IMF Working Paper

WP/98/64

INTERNATIONAL MONETARY FUND

Monetary and Exchange Affairs Department

The Domestic and Foreign Price Gaps in the P-STAR Model: Evidence from Spain

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July 1998

Abstract

The paper uses the P-STAR model to analyze Spanish prices from 1970 to 1996, adding the foreign price gap to the standard domestic definition of the P-STAR model (the domestic price gap) to assess the role German price movements played in Spanish inflation. The domestic price gap turns out to be the major explanatory variable for inflation, even after the entrance of Spain in the exchange rate mechanism (ERM). This result suggests that the successful disinflation experienced in Spain in the past few years may be more related to domestic conditions than to foreign ones.

JEL classification numbers: E30, ES2

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SUMMARY

The P-STAR model is based on the assumption that a long-run equilibrium of prices (P*) exists. Deviations of the actual price level (P) from P* (defined as price gaps) indicate the amount of price adjustment that has not materialized yet, and they can be used to draw inferences about the future behavior of inflation.

The paper uses the P-STAR model to analyze Spanish price developments from 1970 to the end of 1996 and it breaks the sample period in two parts, before and after Spain's entrance in the European exchange rate mechanism (ERM). While most of the literature concentrates on the standard definition of the P-STAR model, which describes a closed economy, the paper includes the foreign price gap to account for the openness of the Spanish economy and the importance of foreign prices in the explanation of Spanish inflation. Given the importance of the Deutsche Mark as an anchor currency, especially after the entrance of Spain in the ERM, the behavior of foreign prices is proxied by German prices. The results show that the domestic price gap—composed of the output and velocity gaps—is the major explanatory variable for inflation, particularly before the entrance of Spain in the ERM but also thereafter. This finding suggests that the successful disinflation experienced in Spain in the past few years may be more related to domestic conditions (output and velocity gaps), rather than to foreign ones (German prices).

I. INTRODUCTION

For a long time, the quantity theory of money has been considered a useful tool to analyze empirically the relevance of money in the economy. During the 1980s, however doubts about the usefulness of the quantity theory in the short run arose because of the perception that the links between money and prices, and money and output had weakened or simply vanished. The changes in velocity developments during the last decade were the main reason for this change of perception.[1]

The P-STAR model introduced by Hallman, Porter and Small (1991) has drawn new attention to the quantity theory by explicitly linking the determinants of long-run equilibrium prices to the short-run dynamics of prices. The underlying assumption of the P-STAR model is that a long-run equilibrium exists and that it can be used to draw inferences about the short-run behavior of inflation. If the actual price level deviates around some long-run equilibrium level, then movements in prices can be predicted using the magnitude and direction of this gap. Price levels lower than the equilibrium can be expected to rise to the long-run equilibrium level. Similarly, a reduction in prices can be predicted if the price level is above the long-run equilibrium level. In the standard definition of the P-STAR model, the deviation of prices from the long-run equilibrium level is explained in terms of a monetary and real component, derived from the quantity equation. Under the assumption of a stable long-run relation between money and income, both the monetary and the real component of the price gap provide statistically significant and independent information about future price inflation.

The empirical results obtained so far for a wide set of countries are supportive of the P-STAR model, although it appears to have worked better for larger countries than smaller ones, particularly if the latter were under a fixed exchange rates regime.[2] Recent studies have attempted to solve for the possibility of money endogeneity in smaller countries under a fixed exchange rate regime by introducing a foreign price gap to account for changes in macroeconomic variables of large 'neighbor' countries. A neighbor country may be defined as one with strong trade relations with the country being studied or an anchor country from which inflation or deflation could be imported via the exchange rate link. Kool and Tatom (1994) find evidence that price levels in five European small economies are determined, at least in part, by German prices and that this effect is proportional to the tightness of the exchange rate peg.

The format of the paper is as follows: In the next section, the P-STAR theoretical framework is developed, focusing first on the standard P-STAR model, following the approach of Hallman, Porter and Small (1991). Then, following Kool and Tatom (1994) a variant of the monetary approach to the balance of payments is introduced as a theoretical basis to include the impact of foreign prices in the P-STAR model.

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[1]For a review of past discussions on this issue see Dewald (1988).

[2]See, for example, Hoeller and Poret (1991).

II. CONSTRUCTION OF THE P-STAR MODEL

The P-STAR analysis uses the 'price gap' as an indicator of inflation in the domestic economy—the price gap being defined as the deviation of the actual price level (P) from its equilibrium level (P*) or else the amount of price adjustment that has not been materialized yet in order to reach P*. We will first construct the domestic price gap, the only component of the standard P-STAR model and then the foreign price gap, foreign prices being very important for an open economy, such as Spain.

The domestic price gap

The domestic price gap originates from the deviation of the actual price level from its domestic long-run equilibrium level (P*). Following the equation for the quantity theory of money, P will be determined by:

$$P=\frac{MV}{Y} \tag{1}$$

where M stands for the money stock, V for actual velocity, and Y for real output. The equilibrium domestic price level, P*, is assumed to be the level to which prices converge in the long run and is determined by:

$$P^*=\frac{MV^*}{Y^*} \tag{2}$$

where V* stands for the long-run equilibrium velocity and Y* for the long-run equilibrium output.[3] Writing the equation in logs and manipulating, we have an equation for the Domestic Price Gap :

$$(Gap)_d = (p^*-p) = (y-y^*) + (v^*-v) \tag{3}$$

Different approaches have been taken in the literature in defining potential values of output and velocity—and therefore the output and the velocity gaps. Christiano (1989), Hannah and James (1989) use linear trends for potential output. For potential velocity, a linear trend is used in some cases particularly in countries where velocity has clearly followed a downward- trend, (Bank of Japan, 1990) while Christiano (1989) calculates a simple average value. More recently, more advanced techniques have been applied to calculate potential output and velocity. Hoeller and Poret (1991) use the Hodrick-Prescott filter, and Bomhoff (1990) uses the Kalman filtering approach. Structural models have also been introduced in the literature for the calculation of potential output and velocity. The Bank of Japan uses an

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[3]Note that M is the same as in equation (1) because what P* intends to measure is the price level that would be attained at the actual money stock if real output and velocity were at their equilibrium level.

aggregate production function framework to calculate potential output, while Ebrill and Fries (1990) calculate potential velocity from a cointegration equation explaining long-run velocity by own and competing rates of return of M2. Finally, Coe and McDermott (1996) carry out a non-parametric estimation to compute equilibrium values for the output and velocity series. For our analysis, we use the Hodrick-Prescott filter to extract equilibrium time series for real output and velocity from the data, following the conclusions reached by Holler and Poret (1991) in an application of the P-STAR model to 20 countries. Holler and Poret find that for the case of Spain the Hodrick-Prescott filter gives better results than a linear trend. Using the Hodrick-Prescott filter, we detrend the velocity and output series into their long-run and short-run components,[4] obtaining in this manner their potential values (V* and Y*). The deviations of actual values from their potential values result in the output and velocity gaps. Using these gaps according to equation (3), the domestic price gap is obtained.

The foreign price gap

The foreign price gap is based on the assumption that a small country is committed to a fixed exchange rate objective with a neighbor country. If the neighbor country becomes the anchor country, the small country will take the anchor country's monetary policy as given. Using the generalized monetary approach to the balance of payments followed by Kool and Tatom (1994), the exchange rate constraint determines the equilibrium domestic price level (P^{d*}) for a small country as:

$$P^{d*} = E(P^{f*})/ER^* \tag{4}$$

Where E is the nominal exchange rate, ER* is the corresponding equilibrium real exchange rate and P^{f*} is the equilibrium price level in the foreign country.[5] The fact that two exchange rates, the actual one (E) and the equilibrium real exchange rate (ER*), are included in the definition of the domestic price level (Equation 4) is based on the assumption that the Purchasing Power Parity (PPP) holds only in the long run.[6] With the domestic price level conditioned by equation (4), the domestic money stock must adjust to bring about equilibrium in the domestic money market. For this reason and taking logs, the foreign price gap is determined as:

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[4]For a discussion of the Hodrick-Prescott Filter, see Stadler (1994).

[5]Note the construction of P^{f*} is similar to that of P* in equation (2).

[6]In the traditional pure monetary approach to the balance of payments (in which the PPP always holds), the real exchange rate is assumed to be a constant and may be deleted from the analysis.

$$(Gap)_f = (p - p^{d*}) = [(p^{f*} + e - e^{r*})] \quad (5)$$

When domestic prices exceed the foreign-determined equilibrium price level, there is downward pressure on current domestic inflation if the above equation is to hold. Alternatively, the gap could be reduced by the devaluation of the domestic currency. Since we prefer to assume that the PPP only holds in the long run, which is less restrictive and more consistent with the data, the equilibrium real exchange rate is not a constant. We thus need to use the Hodrick-Prescott filter to determine the equilibrium real exchange rate.

III. Econometric Specification of the P-STAR Model

The domestic price gap

The relationship between the domestic price gap, the output gap and the velocity gap is set in an econometric specification to explain inflation. Following the literature, the output and velocity gaps are given equal weights in the construction of the domestic price gap.[7] This is the implicit equivalent of using the output gap and the velocity gap as separate regressors with their coefficients constrained to equal each other. The general to specific approach to modeling was chosen in order to avoid mis-specification problems. The most general Auto-regressive Distributed Lag model (ARDL) would be:

$$\Delta p_t = \alpha + \beta_1(p^*-p)_t + \beta_2\Sigma i\Delta p_{t-i} + \beta_3\Sigma_i((p^*-p)_{t-i} + e_t \qquad i=1,..n \quad (6)$$

where (p^*-p) is the domestic price gap, $(Gap)_d$, defined in equation (3) and β should be a positive coefficient to reflect the acceleration in inflation as the price gap increases.[8]

To see the prior of the sign for the β coefficient more clearly, we will consider the effects of the two components of the domestic price gap on the change in prices. Consider a situation where actual output is below potential output. An increase in aggregate supply would raise actual output toward the potential level leading to a reduction of the output gap. This would tend to reduce the domestic price gap through a fall in prices. Similarly, starting from a situation where actual velocity is below potential, an increase in velocity would narrow the velocity gap, which would also reduce the domestic price gap through a fall in prices.

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[7] A valid test for linear restrictions was conducted to make sure that the restriction of equal coefficients for the output and velocity gaps could be carried out.

[8] The choice of the appropriate number of lags of the dependent and independent variables will be based on a number of criteria including the Schwarz-Bayesian Criterion and tests for model reduction.

Capturing the foreign price gap effect

We now extend the traditional P-STAR model by adding the foreign price gap to the domestic price gap, following Kool and Tatom (1994). From equation (5), the foreign price gap is defined as:

$$(Gap)_f = [(p^{f*} + e - er^*) - p]$$

Akin to the two components of the domestic price gap (output and velocity gaps), the foreign price gap should also have a positive coefficient. In fact, a depreciation of the exchange rate away from its equilibrium level, given the equilibrium foreign price level, will widen the foreign price gap, and inflation will rise.[9]

The previous general specification is, therefore, extended to:

$$\text{Price Gap } (p^*-p) \;=\; \text{Domestic Price Gap } (Gap)_d + \text{Foreign Price Gap } (Gap)_f$$

This implies:

$$(p^*-p) = [(y-y^*) + (v^*-v)] + [(p^{f*} + e - er^*) - p] \qquad (7)$$

The Domestic Price Gap and the Foreign Price Gap are used as separate regressors in the econometric specifications and no restrictions are placed on their coefficients. Including the more general price gap determined by (7) into (6) we can see that inflation is likely to rise when output is above its equilibrium level (probably because of higher than usual aggregate demand), and where there is more money in the economy than it would be warranted by the equilibrium velocity. Inflation is also likely to rise when the exchange rate is more depreciated than what would be its equilibrium level.

The domestic price gap versus the foreign price gap

While following the literature, the velocity and output gaps were constrained to have the same coefficient, the domestic and the foreign price gap were not.[10] Indeed, the question to be analyzed is whether a particular gap (the domestic or the foreign price gap), or both, explains inflation developments better for the case of Spain. Given the structural change that Spain went through with its entrance in the ERM in June 1989, the sample period (1970–1996) is divided into two periods: before and after June 1989. A flexible model needs

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[9]The choice of the appropriate number of lags will be determined as previously described for the domestic price gap.

[10]This again follows the literature on P-STAR models for small open economies (see Kool and Tatom, 1994).

to be run to include each or both of the gaps for each of the periods. To this end, we implement interactions between the domestic and foreign price gaps and dummy variables are created to differentiate between the effects of these gaps in the two subperiods. The advantage of using the dummy interaction approach is that the importance of each of the gaps can be assessed separately for each period. Thus, we may be able to identify, for example, a prior of a strong effect of the foreign price gap in the period of fixed exchange rates and relatively weaker effect of that gap in the period of flexible exchange rates. Similarly, we should be able to observe whether the prior of the reduced importance of the domestic price gap after June 1989 holds.

IV. Monetary Policy and Inflation Developments in Spain

In the early 1970s, the Bank of Spain did not have an official policy target but, in practice, the exchange rate was used as a nominal anchor. Interest rates were controlled administratively. The oil shock of the early 1970s ended a period of fixed exchange rates and the Bank of Spain switched from managing the exchange rate to targeting the money supply. The decision of monitoring the rate of growth of money supply was based on the assumption that a close relationship between money and nominal income existed. A broad monetary aggregate, M3, was chosen because of its closer relationship with nominal income and a band was set for the rate of growth of M3. To allow for greater flexibility, apart from the money supply target, the Bank of Spain started to use an instrumental target based on the evolution of liquidity in the banking system. However, with the fast development of the Spanish financial markets in the early 1980s, M3 became less and less related to income developments (see Escriva and Malo de Molina, 1991). Furthermore, the instrumental target based on the evolution of liquidity in the banking system was also distorted due to the banking crisis that Spain underwent in the early 1980s. Eventually, in 1984, the Central Bank decided to move to a broader monetary target, the ALP.[11]

In the following years, the maintenance of moderate interest rates acquired more importance as a short-run target in order to foster the economic recovery that had just started after several years of recession. Notwithstanding the importance that the Bank of Spain gave to interest rate stability, interest rates were allowed to move when inflationary pressures emerged or the exchange rate was under attack. Since 1986, when Spain entered the European Community, the exchange rate objective became more and more relevant. However, the high interest rates that needed to be maintained to reduce inflation, coupled with the authorities' informal exchange rate commitment, attracted large capital inflows, putting appreciating pressure on the Spanish peseta. The substantial sterilization that the Bank of Spain had to undertake to stabilize the exchange rate led to sharp movements in the ALP. In light of this increased instability, the ALP became less and less of an intermediate target for the Bank of Spain.

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[11]The ALP (activos liquidos en manos del público) are liquid assets that include final assets that are substitutes to deposits.

With the entrance of the peseta in the ERM in June 1989, maintenance of the exchange rate within the ±6 band against the other ERM currencies became the overriding objective of monetary policy (together with keeping inflation under control). The behavior of the ALP was only a reference that warned possible inconsistencies between the domestic target (inflation) and the external target (the exchange rate). Persistent sterilization was required to keep the Peseta from appreciating above the permitted band of fluctuation. At the same time, inflation started to be monitored more closely through the control of potential sources of inflationary pressures. One of the most important sources was the increase in credit that could stem from the capital inflows. To control credit, the Bank of Spain introduced an informal quantitative restriction on credit (based on moral suasion) just after the peseta entered the ERM.

With the ERM crisis in October 1992, the devaluation of the peseta and the subsequent widening of the ERM bands allowed for some more flexibility in the conduct of monetary policy. In this context, a direct target on inflation was introduced and the growth of the ALP remained a key information variable to monitor. More recently, the efforts made by the Spanish authorities to be in the first group of countries joining the European Monetary Union (EMU), have again brought to the forefront the objective of stability of the exchange rate— being one of the Maastricht criteria—but the inflation target has remained the Bank of Spain's main objective of monetary policy.[12]

In the context of such monetary and inflation developments in Spain, we will try to assess, using some graphs describing price output and velocity developments, whether the P-STAR model can be of use to explain inflation in the period 1970–1996.

Figure 1 shows the evolution of real GDP. From 1970 to just before the first oil crisis, GDP growth was relative high, compared to Europe. In 1973–75, two supply shocks occurred: an external shock coming from the oil crisis, and a domestic one stemming from the substantial increase in real wages as soon as democracy was reestablished in Spain. The two shocks altered the relative prices of the production factors, and led to a surge in inflation and a reduction in real growth (Figures 1 and 2). Inflation accelerated again in 1977, just before the Moncloa Agreements were reached to stabilize the economy. Under the Moncloa Agreements, a very restrictive monetary policy was pursued, which further depressed economic growth. When the second oil crisis erupted in 1979, the Spanish economy was already in a recession which lasted until 1981. With the arrival of the Socialist party to power in 1982, the Bank of Spain continued with its restrictive monetary policy, which was accompanied by a reduction of excessive wage increases. This led to a slow recovery of the recession during 1982 to 1985. From 1985 onwards, an expansionary fiscal policy was conducted and the Spanish economy entered a boom period. Growth rates from 1986 to 1988 continued to be high relative to other European countries but the overheating of the economy led to relatively high inflation. Economic growth started to decelerate in 1989 and in 1992, at the time of the ERM's

[12]For a more detailed description of Spain's monetary parity see Ayuso and Scriva (1997).

Figure 1: Actual and Potential Real Output and Growth of Actual Output 1/

(In logs)

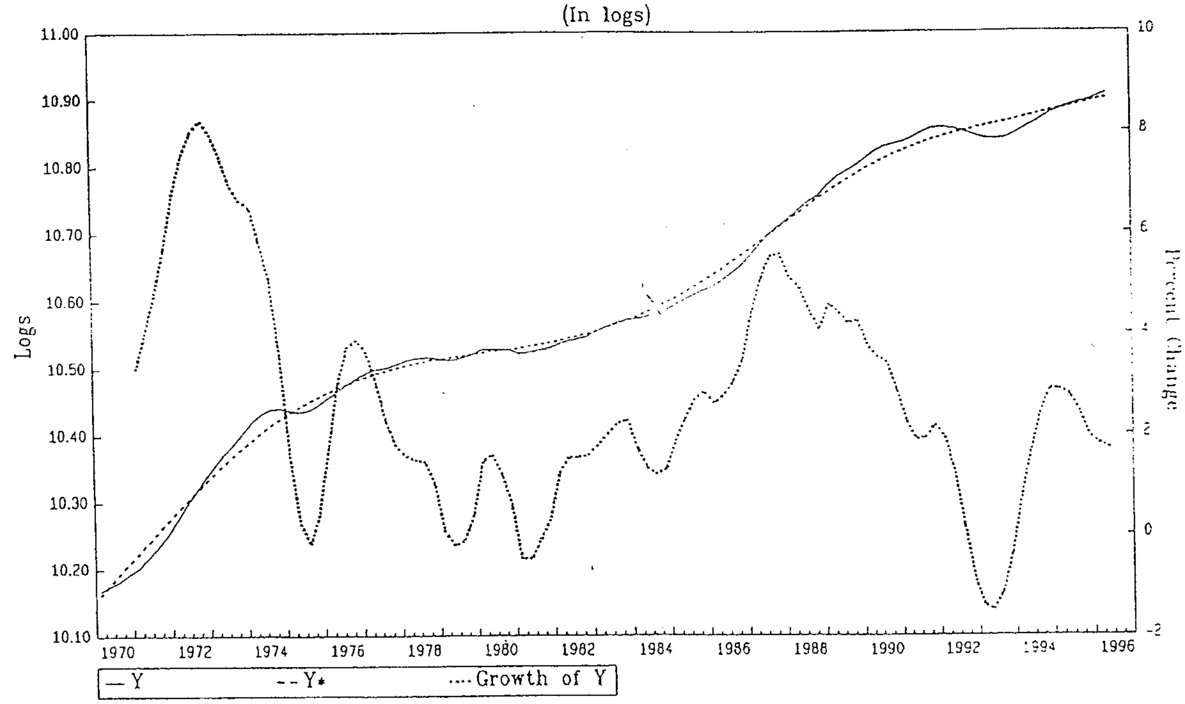
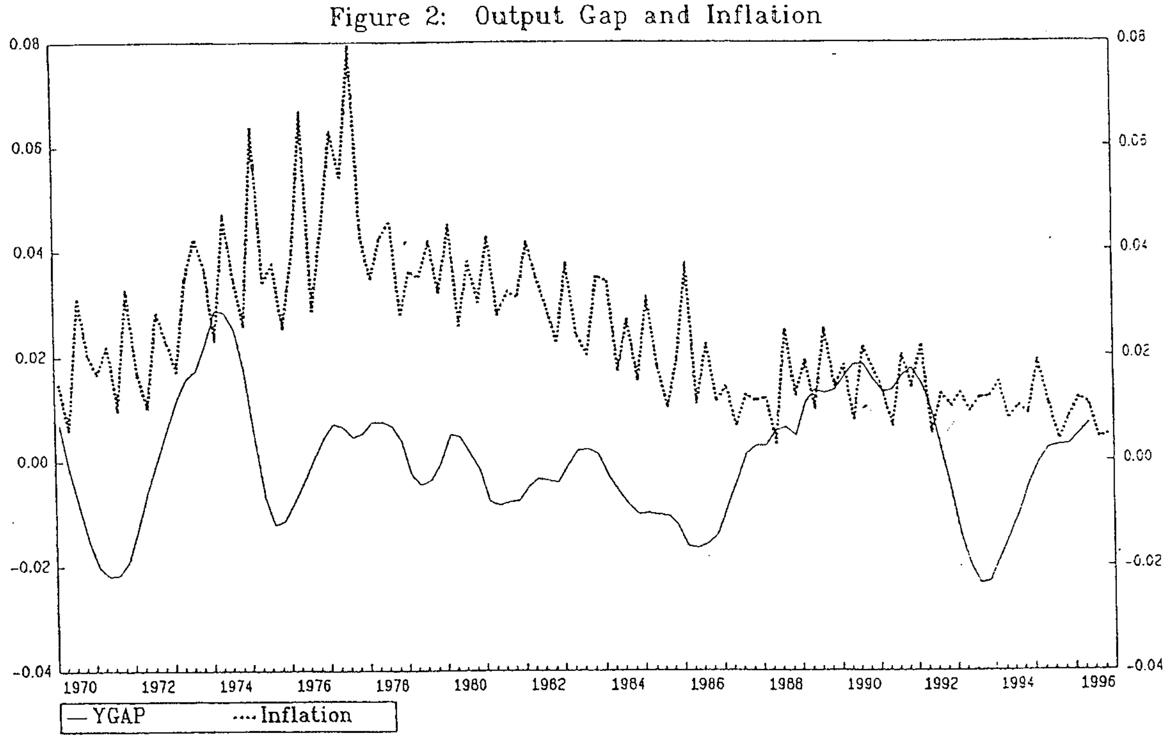


Figure 2: Output Gap and Inflation



1/ Potential real output has been calculated using the Hendry and Prescott filter.

collapse, the country entered the sharpest recession of the last decades. The economy started to recover in 1993, in part due to the devaluation of the Spanish peseta and the improved business cycle in the rest of Europe.

Figure 2 depicts the relation between the output gap and inflation. As the model would predict, there were periods of increased capacity utilization (from situations in which output was below potential) when inflation accelerated. This was the case just before the first oil crisis (1971–73) and just after democracy was reestablished (1975–77). However, the downward-trend in capacity utilization (from positive levels) after the first oil crisis was not accompanied by a reduction in inflation as the model would predict. Finally, the increase in capacity utilization (from negative levels) in the late 1980s did not lead to a surge in inflation either.

Figure 3 shows the evolution of velocity. It broadly followed a downward-trend during the sample period but especially since 1977. Actual velocity was below potential velocity during the early and mid-1970s and reached levels well above potential in the late 1970s. These sharp changes in velocity were due not only to financial innovation but also to the banking crisis that Spain underwent from the late 1970s to the early 1980s.

Figure 4 shows the relation between the velocity gap and inflation. Compared to the output gap, the velocity gap explains better the price movements in the mid-1970s (just after the oil crisis), because of the sharp increase in velocity, above its equilibrium level, that occurred at that time. However, the velocity gap does not contribute to explaining the disinflation of the early 1990s and performs badly during the late 1970s as well, when velocity started to fall from very high levels and the velocity gap became negative.

Figure 5 shows the relation between the domestic price gap, measured as the sum of the output and velocity gaps, and inflation. The importance of adding the velocity gap lies on the better explanatory power of the domestic price gap in the period after the first oil crisis (mid- 1970s). As regards the disinflation of the 1990s, the poor explanatory power of the model could be due to the misspecification of the traditional P-STAR model. Indeed, it only includes the domestic price gap for a small economy which was committed to maintaining the exchange rate within a relatively narrow band for a good part of the sample period—from June 1989 until the ERM broke down in October 1992 and again recently with Spain's commitment to be a first-round member of the EMU. The foreign price gap was, therefore, included in the model, and as will be shown later, increases the model's explanatory power of the 1990s disinflation period. (We use the Spanish Peseta exchange rate against the Deutsche Mark, rather than the nominal effective exchange rate, because Germany's monetary policy, as ERM's anchor country, is supposed to have been more important for the determination of Spanish inflation than monetary policy in the main trade partners.)

Figure 3: Actual and Potential Velocity and Growth of Actual Velocity 1/

(In logs)

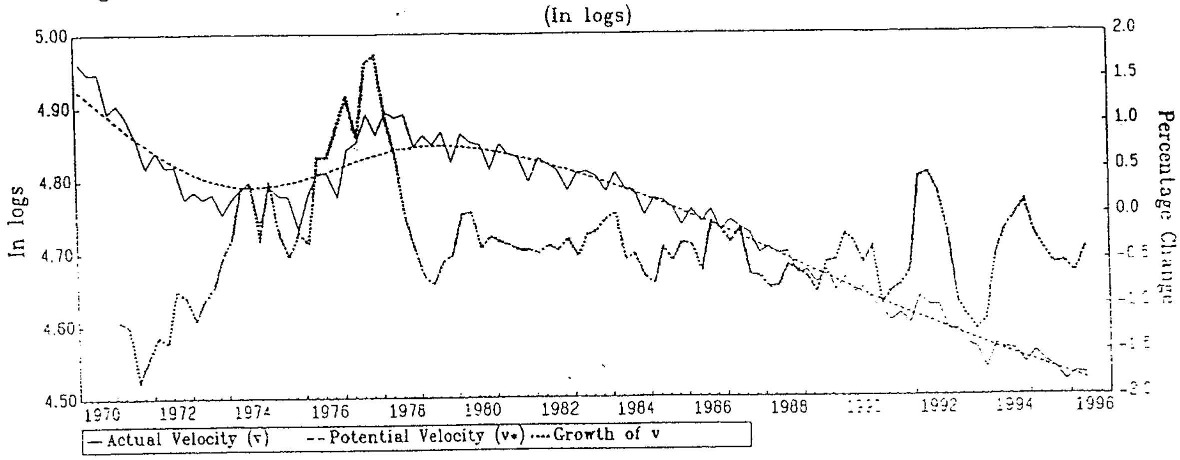


Figure 4: Velocity Gap and Inflation

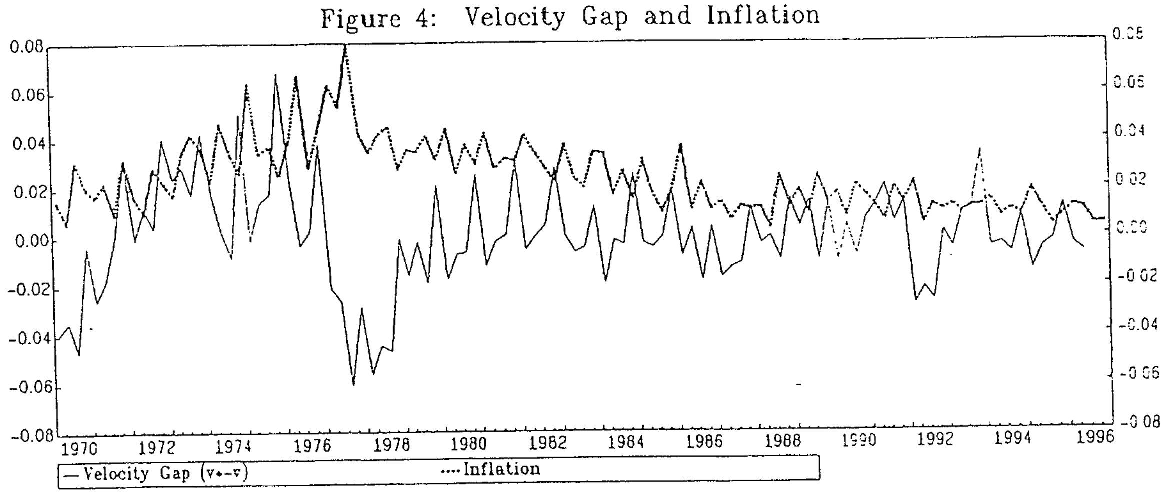
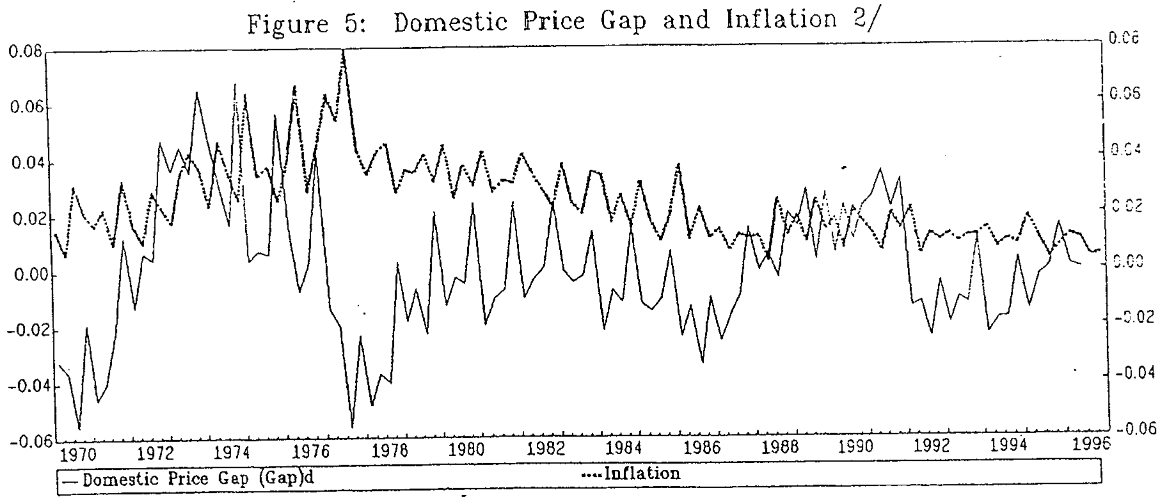


Figure 5: Domestic Price Gap and Inflation 2/



Source: International Financial Statistics.

1/ Velocity has been calculated for the ALP. Potential real output has been calculated using Hendry and Prescott filter.

2/ The domestic price gap has been constructed adding the output and velocity gap (y-y* and v-v*) with equal weights.

V. Data Description

We use Spanish data and German price and exchange rate data from the International Financial Statistics of the International Monetary Fund. The quarterly data series span from 1970 to 1996. The measure of prices and inflation in the economy is the Consumer Price Index (CPI). The output variable is GDP at 1990 prices. The German CPI and the DMark-peseta exchange rate (calculated as a cross rate from the U.S. dollar-peseta and U.S. dollar-DMark) are also taken from the IFS. Following the result that broader monetary aggregates yield better performance for a purely domestic P-STAR model (García-Herrero and Ortiz, 1994), we chose a broader measure of money, the ALP. The Hodrick-Prescott filter is used to obtain the potential values of all the series (real output, velocity, the DMark-peseta exchange rate and German prices) and is set at the conventional bandwidth for quarterly data, i.e., 1600.

We employ dummy variables and have them interact with the domestic and foreign price gaps to identify the effect of these gaps before and after June 1989. The interaction terms are constructed as follows: The variable in question is multiplied by step dummies which have a value of 1 for the period of June 1989 onwards and 0 for the period before. The first interaction variable is defined as the domestic price gap times the step dummy. This allows the interaction term to take the values of the domestic price gap from June 1989 onwards and 0 before. The second interaction variable is the product of the foreign price gap times the step dummy. Like the first interaction term, this variable takes the values of the foreign price gap after June 1989 and 0 before. With the introduction of the dummy interaction for the domestic price gap, the effect of the domestic price gap on inflation after June 1989 is given by the sum of the coefficients of the domestic price gap variable and the coefficient of the dummy interaction variable. The same applies to the foreign price gap and its corresponding interaction variable. As a variant of the two previous models specifications, we use the step dummy approach to allow the domestic price gap and/or the foreign price gap to be active prior to June 1989 (and not in the period thereafter).

VI. Econometric Results

Data properties

The Engle-Granger methodology is used to test for cointegration.[13] The levels of the components of the domestic and foreign price gap cannot reject the Augmented Dickey-Fuller (ADF) test for a unit root but their first differences do. This leads to the conclusion that these variables may be classified as I(1) variables. A necessary condition for cointegration is that the cointegrating relationship among I(1) variables should yield an I(0)series. ADF tests show that

[13]Structural techniques, such as the Johansen procedure, would not have proved useful, all gaps (output, velocity and foreign price) being stationary series.

the hypothesis of a unit root of the residuals can be rejected, and that the residuals are therefore I(0) (Table 1). The foreign price gap, however, cannot reject the hypothesis of a unit root. Thus, the inferences drawn from the analysis of the foreign price gap should be dealt with caution.[14]

Table 1. ADF Test Statistics for Price Gaps

Variable Name	t-adf	betaY_1	Critical 5%	Critical 1%
$(Gap)_d$ Trend included	-5.9153**	0.4925	-1.943	-2.586
$(Gap)_f$ Constant and trend included	-0.9486	0.9809	-3.444	-4.029

Estimation results

A first set of results compares the coefficients obtained when considering the domestic and foreign price gaps for both periods in the sample (Table 2). For the domestic gap, the prior of a positive coefficient holds in all model specifications, and the size of the coefficient is robust to changes in the lag structure. The size of the coefficient indicates an adjustment of prices to their long-run level of approximately 17–18 percent a quarter.

A way to assess the relative importance of the domestic gap after the entrance of Spain to the ERM is to introduce a step dummy that interacts with the domestic price gap for the second part of the sample—from June 1989 onwards. As expected, the introduction of the dummy interaction reduces the coefficient of the domestic price gap to an adjustment speed of around 10–11 percent a quarter. This implies that the response of domestic prices to the domestic price gap decreases as the economy switches to a fixed exchange rate.

For the foreign price gap, the prior of a positive coefficient holds as well. Notwithstanding its statistical significance, the coefficient is very small in size, suggesting that the adjustment of Spanish prices to the foreign-determined equilibrium level is very slow. This is especially true for the first period of the sample, before Spain entered the ERM, as can be shown when comparing the extremely low coefficient of the foreign price gap for the full sample to the relatively higher coefficient of the foreign price gap in the second period. This comparison has been performed employing the dummy variable interaction technique, previously mentioned.

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[14]Kool and Tatom (1994) encounter a similar problem in the case of Denmark: the ADF test cannot reject the hypothesis of a unit root for the residuals of the foreign price gap but this is introduced as an explanatory variable of inflation anyway accompanied by a word of caution.

Table 2. Preliminary Results Using Interaction Dummies

Variable	Coefficients
Constant	0.002946
	1.169
Dp_1	0.10085
	1.115
Dp_2	0.17355
	2.076
Dp_3	0.29352*
	3.555
Dp_4	0.25193
	2.912
$[(Gap)_d]_{-1}$	0.17274*
(Both periods)	*4.297*
$[(Gap)_d]_{-1}$	-0.05445
(Active in second period only)	*-0.546*
$[(Gap)_f]_{-1}$	0.00318
(Both periods)	*1.531*
$(Gap)_f]_{-1}$	0.017000
(Active in second period only)	*0.67*

On the basis of these preliminary findings, five different specifications of error corrections models (ECM) for the P-STAR were constructed to assess the relative importance of the domestic and foreign price gaps in Spain (see Table 3 for a summary of the five different specifications). The exclusion of a variable (foreign or domestic price gaps) in the first period is equivalent to restricting its coefficient to zero in the first period. If the variable excluded were relevant, though, the coefficient of the remaining variables would be biased upwards due to the omitted variable bias problem. However, if the variable excluded were irrelevant, we should see little or no change in the coefficient of the remaining variables and perhaps an improvement in the standard errors.

Table 3. Specification of Price Gap Terms in Models Employed

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
$(Gap)_d$ (both periods)	✓	✓	✓	✓	
$(Gap)_d$ (Active in second period only)		✓	✓		
$(Gap)_d$ (Active in first period only)					✓
$(Gap)_f$ (Both periods)	✓	✓			
$(Gap)_f$ (Active in second period only)			✓		✓

Model reduction tests appear to rule weakly in favor of Model 1, the most general specification of the P-STAR model (domestic and the foreign gap included for the full sample),[15] that is

$$\Delta p = \beta_0 + \Sigma_{i=1,2,3,4}\beta_i \Delta p_{t-i} + \beta_5[(gap)_d]_{t-1} + \beta_6[(gap)_f]_{t-1} + e$$

This indicates that both gaps are relevant throughout the full sample, but the size of the coefficients shows that the foreign price gap plays a much smaller role in explaining Spanish price movements. The low significance of the foreign price gap may be related to the absence of a cointegrating relationship, which could imply spurious results, but it could also indicate that German prices were not such a powerful source of information in the sample period.

Table 4 summarizes the results of the five ECM specifications and Table 5 ranks the 5 models from best to worst fit in terms of the residual sum of squares, sigma parameter and the Schwarz-Bayesian Criterion. As previously mentioned, Model 1 appears to be marginally superior to Model 2 and clearly superior to the rest of the models.

A look at the fits of the various models employed shows some interesting results. A good part of the movements in prices is auto-regressive and thus can be explained by an ARMA(1,1) process. Nevertheless, any definition of the P-STAR model, especially the most general one (Model 1), is clearly superior to the ARMA(1,1) process (Table 4 and Figures 6 and 7). The very slight differences between Model 1 which includes both gaps in both periods, and Model 2, which excludes the foreign gap in the first period, could indicate that German prices played a very small role in determining Spanish prices prior to the entrance of the peseta in the ERM. As would have been expected, Model 2, which excludes the foreign price

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[15]Model reduction tests involve a combination of tests and comparisons of the residual sum of squares, standard error, and Schwarz Bayesian Criterion.

Table 4. Estimation Results

	Model 1	Model 2	Model 3	Model 4	Model 5
Model Statistics					
R^2	0.659	0.660	0.645	0.636	0.641
Overall Sig. (F-Test)	31.938	27.163	25.480	28.768	29.407
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
Sigma	0.009	0.009	0.009	0.009	0.009
Diagnostic Tests					
AR 1- 5 (F-Test)	1.710	1.710	1.613	1.520	1.436
	0.140	*0.140*	*0.164*	*0.191*	*0.218*
ARCH 4 (F-Test)	0.772	0.743	0.689	0.866	0.713
	0.546	*0.565*	*0.601*	*0.487*	*0.585*
Normality (Chi^2)	23.144 **	23.532 **	21.049 **	20.706 **	20.863 **
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
Xi^2 F(12, 86) =	1.695	1.403	1.206	1.471	1.373
	0.082	*0.170*	*0.287*	*0.151*	*0.195*
Xi*Xj F(27, 71) =	2.743 **	1.981 **	1.760 **	2.157 **	2.455 **
	0.000	*0.010*	*0.027*	*0.006*	*0.002*
RESET (F-Test)	0.082	0.196	0.906	0.337	0.634
	0.776	*0.659*	*0.344*	*0.563*	*0.428*

Note: The figures in italics are the t-values and ** indicates that the coefficients are significant at the 5 percent level.

Table 5. Comparison Between Alternate Specifications

Model	Dep. Var	RSS	Sigma	Schwarz
1	Dp	0.00749785	0.00879188	-9.22493
2	Dp	0.00788927	0.00897233	-9.15373
3	Dp	0.00822546	0.00916151	-9.11200
4	Dp	0.00845487	0.00924136	-9.12849
5	Dp	0.00833706	0.00917675	-9.14252

gap in the first period, is accepted more readily than Model 3, which excludes the foreign gap in the second period (Figure 8).

Comparing Model 3 with the other models shows that the exclusion of the foreign price gap in the second period leads to a worse fit (Figure 9). Model 4, which excludes foreign prices throughout the full sample, also fits inflation worse than Model 1 (Figure 10). Comparing Model 5, which excludes foreign prices in the first period and domestic prices in the second period, with Model 1, we conclude that using the foreign price alone in the second period clearly overstates inflation (Figure 11). The fact that disinflation during the second period, and especially after the devaluation of the peseta in October 1992, cannot be explained by the foreign gap suggests that the recent successful disinflation in Spain may be more related to domestic conditions (output and velocity gaps) rather than to foreign ones (German prices).[16] Nevertheless, the fact that the fit of the model is particularly poor in the early 1990s points to the importance of the structural changes recently experienced by the Spanish economy for explaining disinflation. Some of those structural changes, such as labor reform, are clearly not imbedded in the P-STAR model.

[16]Another possible explanation described in Murgasova, 1996, is based on the structural change that occurred in the exchange rate pass-through in recent years, whereby large depreciations would not lead to a surge in inflation. Such structural changes are not imbedded in the P-STAR model.

Figure 6: Parameter Stability Tests for the Domestic Price Gap

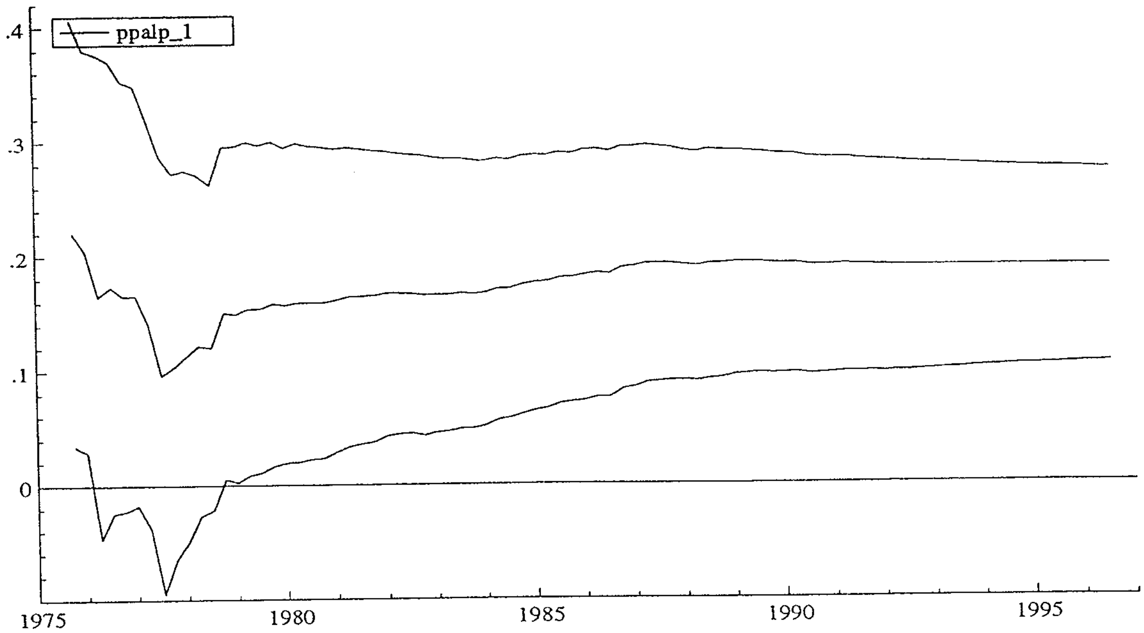


Figure 7: Parameter Stability Tests for the Foreign Price Gap

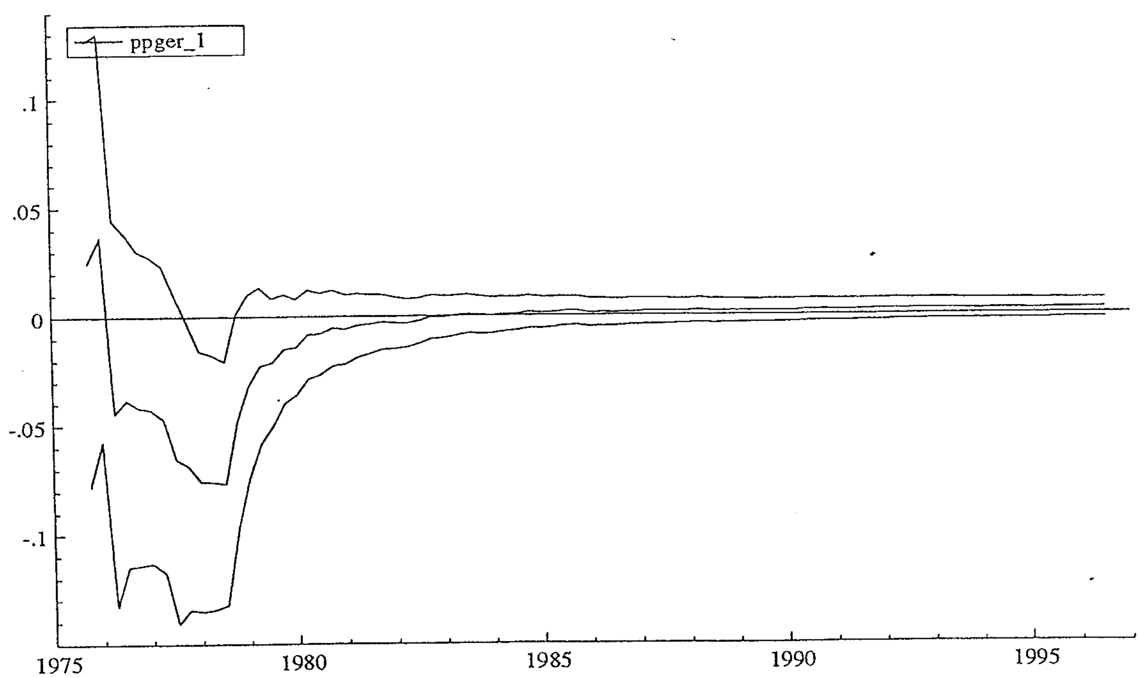


Figure 8: Actual Inflation and Fitted Values for Model 1

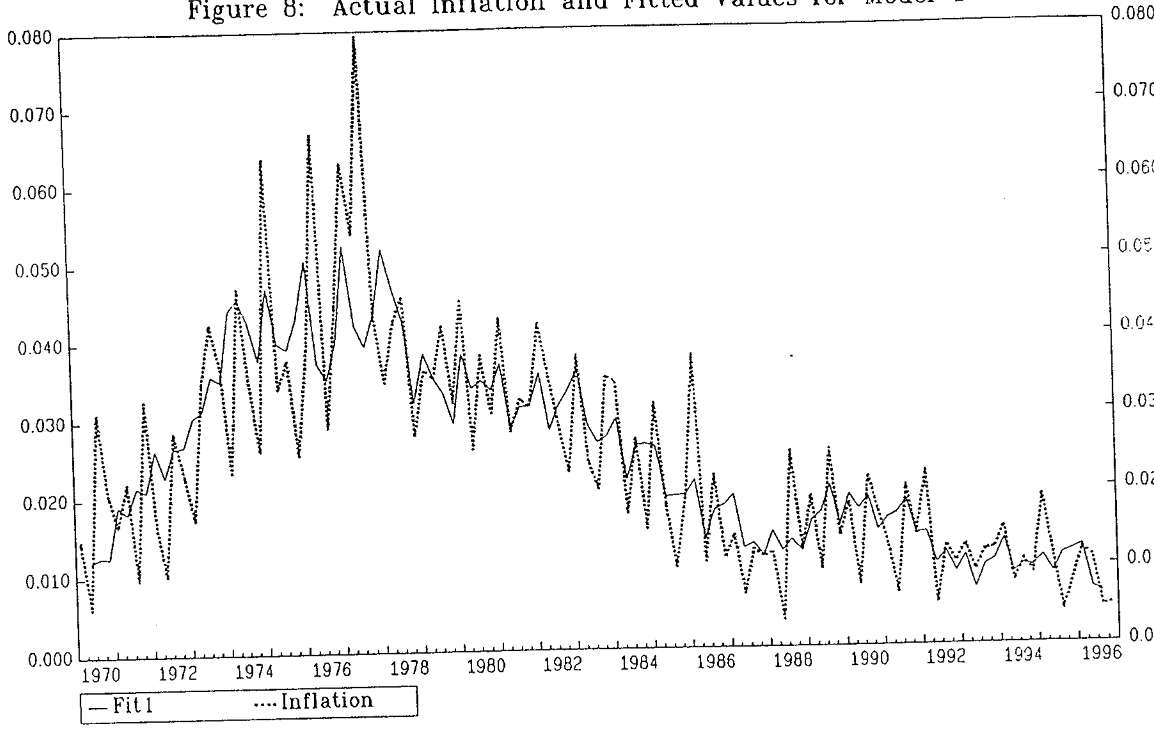
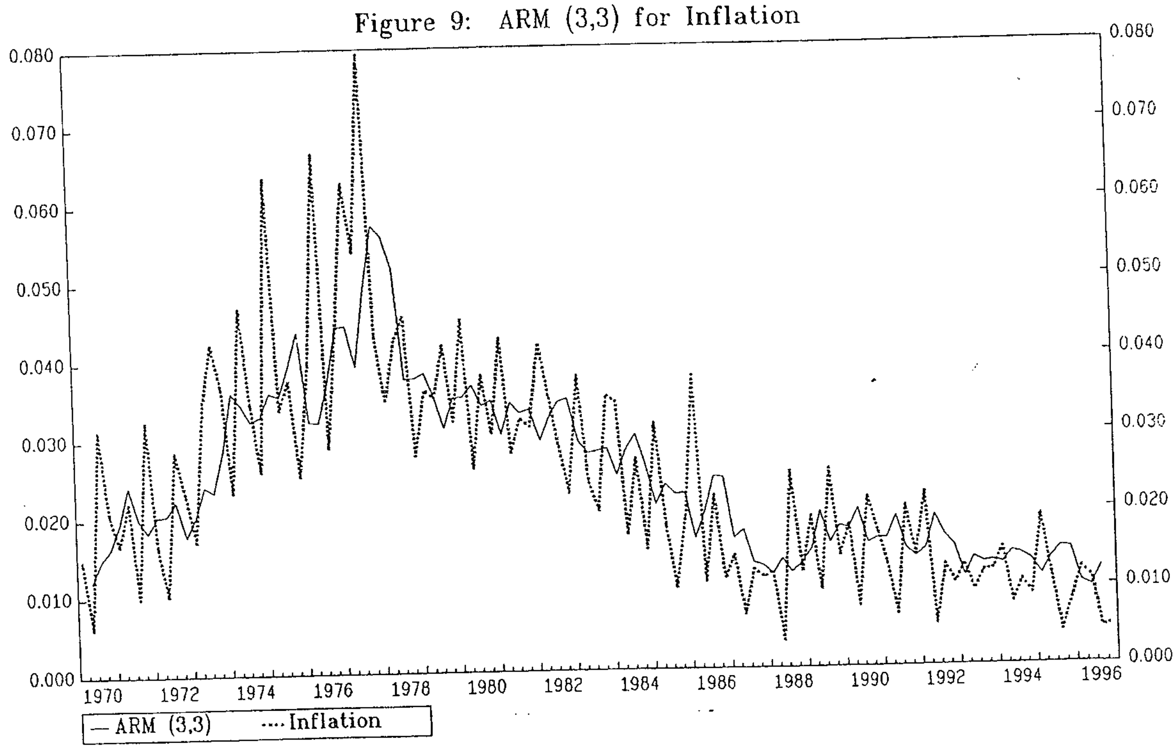


Figure 9: ARM (3,3) for Inflation



Source: International Financial Statistics.

Figure 10: Model 1 Versus Model 2

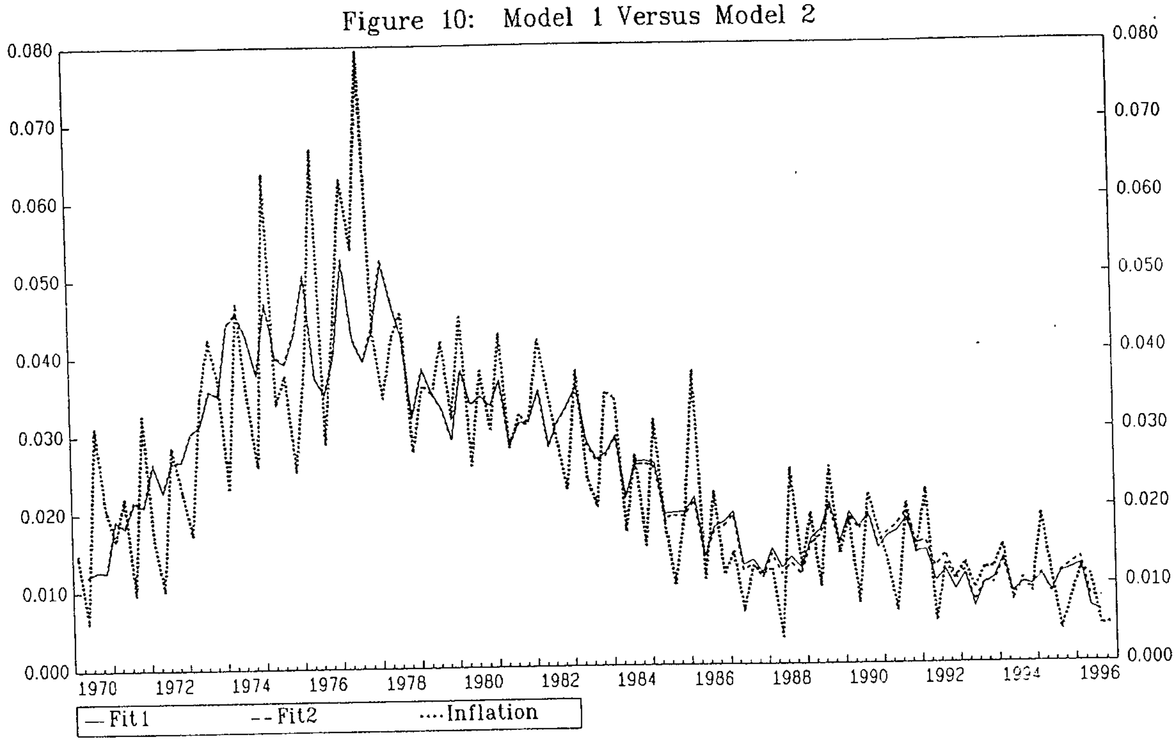
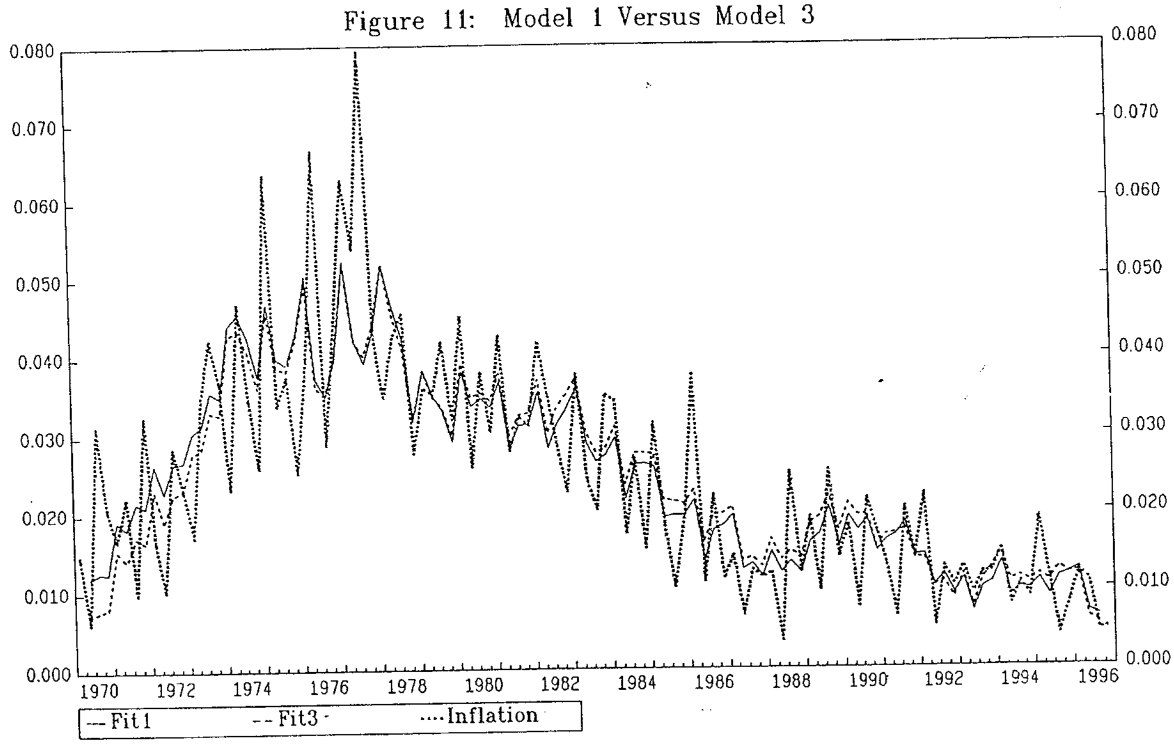


Figure 11: Model 1 Versus Model 3



Source: International Financial Statistics.

Figure 12: Model 1 Versus Model 4

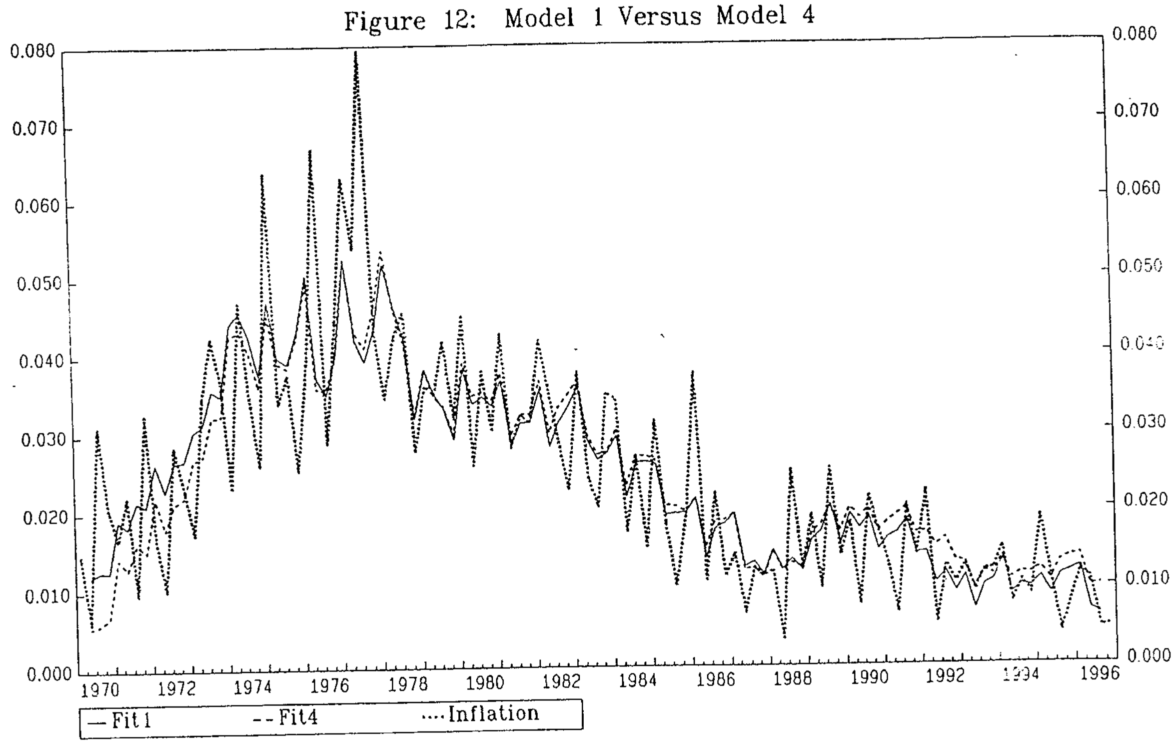
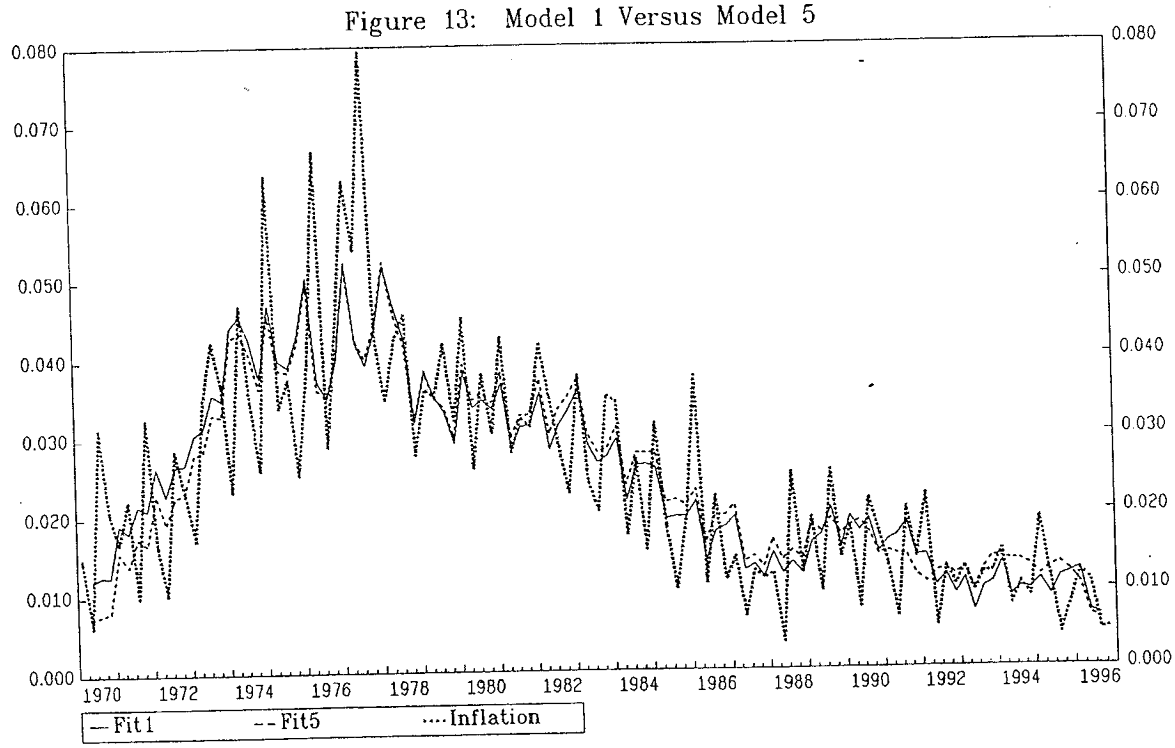


Figure 13: Model 1 Versus Model 5



Source: International Financial Statistics.

VII. CONCLUSIONS

The P-STAR model performs well in the case of Spain. The specification is straightforward and the model yields a simple rule of thumb to understand the direction and magnitude of changes in inflation.

While the model's fit does not worsen noticeably when the foreign price gap is excluded in the first sample period (before Spain's entrance in the ERM), the foreign price gap becomes more relevant, and has a higher coefficient, for the second sample period (from June 1989 to end-1995). Hence, the inclusion of the foreign price gap increases the fit of the P-STAR model. Anyhow, the domestic price gap remains the strongest force in explaining Spanish price movements even after Spain's entrance in the ERM. This suggests that the successful disinflation that Spain has undergone in the past few years may be more related to domestic conditions (output and velocity gaps) rather than to foreign ones (German prices).

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