Clemens J.M. Kool and John A. Tatom

Clemens J.M. Kool is associate professor of international and monetary economics at the University of Limburg, the Netherlands. John A. Tatom is an assistant vice president at the Federal Reserve Bank of St. Louis. *Jonathan Ahlbrecht provided research assistance. The authors are grateful to Martin M.G. Fase, Eduard Hoechreiter and Dieter Proske for helpful comments.*

The P-Star Model in Five Small Economies

THE QUANTITY THEORY AND its equation of exchange provide a proven and useful framework to empirically analyze the relevance of money in the economy. During the past decade, however, doubts about this approach arose because of the perception that the links between money and prices and money and output had loosened or vanished.[1] Recently, Hallman, Porter and Small (1991)—henceforth HPS—have drawn new attention to the quantity theory by explicitly linking the determinants of long-run equilibrium prices to the short-run dynamics of actual inflation in the so-called P-star approach. In this framework, deviations of the actual price level from equilibrium push current prices and inflation in the direction of equilibrium.

The empirical results obtained so far for a wide set of countries, are supportive of the P-star approach, although it seems to work better for larger than smaller countries.[2] One neglected aspect which may explain this apparent dichotomy is the importance of the prevailing exchange rate regime for the determinants of prices and inflation. The original P-star approach assumes that the equilibrium price level is a function of the domestic money supply. Under a system of fixed exchange rates, however, the domestic price level in a small country is determined abroad and the domestic money stock becomes endogenous and demand-determined.

This article develops a generalized P-star model that accounts for this international effect by including cross-country price gaps. It is tested using annual data from 1960 to 1992 for five small European countries—Austria, Belgium, Denmark, the Netherlands and Switzerland. During the Bretton Woods period, these countries pegged their exchange rates to the United States dollar. Since then, four of the five pegged their currencies to the German mark, with varying degrees of success. Only Switzerland has had a floating exchange rate regime continuously since the breakdown of Bretton Woods. We investigate the extent to which prices in these countries have been affected by developments in Germany, as well as domesti-

[1]For an overview of past discussions on this issue, see Batten and Stone (1983), Dwyer and Hafer (1988) and Dewald (1988).

[2]See, for example, Hoeller and Poret (1991). They also indicate that there generally are superior models for forecasting inflation movements, even for countries where the P-star model is not rejected.

cally. To assess the tests used here, we also investigate the effect of U.S. price developments on the price level in these five countries and in Germany.

The results below indicate that the five small countries' equilibrium price levels are determined in Germany under the fixed exchange rate regime and that this effect has been proportional to the tightness of the exchange rate peg. In contrast, foreign-based equilibrium prices are found to be insignificant for the United States and Germany, the two countries that generally floated over the period examined here.

In the next section, the theoretical framework is developed, focusing first on the P-star model for a closed economy. Then, a generalized variant of the monetary approach to the balance of payments is used to show that under fixed exchange rates, domestic price developments in a small country are determined abroad, and that domestic money becomes endogenous. Combining these ingredients, it is shown that both their own price gap and a price gap based on equilibrium prices determined abroad can affect a country's inflation, depending on the exchange rate regime. The subsequent sections discuss the data, present the empirical results, and summarize the paper.

THE P-STAR MODEL IN CLOSED AND OPEN ECONOMIES

The Closed Economy Model

The simple Quantity Theory's equation of exchange is

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

where P denotes the price level, M is the domestic stock of money, Y is real output and V is the velocity of money. For convenience, time subscripts are omitted. Equation 1 simply pins down (nonobservable) actual velocity for given observations on P, M and Y.

HPS (1991), however, hypothesize the following long-run equilibrium relationship based on the identity in equation 1:[3]

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

where P^* denotes the equilibrium price level to which actual prices converge in the long run, Y^* is potential real output, and V^* is the equilibrium velocity of money. Following the Quantity Theory, they assume that V^* and Y^* are determined independently, and, more importantly, that both are independent of the money stock. Thus, the equilibrium price level moves proportionally with the stock of money. HPS further hypothesize that the equilibrium price gap, $(lnP - lnP^*)$, has a theoretical value of zero so that P adjusts to equal P^*. The combination of equations 1 and 2 implies that the change in the actual price level should be negatively related to the existing gap between P and P^*.

This relationship is formally indicated by the hypothesis that α_1 is negative in the second term of the inflation equation:

$$(3)\ \Delta lnP_t = \alpha_0 + \alpha_1\,(lnP - lnP^*)_{t-1} + \sum_{j=1}^{N} \beta_j\,\Delta lnP_{t-j} + \epsilon_t.$$

The inflation lags ΔlnP_{t-j} are added to the equation to account for short-run dynamics and ϵ_t is the random error term.

If actual inflation, ΔlnP, is nonstationary, then it does not have a fixed theoretical mean, possibly leading to problems in the estimation of equation 3. To accommodate this possibility, equation 3 can be rewritten without loss of generality as

$$(4)\ \Delta\pi_t = \alpha_0 + \alpha_1\,(lnP - lnP^*)_{t-1} + \sum_{j=1}^{N-1} \delta_j \Delta\pi_{t-j} + \delta_0 \pi_{t-1} + \epsilon_t,$$

where π now denotes inflation.

If inflation is not stationary (and its first difference is stationary), then δ_0 in equation 4 has a theoretical value of zero, and lagged inflation can be omitted. Thus, equation 4 would contain only stationary variables (since π_{t-1} can be omitted). Since this is not the case in equation 3 unless inflation is stationary, equation 4 is generally a more useful equation to estimate. Although it would be possible to include other transitory influences on prices, such as price-control proxies or energy price shocks, we

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

abstract from these factors and focus on the interaction between changes in inflation and deviations from long-run equilibrium.

HPS (1991) originally applied a version of equation 4 to quarterly U.S. data. They use M2 as the money stock and assume that the corresponding equilibrium velocity is a constant.[4] HPS conclude that the model is supported by the data.[5] Hoeller and Poret (1991) extend the P-star approach to 20 member countries of the Organization for Economic Co-operation and Development (OECD). They use the Hodrick-Prescott filter to extract equilibrium time series for output and velocity from the data.[6] The evidence provided by Hoeller and Poret is mixed. The P-star approach leads to satisfactory estimated equations for most, but not all, countries. In particular, the evidence for small countries tends to reject the P-star model, while the evidence for larger countries tends to conform to the P-star model.

So far, research on the link between exchange rate regimes and macroeconomic adjustment of prices and output is quite limited. Recently, Bayoumi and Eichengreen (1992) use impulse-response functions to analyze the differences between the Bretton Woods and post-Bretton Woods period in this respect for the G7 countries (United States, Canada, United Kingdom, Germany, France, Italy and Japan). They find evidence that, under the floating rate regime, countries' aggregate demand curves become steeper so that various shocks give rise to less output variability and greater price variability than under a fixed rate regime. Tatom (1992) analyzes Austrian price behavior; the P-star model for Austria is rejected but, due to the fixed exchange rate regime, a long-run relationship between German and Austrian inflation is not rejected.[7]

Here, we intend to investigate in more detail how foreign price developments affect domestic prices under a system of fixed exchange rates and the implications of this linkage for the P-star model.

The Generalized Monetary Approach to the Balance of Payments

The starting point of our analysis is a fixed exchange rate regime in which one large country (such as Germany) is the anchor of the system and sets its monetary policy to achieve its own domestic objectives, independent of the objectives of the smaller countries within the system. The large country is assumed to be sufficiently large so that it is unaffected by policy actions and outcomes in the small countries.[8] Each small country, in contrast, takes the anchor country's monetary policy as given and is committed to a fixed exchange rate objective.

Equations 5 and 6 represent money demand and money supply, respectively, in the large foreign country:[9]

$$(5)\ M^f_D = [V(R^f, Y^f)]^{-1} P^f Y^f$$

$$(6)\ M^f_s = \overline{M^f},$$

where the inverse of velocity is assumed to be a function of real output (Y^f) and a vector of nominal interest rates (R^f).[10] When both output and the real interest rate are at their long-run equilibrium values determined elsewhere in the economy, money market equilibrium determines

[4]Tatom (1990) points out that M2 velocity has exhibited semipermanent trends over time, so that the assumption of a constant equilibrium velocity may be flawed.

[5]HPS also split up the total price gap in separate output and velocity gaps, but find no additional explanatory power from this less-restricted variant.

[6]Hoeller and Poret also conduct tests using simple linear trends for the equilibrium levels of output and velocity. The Hodrick-Prescott filter allows time series with stochastic trends to be detrended. See Hoeller and Poret (1991) for a discussion. King and Rebelo (1989) contains a more technical analysis. An application and an appendix with the appropriate formulas can be found in Mills and Wood (1993).

[7]The Bundesbank (1992) develops and tests a P-star model for Germany based on its M3 measure.

[8]In the P-star model, this means that the large country's potential output, equilibrium velocity and long-term inflation objectives are independent of foreign developments.

[9]A superscript *f* will be used to denote the large foreign country (Germany or the United States), while a superscript *d* will be used for the small domestic country (Austria, Belgium, Denmark, the Netherlands and Switzerland).

[10]The relationship of equilibrium velocity and equilibrium nominal interest rates is generally ignored in formulations of the P-star model. This practice is consistent with the assumptions that movements in the equilibrium real rate are not empirically significant and that movements in the expected rate of inflation have little effect on velocity; moreover, even if this latter effect is not small, it is captured in the growth of the money stock or, given the dynamics included in the P-star model, in the lagged inflation terms.

the equilibrium price level in the large foreign economy (Germany).

The exchange rate constraint in a fixed exchange rate system then determines the equilibrium domestic price level for a small country as

$$(7)\ P^{d*} = EP^{f*}/ER^*,$$

where E is the fixed nominal exchange rate, equal to the number of equilibrium domestic currency units per unit of foreign currency, and ER^* is the corresponding equilibrium real exchange rate.[11] With the domestic price level conditioned by equation 7, the domestic money stock must adjust to bring about equilibrium in the domestic money market.

P-Star in Open Economies Under Fixed Exchange Rates

The above analysis has two major implications for the short-run price dynamics in small countries under fixed exchange rates. First, a price gap determined abroad through the exchange rate constraint should be expected to influence domestic inflation. This gap can be defined as

$$(8)\ GAP^f = (p^d - p^{d*}) = [p^d - (p^{f*} + e - er^*)],$$

where lower-case symbols denote logarithmic levels and a d superscript has been added to the logarithm of the domestic price level to distinguish it from a foreign measure. When domestic prices exceed the foreign-determined equilibrium price level, downward pressure on current domestic inflation and prices results.[12] The amount of pressure this gap exerts on current domestic inflation and the speed of adjustment toward equilibrium depend on the extent of arbitrage in goods and capital markets, and the degree to which the economies are integrated.[13]

Second, the domestic price gap should lose its influence if the exchange rate is pegged; domestic money becomes endogenous. Suppose, for example, current domestic prices are consistent with the foreign-determined P-star measure, that is, the foreign-determined gap is zero, while simultaneously the domestic gap is positive, because actual prices exceed the equilibrium measure of prices indicated by the domestic money stock. In this case, the domestic gap is expected to close by adjustment of the money stock, not by an adjustment of domestic prices and inflation. The extent to which this holds will be a function of capital mobility. The literature on sterilization and capital offset suggests that small countries may have some freedom to manipulate the domestic money supply in the intermediate run to determine monetary conditions at home to the extent that capital mobility is limited.[14]

Both of these hypotheses are tested below. In particular, the model in equation 4 is supplemented with the foreign price gap so that the appropriate equilibrium gap measure is a weighted average of the domestic gap in equation 4 and the foreign-determined gap in equation 8 or

$$(9)\ (1-w)\ (p^d - p^*) + w\ (p^d - p^{d*}),$$

where w is the weight attached to a fixed exchange rate regime. For a closed economy or a floating exchange rate regime, w equals zero and the appropriate equilibrium price level and gap measures are the conventional, domestically determined ones used in equation 4. If there is a credible fixed exchange rate regime with the domestic currency pegged to the foreign country, f, then w equals one and the equilibrium price level is that determined abroad and indicated as p^{d*} in equation 8. In this case, the appropriate P-star and its related gap measure are determined abroad. Since w may change over the sample period, but is unobservable, the

[11]In the traditional pure monetary approach to the balance of payments, the real exchange rate is assumed to be a constant and may be deleted from the analysis.

[12]Alternatively, the gap can be closed by a discrete decision to correspondingly devalue the currency. Afterwards, the peg could be resumed.

[13]Although the degree of integration may have increased over time and may also be a function of the exchange rate regime, rising with a credible fixed rate regime, the effects of these changes are ignored below.

[14]See Roubini (1988) for an overview of the literature, and Kool (1994) for a recent empirical analysis. Also, see Stockman and Ohanian (1993).

coefficients on the gaps are theoretically the mean levels reflecting the sample experience and they sum to the mean level of α_1.

While it would be desirable to characterize the prevailing exchange rate regime over time for each country and to incorporate this information in the analysis, this is not feasible. It may seem straightforward to distinguish between fixed and floating exchange rate regimes, but departures from these idealized extremes are economically and qualitatively important in practice and are hard to quantify. Moreover, changes in the degree of international capital mobility and economic integration over time may change the speed of response to existing gaps. Finally, the limited number of observations available below severely constrains the use of extensive sets of dummy variables. For these reasons, we include both the domestic price gap (defined in equation 4) and the foreign-determined price gap (defined in equation 8) in the final specification.

THE DATA AND THEIR TIME SERIES PROPETIES

Annual data for seven countries—Austria, Belgium, Denmark, Germany, the Netherlands, Switzerland and the United States—for the period 1960-92 are used to test the model. Consistent nominal and real GDP data have been obtained from the Organization for Economic Co-operation and Development (OECD, 1993) for the six foreign countries.[15] U.S. Department of Commerce data are used for the U.S. nominal and real GDP measures. These series have been used to compute the implicit GDP deflator.

Average U.S. dollar exchange rates have been taken from the International Monetary Fund's *International Financial Statistics* (*IFS*) database (line rf). Similarly, two money stock definitions from the *IFS* have been used: narrow money (line 34), which is called M1 here, and the sum of narrow money and quasi-money (line 35), which is comparable to M2 and will be denoted here as broad money, MB. The main advantage of using these series is their harmonization across countries. For Belgium, the monetary aggregates series stop in 1990.

Exchange Rate Movements

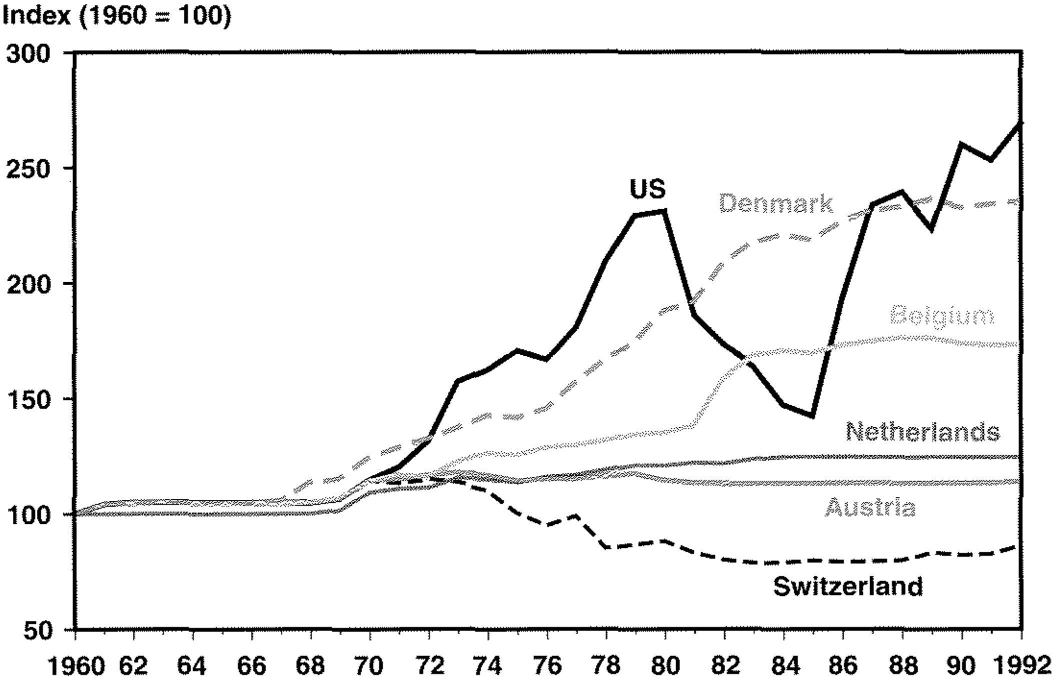
Figure 1 presents the nominal exchange rate (defined as the domestic currency price of German marks) time paths for all countries relative to Germany, with the 1960 exchange rate indexed to 100. The Bretton Woods fixed exchange rate regime is clearly visible until the late '60s. Note, that although the formal end of Bretton Woods is often set in 1973 and sometimes in 1971, exchange rates start moving already in the period 1967-70. After the breakdown of Bretton Woods, exchange rates move least for Austria and the Netherlands. These countries have most persistently sought fixed exchange rates with Germany in the '70s and '80s.

Much more exchange rate variability has been present, on the other hand, for the United States, where the exchange rate has floated and, to a lesser extent, for Denmark and Belgium. Despite a floating rate, the Swiss exchange rate has exhibited less variability than that in Denmark and Belgium. The latter two countries have had mixed exchange rate regimes. While they have been on fixed exchange rates, at least nominally, they periodically devalued to escape the exchange rate constraint on domestic monetary policy. Some degree of exchange rate stabilization appears to have set in the middle- and late-'80s for Belgium and Denmark, however, due to the effective functioning of the European Monetary System during that period.[16]

[15]Series in this publication are for 1960 and from 1963 to 1991. We are grateful to Amber DeBayser at the OECD for providing the consistent 1961 and 1962 data, which are not listed in the publication cited. Data for 1992 were computed from comparable OECD data. In Belgium, Denmark and Germany, 1992 data were not included due to lack of comparability.

[16]In August of 1993, both the Belgian franc and Danish krone were forced to accept wider fluctuation margins in the European exchange rate mechanism and experienced a considerable depreciation; subsequently, their exchange rates moved back into the narrow bands that existed earlier, although the wider margins officially still are in place. This experience is outside the sample used here.

Figure 1
Exchange Rates Relative to Germany



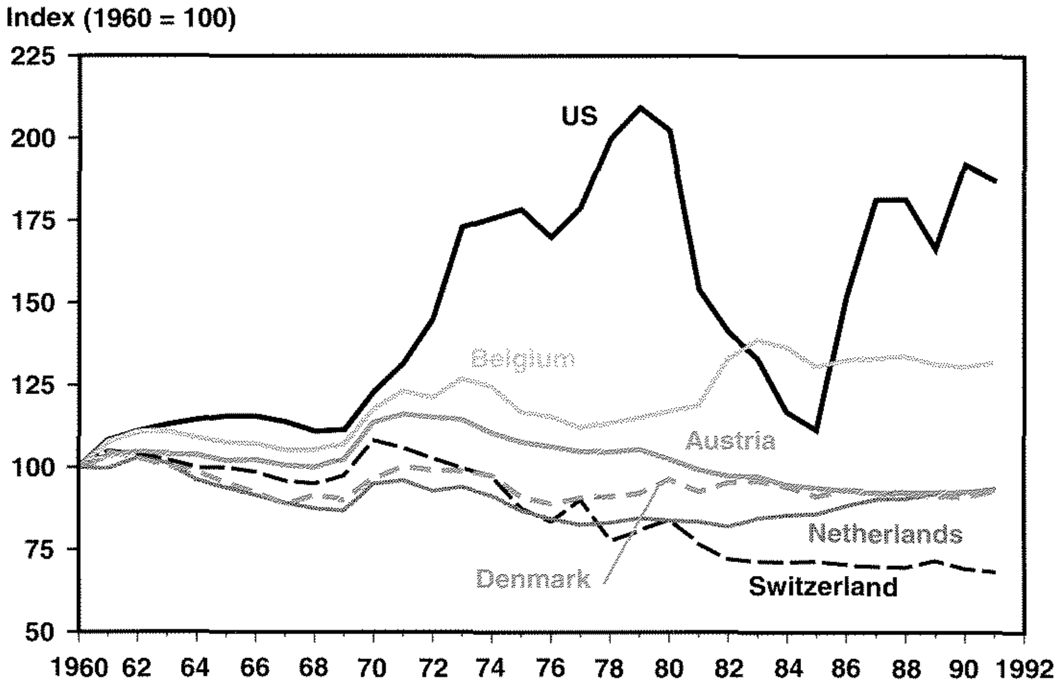
The decision by the four countries, Austria, Belgium, Denmark and the Netherlands, to peg their currencies to the mark is motivated by a desire to "import" German inflation, one of the lowest rates in the world from 1960 until recently. While the Swiss chose to float, their monetary policy has also achieved a similarly low inflation rate. The decision of the four small, open economies to peg to the mark is also presumably influenced by the fact that they are closely tied to Germany through trade. For example, in 1985-89, trade with Germany (both exports and imports) was 20 percent of Denmark's total trade, 21.4 percent of Belgium's, 26.5 percent of the Netherland's, 27.4 percent of Switzerland's and 39.2 percent of Austria's. For trade within the six-country block, the shares were 28.8 percent for Germany, 30.6 percent for Denmark, 38.7 percent for Switzerland, 41.3 percent for Belgium, 44.8 percent for the Netherlands and 51 percent for Austria.

Real exchange rates, defined as the nominal exchange rate multiplied by the ratio of German prices relative to each country's price level, are displayed in Figure 2. For the United States, Switzerland and Belgium, sizeable permanent real exchange rate changes relative to Germany appear to have taken place. Nominal and real exchange rate patterns are quite similar for these three countries. Real exchange rate movements have been smaller in magnitude for Austria, Denmark and the Netherlands. While the Danish krona has continuously depreciated in nominal terms over time, the real exchange rate has fluctuated around the same level for the entire sample.

Unit Root Tests

One important issue for the correct specification of the price equation to be estimated, is the (non)stationarity of the variables involved. Tables 1 and 2 report the results of standard augmented Dickey-Fuller (ADF) tests for both log levels and growth rates of prices, output, narrow and broad money, the corresponding velocities of narrow and broad money, and the

Figure 2
Real Exchange Rates Relative to Germany



nominal and real exchange rates.[17] In the tables, we report the *t*-statistic on the one-period lagged level for the preferred specification; this specification is given below the *t*-statistic. Significance at the 5 percent level is indicated (*) and implies rejection of nonstationarity.

With few exceptions, Table 1 indicates that the nonstationarity of the logarithm of the levels of the variables cannot be rejected. Consequently, computation of the equilibrium values of V^* and Y^* by means of a regression with a deterministic trend generally is incorrect. The most important implication of these results is that a procedure capable of handling stochastic trends is required to model the equilibrium levels of V^* and Y^*. The Hodrick-Prescott filter is used to find the equilibrium output and velocity paths.

The growth rates of output, narrow money, and narrow and broad money velocity, and the nominal and real exchange rates, all appear to be stationary according to the unit root tests reported in Table 2. For inflation and broad money growth, a unit root generally cannot be rejected.[18] Note that there are a considerable number of borderline cases. The (marginal) nonstationarity of inflation suggests that equation 4 is appropriate for the ensuing gap analysis.

TESTS OF THE P-STAR MODEL

In this section, we analyze the impact of different price gaps on short-run inflation dynamics. First, we focus on country-by-country estimation using each country's domestically determined price gap only. Then we proceed to

[17]The specification used in each case is a regression of the first difference of the series on a constant, a trend, the one-period lagged level, and up to three lags of the first-differenced variable. Insignificant lags of variables are removed step by step starting at the longest lag, for specifications that include or do not include a time trend. If the trend is statistically significant, this version is reported in the table; otherwise, the estimate without the trend is reported.

[18]Unreported results show that a unit root for the change in inflation and broad money growth can be rejected.

Table 1
ADF Unit Root Results (log levels)

Country	P	Y	M1	V1	MB	VB	E	ER
Austria	−2.19	−2.67	−1.82	−2.54	−2.08	−2.06	−1.78	−1.45
	(T,1)	(C,0)	(C,0)	(T,0)	(C,1)	(C,0)	(C,0)	(C,1)
Belgium	−1.17	−3.26*	−1.45	−3.00	−1.21	−2.95	−2.67	−3.36
	(C,1)	(C,0)	(C,1)	(T,0)	(C,1)	(C,0)	(T,1)	(T,1)
Denmark	−1.98	−2.78	−2.93	−2.36	−2.23	−0.89	−2.07	−5.31*
	(C,1)	(C,0)	(T,3)	(C,3)	(T,1)	(T,0)	(T,2)	(T,3)
Germany	*−2.19*	*−1.93*	*−2.61*	*1.73*	*−4.11**	*−2.24*	*NA*	*NA*
	(T,3)	(C,0)	(T,3)	(C,2)	(C,0)	(C,0)		
Netherlands	−1.64	−4.62*	−2.03	−1.72	−1.95	−2.16	−1.09	−1.77
	(C,1)	(C,0)	(C,0)	(C,0)	(C,1)	(T,0)	(C,0)	(C,0)
Switzerland	−2.22	−1.67	−3.07*	0.96	−1.79	−3.82*	−1.49	−2.32
	(T,1)	(C,1)	(C,2)	(C,2)	(C,1)	(T,1)	(C,3)	(T,0)
United States	−1.33	−2.65	−2.28	−2.25	−1.31	−3.01	−2.86	−1.93
	(C,1)	(T,0)	(T,1)	(C,1)	(C,1)	(T,1)	(T,1)	(C,1)

Note: The entries show the relevant test statistic; the information in parentheses indicates the use of a constant only, C, or a constant and trend, T, followed by the number of lagged dependent variables included. For the longest sample period used, the 5 percent significance level critical values are −3.56 and −2.96, with and without the inclusion of a trend, respectively.

Table 2
ADF Unit Root Results (growth rates)

Country	P	Y	M1	V1	MB	VB	E	ER
Austria	−2.19	−4.60*	−4.72*	−6.33*	−1.54	−4.52*	−4.21*	−3.25*
	(C,0)	(T,0)	(C,0)	(C,0)	(C,0)	(C,0)	(C,0)	(C,0)
Belgium	−2.21	−5.06*	−3.09*	−5.28*	−2.43	−5.53*	−3.82*	−3.84*
	(C,0)	(T,0)	(C,0)	(C,0)	(C,0)	(C,1)	(C,0)	(C,0)
Denmark	−1.06	−5.66*	−5.34*	−5.68*	−2.47	−3.58*	−4.08*	−4.59*
	(C,0)	(T,0)	(C,0)	(T,0)	(C,0)	(C,0)	(C,0)	(C,0)
Germany	−2.15	−3.82*	−4.42*	−5.58*	−3.90*	−4.07*	NA	NA
	(C,0)	(C,0)	(C,0)	(T,1)	(T,0)	(C,0)		
Netherlands	−3.26	−3.87*	−3.81*	−5.04*	−2.71	−5.68*	−4.70*	−4.01*
	(T,0)	(T,0)	(C,0)	(C,0)	(T,0)	(T,0)	(C,0)	(C,0)
Switzerland	−2.75	−3.01*	−6.07*	−6.16*	−2.96	−4.55*	−5.48*	−6.05*
	(C,0)	(C,0)	(T,1)	(C,1)	(C,0)	(C,1)	(C,0)	(C,0)
United States	−1.66	−3.96*	−3.81*	−3.89*	−2.83	−4.17*	−3.86*	−3.69*
	(C,0)	(C,0)	(T,1)	(T,1)	(C,0)	(C,0)	(C,0)	(C,0)

Note: The entries show the relevant test statistic; the information in parentheses indicates the use of a constant only, C, or a constant and trend, T, followed by the number of lagged dependent variables included. For the longest sample period used, the 5 percent significance level critical values are −3.57 and −2.96, with and without the inclusion of a trend, respectively.

Table 3
ADF Unit Root Results: Own Price Gaps Based on M1 and MB

Country	GAP[1]	GAP[2]
Austria	−3.14* (C,0)	−3.39* (C,1)
Belgium	−4.83* (C,1)	−3.68* (C,1)
Denmark	−2.75 (C,0)	−3.91* (C,3)
Germany	−3.17* (C,3)	−3.25* (C,1)
Netherlands	−3.44* (C,1)	−2.99* (C,0)
Switzerland	−6.47* (C,1)	−3.99* (C,1)
United States	−4.39* (C,1)	−4.28* (C,1)

Note: The entries show the relevant test statistic; the information in parentheses indicates the use of a constant only, C, or a constant and trend, T, followed by the number of lagged dependent variables included. The critical value for 5 percent significance level is −2.96, for the longest sample period used.

the measurement and inclusion of foreign-based price gaps.

The Domestic Price Model

The Hodrick-Prescott filter is used to determine equilibrium time paths for output (lnY), narrow money velocity ($lnV1$) and broad money velocity ($lnVB$).[19] Subsequently, two domestic price gaps are computed for each country:

$$(10)\ GAP^1 = (p - p^{*1}) = (lnV1 - lnV1^*) - (lnY - lnY^*),$$

$$(11)\ GAP^2 = (p - p^{*2}) = (lnVB - lnVB^*) - (lnY - lnY^*),$$

where p^{*1} equals $(lnM1 + lnV1^* - lnY^*)$, and p^{*2} *equals* $(lnMB + lnVB^* - lnY^*)$, the respective measures of the equilibrium price level based on domestic M1 and broad money. Table 3 shows ADF test results for these price gaps. The layout follows that of Tables 1 and 2. Overall, the price gaps appear to be stationary, with the exception of the M1 price gap for Denmark. This Danish price gap is stationary only at the 10 percent level. Stationarity of the price gap is a necessary condition for the further analysis. Short-run inflation dynamics are theoretically assumed to be influenced by the price gap because of the existence of an underlying equilibrating adjustment process. If actual prices do not converge to the computed equilibrium prices, as is the case with nonstationary gaps, the fundamental P-star hypothesis that, in the long run, prices converge to these equilibrium measures is rejected; no theoretical foundation exists for including such a measure of the gap in the inflation specification. This is the case for the Danish M1-based P-star model.[20]

Table 4 presents estimates of the domestic P-star model based on each country's own M1 (GAP[1]) and broad money (GAP[2]). In the general specification, one lag of the dependent variable and the lagged inflation level are included along with the gap and a constant. The reported results are for estimates in which insignificant lagged inflation variables have been dropped from the general specification.

The results are supportive of the P-star approach. Save for Denmark, the price gap with respect to broad money is significant with the correct negative sign. The price gap calculated with narrow money is significant only for the United States, Switzerland and Denmark, and

[19]Basically the trend is derived by minimizing an objective function that consists of the sum of squared deviations of actual observations from the (unobservable) trend and a multiple, λ, times the sum of squared changes of this trend. A smoothing factor λ of 100 is used here, following Kydland and Prescott's (1989) suggestion that this value is appropriate for annual data. Hodrick and Prescott (1981) show, using quarterly data, that a choice of λ of up to four times or one-fourth as large has no practical effect on the results of applying the filter. The limiting case, λ approaching infinity, is a linear trend; this case was also examined (for Y, V and the real exchange rate below). Differences arising from the use of linear trend filters are noted below because the results are sensitive to this choice.

[20]When linear trends are used to construct equilibrium measures for the broad money-based P-star variables, only the U.S. and Swiss gap measures are stationary; the domestic gap measures for Germany and for the four other countries based on these measures are not stationary. The domestic version of the P-star model based on these equilibrium estimates is rejected because these measures cannot be equilibrium levels. Thus, the failure to reject the P-star model in the text is conditional upon the method of estimating equilibrium output and velocity. The Swiss and U.S. models using linear trends do not fit the data as well as the estimates reported below.

marginally so for Germany. Since Denmark's M1-based domestic price gap is nonstationary, this result in Denmark may well be spurious. Thus, Denmark's evidence rejects the domestic P-star model, a result obtained by Hoeller and Poret (1991) as well. In the other countries, the broad money-based P-star model generally fits the data somewhat better (judged by the adjusted-R^2) and fails to reject the model (judged by the statistical significance of the negative coefficient on the price gap).[21]

For five of the seven countries there is a high coherence between the narrow and broad money price gap; the exceptions are Austria and the Netherlands.[22] Apparently, deviations from equilibrium levels for narrow and broad money velocity or, more precisely, deviations from equilibrium nominal GDP, usually are closely related. Based on the superior results for broad money in Table 4 and the close coherence of the broad and narrow gaps, only the broad money-based domestic gaps are used in the discussion of the open economy model.

Calculating An Appropriate Foreign-Based Price Gap

To examine the German influence on each of the five small European countries, the foreign (German) gap is defined as

$$(12)\ GAP^f = [p^d - (p^{f*} + e - er^*)].$$

To compute this price gap, however, one needs a measure of the equilibrium value of the real exchange rate (er^*).[23] Two alternative measures of the equilibrium real exchange rate are presented here. The first measure assumes that the equilibrium real exchange rate is a constant, which is equivalent to assuming that purchasing power parity (PPP) holds in the long run. The second measure is based on using the Hodrick-Prescott filter to find the equilibrium component of the real exchange rate. This measure is less restrictive and more consistent with the data, but the other assumption, the PPP-based measure, has strong theoretical appeal.[24]

PPP-Based Measures

Suppose that each real exchange rate is stationary and converges to a constant long-run equilibrium level.[25] Then, the gap with this constant, equilibrium real exchange rate removed is

$$(12')\ GAP^{f1} = [p^d - (p^{f*} + e)].$$

This gap is consistent with the pure theory of the monetary approach to the balance of payments.[26] As could be expected, however, this gap is generally nonstationary. Relevant ADF test results are shown in the first column of Table 5. This gap measure is generally not the preferred specification because the statistical

[21]Hoeller and Poret (1991) also report that the domestic P-star model is rejected for Austria and the Netherlands when the Hodrick-Prescott filter is used, but not when linear trends are used to find equilibrium output and velocity. Their study uses semiannual data and, for the seven countries examined here, uses sample periods beginning in 1962 for the United States, 1963 for the Netherlands, 1964 for Denmark, 1969 for Austria and Germany, 1971 for Belgium and 1973 for Switzerland. The last data point is in 1989 in each country. Their results also differ in choosing the monetary aggregates used for each country based on each country's target. These are generally broad measures, but not necessarily the broad measure used here.

[22]The correlation coefficient for the U.S. broad-money and narrow-money-based price gaps is 0.74 and that for the German broad-and narrow-based price gaps is 0.71. The correlations of the gaps based on narrow and broad domestic monetary aggregates are 0.79 in Belgium and Switzerland, and 0.83 in Denmark. In the Netherlands, this correlation is only 0.25 and in Austria it is only 0.09; neither of these is statistically significant at a 5 percent level.

[23]For an analysis of the U.S. impact on the six European countries, see the appendix to this article.

[24]A third measure was also investigated. It assumes that the measured real exchange rate is always the equilibrium value, so that all changes in the real exchange rate are permanent. With this measure, the foreign-based price gap is Germany's domestic price gap, which is stationary (see Table 3). The inflation model using this real exchange rate assumption is consistently dominated by the fit of the model using the Hodrick-Prescott filtered real exchange rates.

[25]Although the analysis above and the evidence in Figure 2 suggest this assumption is incorrect, it provides a convenient and insightful benchmark. Tatom (1992) uses this assumption for Austria; the constant level of the exchange rate is also removed from the foreign gap measures, so that Austrian prices are hypothesized to equal a German P-star in equilibrium. This model is rejected, however, although Austrian inflation is found to be tied to such an equilibrium German inflation measure. These results could arise from ignoring the effects of real exchange rate movements on the level of prices, but the same results—the absence of a tie of the level of prices to an equilibrium level, but a strong tie of inflation to an equilibrium inflation rate—occur for a German money (M3)-based P-star measure and German prices.

[26]For recent discussions of the evidence against PPP, see Coughlin and Koedijk (1990), Dueker (1993) and Huizinga (1987).

Table 4
Short-Run Inflation Equations Including Own Price Gaps

Country	C	$\Delta\pi_{-1}$	π_{-1}	GAP^1_{-1}	GAP^2_{-1}	$\bar{R}^2$	SEE	LM (4)	CHOW (77)	Last Period
Austria	1.40	—	−0.32	−7.78	—	0.137	1.242	0.71	0.76	92
	(2.21)		(2.41)	(1.24)						
	1.23	—	−0.28	—	−24.17	0.221	1.180	0.64	2.29	92
	(2.05)		(2.23)		(2.17)					
Belgium	1.23	—	−0.25	−14.41	—	0.148	1.610	0.89	0.75	91
	(1.84)		(2.01)	(1.41)						
	1.36	—	−0.27	—	−35.29	0.355	1.400	1.53	2.52	91
	(2.38)		(2.59)		(3.36)					
Denmark	−0.06	—	—	−11.36	—	0.111	1.381	0.53	0.72	91
	(0.26)			(2.15)						
	−0.06	—	—	—	−6.48	0.014	1.454	0.27	1.01	91
	(0.22)				(1.19)					
Germany	1.55	0.33	−0.39	−10.28	—	0.260	1.069	0.46	1.36	91
	(2.78)	(1.89)	(2.92)	(1.86)						
	1.26	—	−0.32	—	−29.01	0.511	0.860	2.57	2.36	91
	(3.02)		(3.22)		(4.82)					
Netherlands	0.82	—	−0.19	−11.18	—	0.080	1.775	0.43	1.98	92
	(1.29)		(1.71)	(1.32)						
	0.80	—	−0.19	—	−42.34	0.242	1.612	0.61	5.43*	92
	(1.40)		(1.86)		(2.84)					
Switzerland	1.87	—	−0.44	−12.83	—	0.333	1.653	3.13*	1.07	92
	(2.64)		(3.05)	(2.71)						
	2.12	—	−0.50	—	−20.28	0.523	1.400	0.89	0.78	92
	(3.53)		(4.09)		(4.63)					
United States	0.07	—	—	−21.12	—	0.349	1.027	0.40	1.46	92
	(0.40)			(4.13)						
	0.01	—	—	—	−21.00	0.408	0.978	0.68	1.58	92
	(0.04)				(4.66)					

Notes: LM (4) is a Breusch-Godfrey test on serial correlation of the residuals using four lags of the residual; it has a $\chi^2(4)$ distribution. CHOW (77) is a test on parameter stability with the break point in 1977; it follows an F-distribution.

evidence rejects the hypothesis that domestic prices have a long-run relationship to this measure of the foreign-determined, equilibrium price level. The irrelevance of this measure, except for Denmark, is consistent with the evidence for real exchange rates in Table 1, which indicates that the real exchange rate is nonstationary in all cases except for Denmark.

Equilibrium Real Exchange Rates from the Hodrick-Prescott Filter

The second alternative explicitly tries to find a statistical estimate for the time path of the equilibrium real exchange rate. To this end, we write the real exchange rate as

(13) $er = e + p^f - p^d = er^* + u,$

where u is a stationary, unobservable error term. In this case, the actual real exchange rate is equal to its long-run value (er^*) plus a transitory deviation. Neither er^* nor u are observable. It is possible, however, to obtain an estimate of the equilibrium component of the real exchange rate, er^*, again using the Hodrick-Prescott filter. This equilibrium component, $\hat{er}^*$, is substituted into equation 8 to obtain:

(12″) $GAP^{f2} = [p^d - (p^{f*} + e - \hat{er}^*)].$

The second column of Table 5 shows this gap to be stationary at the 5 percent level for Austria, Belgium, Denmark and the Netherlands. For Switzerland, a unit root can be rejected only at the 10 percent level.[27]

A Comparison of Alternative Foreign Gap Measures

To compare the alternative measures of the foreign-determined domestic price gap, labeled GAP^{f1}, and GAP^{f2}, respectively, equation 4 is reestimated with each of these gaps replacing the domestic gap. Table 6 contains the coefficient on the gap, the absolute value of its t-statistic in parentheses, and the adjusted R-squared of the equation in square brackets.[28] GAP^{f1} is only relevant for Denmark, where its stationarity and that of the real exchange rate are supported by the data; nevertheless, this gap has been included as a benchmark for the other countries as well. All coefficients in Table 6 are of the correct sign. Judged both by significance and the amount of explanatory power, GAP^{f2} outperforms the other measure, except in Denmark, where GAP^{f1} is better.

Table 7 similarly contains results for regressions with both the domestic price gap and the German-based price gap included. The dynamic specifications are the same as those in Tables 4 and 6.[29] In Austria, the comparison of explanatory power favors GAP^{f1} slightly, but GAP^{f1} is nonstationary and, judged by the most relevant comparison of performance shown in Table 6, GAP^{f2} again has more explanatory power. Overall, the evidence suggests that GAP^{f2} is the preferred measure for both empirical and theoretical reasons, except in Denmark, where GAP^{f1} is preferred. These gaps are shown in Figure 3 along with the domestic price gaps based on the broad money aggregate.

Table 5

ADF Unit Root Results: Price Gaps Relative to Germany (only MB)

Country	GAP^{f1}	GAP^{f2}
Austria	−1.52	−3.01*
	(C,1)	(C,1)
Belgium	−2.44	−3.36*
	(T,0)	(C,1)
Denmark	−3.72*	−3.60*
	(C,1)	(C,1)
Netherlands	−1.44	−3.02*
	(C,0)	(C,1)
Switzerland	−0.75	−2.72
	(C,0)	(C,0)

Note: The entries show the relevant test statistic; the information in parentheses indicates the use of a constant only, C, or a constant and trend, T, followed by the number of lagged dependent variables included. For the longest sample period used, the 5 percent significance level critical values are −3.57 and −2.96, with and without the inclusion of a trend, respectively.

The Impact of Foreign-Based Price Gaps

Table 8 restates the results of estimating equation 4 using the most appropriate foreign price gap for each country. For each of the five, small, European countries, Table 8 contains an equation with only the German-based gap included (from Table 6) and an equation with both the domestic gap and the German-based gap (from Table 7).

Comparing the results of Tables 4 and 8, a number of findings emerge:

[27]When linear trends are used to find equilibrium real exchange rates, output and velocity, the foreign-based gaps are not stationary, indicating that this approach to deriving the foreign-based P-star measure is inappropriate.

[28]The dynamic specifications used for the results reported in Table 6 follow those used in Table 4, although different specifications could have been used in two cases without changing the qualitative results. For Denmark, the lag of inflation is statistically significant at a 10 percent level (t= −1.83) when GAP^{f2} is used, but it is omitted in Table 6 to facilitate comparison to the GAP^{f1} case and to the Table 4 results. When this term is included using GAP^{f1} and GAP^{f2}, the comparable adjusted-R^2 are 0.266 and 0.240, respectively. For Switzerland, adding the first lagged dependent variable is statistically significant with either foreign gap; in this case, the adjusted-R^2 is 0.386 and 0.616 for GAP^{f1} and GAP^{f2}, respectively.

[29]For the Swiss equation, using GAP^{f1}, a lagged dependent variable is significant at a 10 perent level (t= 1.85), but it is omitted in the table to facilitate comparison with the equation containing the second foreign gap measure in which the lagged dependent variable is not statistically significant. When this lagged dependent variable is included with each foreign gap measure, the relevant adjusted-R^2 is 0.624 for the first foreign gap measure and 0.680 for the second foreign gap measure, so the comparison of the two remains unaffected.

Table 6
Comparison of the Impact of Two German-Based Price Gaps

	GAP^{f1}	GAP^{f2}
Austria	−11.07	−19.64
	(3.86)	(3.91)
	[0.406]	[0.411]
Belgium	−2.15	−24.02
	(0.58)	(3.52)
	[0.097]	[0.373]
Denmark	−16.73	−18.89
	(3.00)	(2.68)
	[0.216]	[0.176]
Netherlands	−10.73	−27.79
	(2.21)	(3.23)
	[0.168]	[0.288]
Switzerland	−4.52	−27.29
	(2.32)	(5.35)
	[0.293]	[0.583]

Note: In each cell, the top entry is the coefficient for the gap, the middle entry is the absolute value of the *t*-statistic and the $\bar{R}^2$ is the lowest entry given in brackets.

Table 7
Comparison of the Impact of Two German-Based Price Gaps, including Own Price Gap

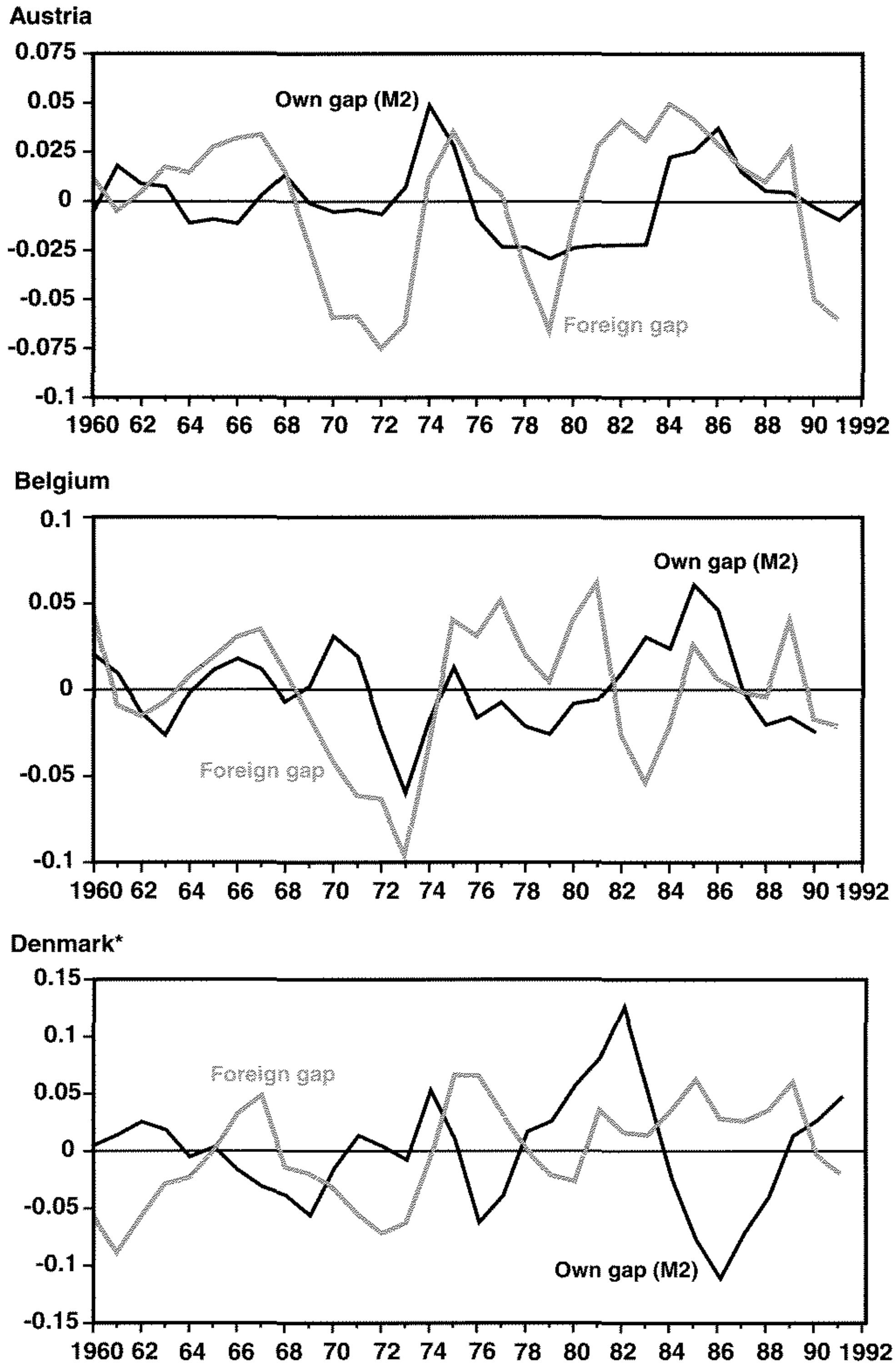
	GAP^2	GAP^{f1}	GAP^2	GAP^{f2}
Austria	−14.15	−9.81	−13.18	−17.39
	(1.41)	(3.32)	(1.30)	(3.31)
	[0.427]		[0.425]	
Belgium	−35.67	−2.62	−30.19	−20.80
	(3.37)	(0.83)	(3.39)	(3.54)
	[0.348]		[0.548]	
Denmark	−11.06	−20.08	−10.40	−22.53
	(2.38)	(3.75)	(2.16)	(3.29)
	[0.328]		[0.271]	
Netherlands	−35.79	−7.83	−24.72	−20.07
	(2.39)	(1.68)	(1.49)	(2.03)
	[0.288]		[0.318]	
Switzerland	−18.96	−3.58	−11.81	−19.19
	(4.64)	(2.40)	(2.66)	(3.47)
	[0.592]		[0.658]	

- The German-based gap provides greater explanatory power than the country's own domestic price gap when each is considered alone.
- Table 8 indicates that adding the German-based gap to a specification already containing the domestic gap (Table 4), on the other hand, always leads to a statistically significant improvement in the inflation model.
- In the case of Denmark, the addition of the foreign gap means the difference between rejecting the P-star model and not doing so. The closed economy model rejects the P-star model in Denmark, but the open economy model does not.
- Adding the domestic gap to the specification already containing the German-based gap leads to a significant improvement in the cases of Belgium, Denmark and Switzerland.
- Overall, the results are supportive of the hypothesis that the domestic price gap is of little importance under a regime of fixed exchange rates, but that, instead, current inflation developments at home are determined by monetary conditions abroad.[30]

A comparison across countries reinforces these conclusions. Austria, for instance, has been most closely linked to Germany over most of the sample, followed by the Netherlands. Consequently, no significant additional information is provided by their own domestic price gap, once account has been taken of Germany's impact. For Belgium and Denmark, on the other hand, both the domestic price gap and the German-based price gap are im-

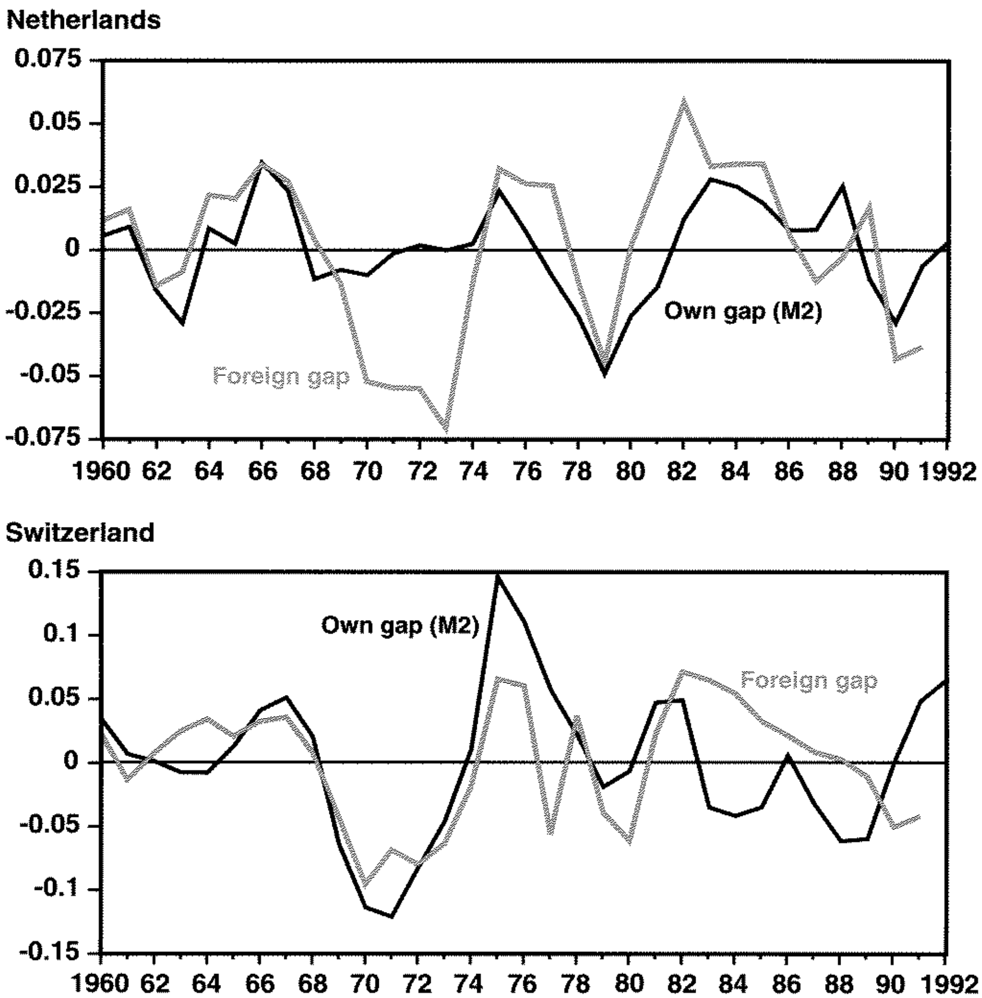
[30]The appendix shows that U.S.-based price gaps have had little impact on European inflation developments over the sample, regardless of the measure used. This provides additional support for our hypothesis that the exchange rate regime determines which price gaps are relevant, that is, to what "equilibrium" measure of prices, foreign or domestic, will actual domestic prices converge. Under floating rates, it should be domestic price gaps that matter, while under fixed rates, the foreign influence will increase. It is true that for a few years early in the period studied here, all these countries were pegged to the dollar, but the P-star influence of U.S. prices due to this experience is not statistically significant. Presumably, the period of the dollar peg in this sample is too brief for the dollar-based gap to be significant.

Figure 3
Domestic and Foreign-Based Price Gaps



*The average value of the log of the real mark exchange rate for Denmark was added to the foreign gap.

Figure 3 (continued)



portant. This may reflect the difficulties these two countries have experienced during the '70s and '80s in keeping their currencies' values and their inflation rates in line with Germany's. By infrequent devaluations, they have allowed their own monetary policy—and related domestic price gaps—to affect domestic inflation. Through their continued efforts to converge to German inflation levels over time, however, German price gaps have mattered as well.

The most interesting set of results is for Switzerland. In contrast with the other four small European countries under consideration, Switzerland has followed a floating exchange rate policy since the breakdown of Bretton Woods. As a result, the impact of German-based price gaps should be insignificant, according to the hypothesis. Our estimates, however, suggest that the German-based price gap has dominated the domestic Swiss gap in the sense that the former has more explanatory power, considered alone, than the latter.

Although far from conclusive, there are some possible reasons for this apparent anomaly. First, monetary policies in Switzerland and Germany have been quite similar during much of the sample period. Both countries faced similar inflationary pressures towards the end of Bretton

Table 8
Short-Run Inflation Equations Including a German-Based Price Gap

Country	C	π_{-1}	GAP^2_{-1}	GAP^{f2}_{-1}	$\bar{R}^2$	SEE	LM (4)	CHOW (77)	Last period
Austria	1.72	−0.39	—	−19.64	0.411	1.026	1.50	1.33	92
	(3.24)	(3.52)		(3.91)					
	1.62	−0.37	−13.18	−17.39	0.425	1.014	1.15	1.83	92
	(3.06)	(3.33)	(1.30)	(3.31)					
Belgium	1.46	−0.30	—	−24.02	0.373	1.381	0.77	3.05*	91
	(2.59)	(2.84)		(3.52)					
	1.45	−0.29	−30.19	−20.80	0.548	1.172	1.61	1.33	91
	(3.01)	(3.32)	(3.39)	(3.54)					
Denmark	−22.06	—	—	−16.73	0.216	1.296	1.73	0.34	91
	(3.01)			(3.00)					
	−26.48	—	−11.06	−20.08	0.328	1.200	1.96	0.44	91
	(3.76)		(2.38)	(3.75)					
Netherlands	1.00	−0.23	—	−27.79	0.288	1.562	0.78	1.94	92
	(1.78)	(2.30)		(3.23)					
	0.94	−0.22	−24.72	−20.07	0.318	1.529	0.34	2.78	92
	(1.71)	(2.23)	(1.49)	(2.03)					
Switzerland	2.42	−0.55	—	−27.29	0.583	1.306	1.49	0.83	92
	(4.27)	(4.83)		(5.35)					
	2.38	−0.55	−11.81	−19.19	0.658	1.184	1.39	0.52	92
	(4.63)	(5.31)	(2.66)	(3.47)					

Notes: For Denmark, the foreign gap used is GAP^{f1} instead of GAP^{f2}. LM (4) is a Breusch-Godfrey test on serial correlation of the residuals using four lags of the residual; it has a $\chi^2(4)$ distribution. CHOW (77) is a test on parameter stability with the break point in 1977; it follows an F-distribution.

Woods, and implemented similar monetary targeting policies in the mid-'70s to reduce inflation. Second, the Swiss franc and the German mark have been attractive—and closely substitutable—investment currencies in international portfolios. The Swiss results could also be interpreted as stemming from close coordination of monetary policies under floating exchange rates.[31]

Similar tests were conducted for the United States and German domestic P-star models to examine the power of the tests of the significance of foreign gaps reported here. In particular, foreign gaps constructed like the gap measure GAP^{f2}, using the five European countries, were constructed and added to the domestic P-star model for the United States and Germany. Also, a German-based gap was added to the domestic P-star model for the United States. In no case was one of the foreign gap terms statistically significant in the domestic model for the United States or Germany. This strengthens the evidence that in floating countries the appropriate P-star model is a domestic one, while the domestic P-star is determined by the anchor country in a fixed rate regime.

SUMMARY AND CONCLUSION

The systematic link between domestic money and the general level of prices is central to the P-star model, which emphasizes this long-run

[31]This is not equivalent to fixing nominal exchange rates, as evidenced by the appreciation of the Swiss franc during the time period considered (see Figures 1 and 2).

relationship as a determinant of short-run movements in the level of prices and inflation. Monetary authorities in countries with fixed exchange rate regimes do not determine their own long-run level of prices, however. Instead, their long-run equilibrium price level is imported from the countries whose currency is the basis of the peg. To varying degrees five, small open European countries have pegged their currency to the German mark. Economic theory suggests that, to the degree they did so, these countries' long-run equilibrium price levels and their inflation rates should be dominated by the German price developments, which, in turn, are presumably controlled by the Bundesbank. An open economy model of inflation in countries with fixed exchange rates must take into account the external basis of the equilibrium price level.

This article develops such a P-star model for domestic prices from 1960 to the 1990s in five European countries: Austria, Belgium, Denmark, the Netherlands and Switzerland. These economies border Germany and have, to varying degrees, fixed their domestic exchange rates based on a peg to the German mark. The evidence presented here shows that the open economy, fixed exchange rate P-star model is not rejected for the countries considered. The inflation model's fit improves for all five countries when allowance is made for the statistically significant foreign (German) influence on equilibrium domestic price levels during fixed exchange rate periods.

Perhaps the best example is Denmark, where the domestic P-star model is rejected. In the open economy model, however, the broad money-based domestic gap and the German P-star-based gap are both highly significant and with the correct sign, showing the importance of accounting for the foreign influence. Two other countries in which the domestic gap is significant in tests of the open economy model are Belgium, the other intermediate case, and Switzerland. In Austria and the Netherlands, where currencies have been most tightly pegged to the mark, the German-based P-star model outperforms the respective domestic models and, when included with the domestic gap, the domestic gap is not statistically significant.

Overall, the results confirm the long-run link between monetary aggregates and domestic prices for both closed or large, flexible exchange rate countries, as well as for fixed exchange rate countries. In the latter case, however, the evidence shows that the long-run equilibrium price level toward which domestic prices adjust is determined by foreign monetary policy.

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Appendix
Are European Prices Influenced By U.S. Monetary Policy?

The analysis in the text focuses on the connections between Germany and a number of small European countries with strong ties to Germany. A similar analysis can, of course, be applied to the United States in relation to the six European countries. Our maintained hypothesis suggests that under the floating exchange rate regime for the U.S. dollar over most of the period, European countries should have been insulated from inflationary or deflationary pressures arising from the United States. For the '60s and early '70s, on the other hand, U.S.-determined price gaps should have influenced Europe, because the United States was the anchor country in the fixed exchange rate system of Bretton Woods.

Figure 1 shows, however, that the relevant Bretton Woods period in our sample has been too short to perform a meaningful test of the significance of U.S.-determined gaps. Our regressions start in 1962 or 1963, depending on the lags included, and nominal exchange rates start moving in 1967-68, thereby reducing the potential impact of U.S. monetary conditions abroad. Thus, for our sample, we do not expect coefficients on U.S.-determined gaps to be significantly different from zero.

Table A1

ADF Unit Root Results: Price Gaps Relative to U.S. (only MB)

Country	GAP^{f1}	GAP^{f2}
Austria	−2.70	−3.35*
	(T,1)	(C,1)
Belgium	−2.67	−3.46*
	(C,1)	(C,1)
Denmark	−1.94	−3.32*
	(C,1)	(C,1)
Germany	−1.83	−3.43*
	(C,1)	(C,1)
Netherlands	−1.56	−3.08*
	(C,1)	(C,1)
Switzerland	−0.77	−3.20*
	(C,0)	(C,1)

Note: For the longest sample period used, the 5 percent significance level critical values are −3.56 and −2.96, with and without the inclusion of a trend, respectively.

First, we present test statistics on the stationarity of the relevant gap variables in Table A1. Gap definitions are similar to those in the main text, with Germany replaced by the United States. The results are very close to those in Table 5, where unit root statistics for German-based gaps are displayed. GAP^{f1} is nonstationary, while GAP^{f2} is stationary. Tables A2 and A3 are comparable to Tables 6 and 7, respectively, and have the same layout. Estimated gap coefficients are generally small in magnitude and insignificant. Only for Belgium are small significant coefficients found for GAP^{f1} and GAP^{f2} in Table A3. Overall, the evidence rejects a link from U.S. monetary conditions to inflationary pressures in Europe. This supports our hypothesis.

To address the issue of the potential impact of the United States on other countries during the Bretton Woods period adequately, a longer sample going back to the early '50s or late '40s would be required. This is left for future research.

Table A2

Comparison of the Impact of Two U.S.-Based Price Gaps

Country	GAP^{f1}	GAP^{f2}
Austria	−0.13	−0.63
	(0.13)	(0.30)
	[0.09]	[0.09]
Belgium	0.21	0.12
	(0.14)	(0.05)
	[0.09]	[0.09]
Denmark	−1.04	0.42
	(0.91)	(0.18)
	[−0.01]	[−0.03]
Germany[1]	−0.27	−1.04
	(0.27)	(0.56)
	[0.16]	[0.17]
Netherlands	−0.74	0.59
	(0.57)	(0.20)
	[0.03]	[0.02]
Switzerland[1]	−1.39	−3.35
	(1.41)	(1.25)
	[0.28]	[0.27]

[1]The specification includes a statistically significant lagged dependent variable which was not significant and not included in that used in Table 4.

Table A3

Comparison of the Impact of Two U.S.-Based Price Gaps, Including Own Price Gap

Country	GAP^{2}	GAP^{f1}	GAP^{2}	GAP^{f2}
Austria	−25.67	−0.57	−27.86	−2.12
	(2.23)	(0.61)	(2.39)	(1.04)
	[0.20]		[0.22]	
Belgium	−51.63	−3.53	−53.83	−5.71
	(4.34)	(2.37)	(4.57)	(2.65)
	[0.45]		[0.47]	
Denmark	−5.71	−0.79	−7.72	1.52
	(1.02)	(0.68)	(1.32)	(0.62)
	[0.00]		[−0.01]	
Germany	−29.97	−0.80	−30.60	−2.44
	(4.95)	(1.08)	(5.23)	(1.79)
	[0.51]		[0.55]	
Netherlands	−50.40	−1.96	−54.13	−4.14
	(3.31)	(1.68)	(3.20)	(1.40)
	[0.29]		[0.27]	
Switzerland	−19.51	−0.67	−21.80	1.64
	(4.34)	(0.85)	(4.38)	(0.67)
	[0.52]		[0.51]	