically insignificant after 1986. Conversely, the relative importance of a European price gap as an indicator for inflationary pressures has clearly increased over time. Our findings support the hypothesis that the exchange rate peg to the Deutsche Mark leaves only limited scope for an independent monetary policy in these countries. Nowadays, their long-run equilibrium price levels are predominantly determined by European instead of national monetary developments.

For Germany, the domestic price gap exerts a stable and significant influence on German inflation even after 1986, which underlines the asymmetric position of Germany in the ERM. Nevertheless, the European price gap becomes significant in the German inflation equation as well after 1986, suggesting that monetary conditions elsewhere in Europe increasingly matter for the path of German inflation. Although the effect of the European price gap on German inflation may still be limited, the observed trend can be expected to continue in light of the increasing European integration.

Our results, therefore, make a case for paying attention to developments in aggregate European monetary conditions in the execution of monetary policy in all countries of the ERM, including Germany. The outcomes underscore the importance of closer monetary policy coordination in Europe. Although our findings provide support for the use of European aggregates in the monetary policy decision process in the current second or future third stage of EMU, it must be stressed that the actual level of inflation also depends on non-monetary factors. In this context, the credibility of monetary policy-makers and the behaviour of social partners are relevant as well.

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