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In 2004 all ECB publications will feature a motif taken from the €100 banknote.

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Abstract

Pricing-to-market (PTM) behaviour implies that exporters adjust their prices to the prevailing prices in their export markets. For the importing country, PTM effects can be interpreted as a measure of the stability of domestic prices against foreign price and exchange rate developments. PTM behaviour can be attributed to the level of competitiveness and price stickiness in the importing country.

This paper investigates PTM behaviour in the euro area from the importing country's perspective, for both individual countries and the euro area as a whole. Analysis firstly involves the estimation of PTM effects in the five largest euro area countries. Secondly, PTM effects in the euro area as a whole are estimated to be slightly higher than one half. The results from illustrative simulations suggest that the increase in euro-area inflation during the first two years of monetary union can be largely attributed to oil price and exchange rate developments.

Keywords: Printing-to-market, import prices, exchange-rate pass-through, euro area.

JEL classification: C32, E31, F14, F47.

Non-technical summary

From a monetary policy perspective, with the objective of price stabilisation, it is important to know the extent to which domestic prices are affected by foreign price developments and exchange rate fluctuations. Foreign prices and exchange rate fluctuations are transmitted to domestic prices through the import deflator. The import deflator, as the link between domestic and foreign prices, is determined by domestic and foreign factors, as well as the exchange rate. The foreign determinants are the index of trade-weighted foreign export prices and oil prices. If there would only be foreign determinants of import prices there would be a full pass-through of foreign price and exchange rate movements. The limitation to the pass-through arises because foreign exporters have to compete against domestic products. In doing so they have to align their prices to some extent to the prevailing domestic market prices in their export markets. One domestic determinant of the import deflator is thus the domestic price level. Moreover, the degree to which foreign competitors have to align their prices to the prevailing domestic prices is also determined by domestic factors, in particular the degree of competitiveness and price stickiness in the domestic markets. This price-setting behaviour of foreign exporters is generally referred to as pricing-to-market behaviour (PTM).

Given the relevance of PTM effects for monetary policy, this paper estimates the magnitude of such effects for the euro area. General empirical difficulties with the estimation of euro area behavioural equations arise in view of the short history of European monetary union. For this reason and for robustness, the analysis of PTM effects is undertaken for EMU countries individually as well as for the euro area as a whole. This approach makes the most out of the information contained in country and area-wide data.

In the first step the analysis involves the estimation of import price equations for the ESCB's multi-country model (MCM), with the focus on the "big-5" member countries Germany, France, Italy, Spain and Netherlands. The results from the country analysis reveal that long-run PTM effects are with 0.44 largest in Germany and lowest (even non-existent) in the Netherlands, suggesting that PTM effects depend on the country size. Long-run PTM effects in the other three countries range between 0.16 and 0.26.

In the second step empirical results are derived for the euro area as a whole. This is done on the one hand by aggregating the single country results derived before, and on the other hand by estimating import price equations from area-wide data. Previous work on country aggregation for the euro area has shown that the main advantage of analysis using country level data is the ability to develop country-specific structures. Furthermore, the potential problem of aggregation bias is of less relevance (Fabiani and Morgan, 2003). A specific case

is given for the aggregation of import price equations. The country-specific intra- and extra-area components of competitors' prices play an important role for the aggregation of country results. This is because intra-area competitors' prices form part of the euro area 'domestic' prices. The analysis of PTM effects in the euro area can thus not be derived from a straightforward aggregation of country results, as the impact from competitors' prices within the euro area forms part of the aggregate PTM effects. Data restrictions preclude a separate treatment of intra and extra area import prices. The paper shows that the use of a simple accounting measure allows the estimation of PTM effects. The evidence from country aggregation, the area-wide model and some new estimates for the euro area point towards PTM effects in the euro area in the order of magnitude of 0.55 in the long run, in other words the pass-through is less than one half. In the short run PTM effects are even as high as 0.80.

The analysis in these first two sections of the paper focuses on the impact of foreign price developments on the import deflator. The results reported above are only static first-round results. Second-round effects arise because the import deflator affects domestic prices, which in turn affect import prices through PTM effects. In order to quantify the second-round effects, simulation analyses are undertaken using estimated import price equations and bridge equations for domestic prices. An important illustrative result from the simulation analysis is that the increase in euro-area inflation during the first two years of monetary union can be largely attributed to oil price and exchange rate developments.

1. Introduction

Pricing-to-market (PTM) effects correspond to the extent to which exporters adjust their prices to reflect the prevailing prices set by their competitors. In other words, PTM effects arise through the limited pass-through of foreign prices and the exchange rate. From a monetary policy perspective, with the objective of price stabilisation, it is important to know the extent to which domestic prices are affected by foreign price developments and exchange rate fluctuations. The degree of openness is often the only indicator used to address this issue. However, a relatively limited pass-through of foreign prices would offset a relatively high degree of openness. The analysis of PTM effects is therefore an important element in assessing the robustness of domestic prices against foreign influences.

Given the relevance of PTM effects for monetary policy, this paper estimates the magnitude of such effects for the euro area. Empirical difficulties arise in view of the short history of European monetary union. For this reason and for robustness, the analysis of PTM effects is undertaken for EMU countries individually as well as for the euro area as a whole. Since PTM behaviour is analysed from the perspective of the importing country, both domestic prices and foreign determinants are considered. The first part of the analysis involves the estimation of import price equations for the ESCB's multi-country model (MCM), with the focus on the "big-5" member countries Germany, France, Italy, Spain and Netherlands[3]. The second part derives empirical results for the euro area as a whole from both an aggregation of the single country results and from area-wide data. Previous work on country aggregation for the euro area has shown that the main advantage of analysis using country level data is the ability to develop country-specific structures. Furthermore, the potential problem of aggregation bias is of less relevance (Fabiani and Morgan, 2003). This part argues that the country-specific intra- and extra-area components of competitors' prices play an important role for the aggregation of country results. This is because intra-area competitors' prices form part of the euro area 'domestic' prices.

The analysis in the first two sections of the paper focuses on the impact of foreign price developments on the import deflator. The remainder of the paper considers in addition the impact on domestic prices. For this purpose, simulation analyses are undertaken using estimated import price equations and bridge equations for domestic prices. The simulation results suggest that the increase in euro-area inflation during the first two years of monetary union can be largely attributed to oil price and exchange rate developments.

The remainder paper is organised as follows. Part 2 provides a theoretical and empirical background to the PTM hypothesis, and highlights some aspects of PTM in the context of

[3] The limitation to the big-5 is a simplification, but they provide a close approximation to the euro area as a whole. According to 1999 GDP weights at actual exchange rates the big-5 comprise of 85.9 % of euro12 (i.e. including Greece) GDP. Using PPP exchange rates their share is 84.9 %.

monetary union. Part 3 briefly introduces the model used for the estimation of import prices. The estimation results are then shown in part 4. Part 5 contains the analysis of import prices and PTM effects in the euro area as an aggregate. Diagnostic simulations of an oil price and exchange rate shocks are conducted in part 6 in order to evaluate the speed of adjustment to long-run equilibrium. Part 7 concludes.

2. Pricing-to-market effects

PTM effects describe the limited pass-through of foreign prices and the exchange rate due to the adjustment to competitors' prices. From a microeconomic perspective, PTM effects are mainly attributed to product differentiation and imperfect competition (see e.g. Krugman (1987)). Following either domestic cost rises or exchange rate movements, exporting firms seek to maintain their market shares in foreign markets and to secure future sales. This is mainly a feature of the short run, especially in situations characterised by considerable volatility in the nominal exchange rate. PTM effects may also feature, however, in the long run when suppliers in imperfect competition set market- and country-specific prices. The mark-up in this case might be expected to be dependent on the elasticity of demand in the respective markets.

One important element of the above arguments is that changes in the exporters' cost structure and exchange rate movements have the same effect on the exporters' profits at a given export price. Fluctuations in the exchange rate are therefore in the long run transmitted in the same way as changes in production costs. However, this is only a feature in a long-run perspective. In comparison to fluctuations in domestic costs, exporters will in the short run react differently to fluctuations in exchange rates, so that the pass-through might be quite different, not least because the exchange-rate is much more volatile than production costs.

Jaeger *et al.* (2001) argue that low inflation regimes may reduce pass-through effects, i.e. exhibit higher PTM effects. That is to say that if prices are relatively rigid, then increases in costs are not passed on, as long as expectations of future costs and prices are low. The formation of monetary union itself could be argued to have had such an impact, increasing PTM effects in two ways. First, it may have caused a regime shift in participating countries towards lower inflation and less exchange rate volatility. Second, as argued by Devereux *et al*. (1999), the adoption of a single currency will have resulted in European prices being more insulated from exchange-rate volatility, as is already the case in the United States. Since retailers must choose whether to set prices in the consumers' or in the producers' currency, the existence of many different currencies in Europe would induce numerous pricing decisions for a retailer dealing in European markets, who may therefore be more likely to set his prices in the

producer's currency or a single numeraire currency, e.g. the US$. In contrast, a single currency in Europe would increase the likelihood of setting prices in euro.

Given the short history of monetary union, the specific effects that could be attributed to its formation can only be minor within the time span that is considered in this paper[4]. Monetary union, however, is not the only common feature of the countries in the euro area. Membership to the EC/EU could also play a role, as 4 of the big-5 are founding members of the EC, and Spain joined already in 1986. The argument here would be that the abolition of customs and duties within the union and later the formation of a single market would have led exporters from both within and outside the union to formulate their prices for this market as a whole. Even more generally, the simple geographic proximity of the countries in Europe might lead exporters to some extent to formulate the same pricing strategy for such an area.

There are various contributions to support the hypothesis for PTM effects. Firstly from a theoretical perspective, Brauer (1999) uses an oligopolistic framework to explain the pass through of prices as a reaction to exchange rate or cost changes. The most influential factor for the price setter is the price elasticity of demand, which is a function of reservation prices and the substitutability between products. Examples for empirical PTM case studies include Khalaf and Kichian (2000) for the case of the transportation equipment industry, Bernhofen and Xu (2000) for the case of the petrochemical industry or Gross and Schmitt (2000) for the case of automobiles. Independent of the particular aspects that the papers deal with, there is unambiguous evidence for the existence of PTM effects.

3. Model for the import deflator

For our model we assume monopolistic competition with product differentiation and a fixed long-run mark-up on production costs. Import prices p^{im} are primarily explained by external factors, since they are mainly set by foreign producers. In addition to competitors' prices on the import side in domestic currency (p^{comp}), the other external determinant for import prices is the price of energy (p^{en}). p^{comp} consists of two components, the price development in the trading partners' countries measured in US$ ($p^{comp,US}$), and the nominal exchange rate against the US$ (er), i.e.

$$p^{comp} = p^{comp,\,US} * er \qquad (1)$$

These are the 'direct' determinants of the import price in terms of a mark-up on marginal costs, including the exchange rate pass-through. Furthermore, following the argument that foreign

[4] The empirical parts of this paper (parts 4 and 5) relate to the sample period 1980 to the second quarter of 1999, i.e. only 2 quarters of monetary union are part of the sample.

trading partners exhibit pricing-to-market behaviour, the prevailing domestic prices *p* will also have an impact on the import price.

The model for import prices under consideration of PTM effects can be thus written as (all variables in logs):

$$p^{im} = \beta_1 p^{comp} + \beta_2 p + \beta_3 p^{en} \quad (2)$$

where domestic prices *p* are given by the GDP deflator at factor costs. The homogeneity restriction implies $\sum_{i=1\text{to}3} \beta_i = 1$. Pricing-to-market behaviour is observed when $\beta_2 \neq 0$.

The long-run model in (2) includes two restrictions. The first is that reflected in (1), i.e. β_1 in (2) is the same for $p^{comp,\ US}$ and *er*. This restriction follows from the fixed mark-up in the framework of monopolistically competing domestic and foreign firms. With a given market power of the importing country, an exporters' pricing strategy will take equal account of changes in production costs and exchange rate movements in order to maintain a constant mark-up. In other words the exchange-rate pass-through is the same as the foreign cost pass-through. This restriction, however, is only plausible in the long run. Especially the different volatilities of production costs and exchange rates may generate different short-run dynamics.

The second restriction is that competitors' prices can be differentiated into their intra- and extra-euro-area component, that is $p^{comp} = s\ p^{comp,intra} + (1\text{-}s)\ p^{comp,extra}$, where *s* is the intra-area import share of a given country. This restriction boils down to a simplification of the model, relevant from the perspective of the importing country, where the domestic products and their price *p* stands in competition to foreign products with their price p^{comp}. The focus of this paper is the market power of the importing country, as measured by β_2. PTM behaviour of foreign producers within and outside the euro area are assumed to be the same and are measured through this single coefficient. This appears at first sight to be a fairly strong assumption, but the perspective taken in this paper is that of the importing country, which means that PTM effects are entirely determined domestically, and it plays no role where the imports originate from. PTM is in that sense a measure of competitiveness and price-stickiness in the importing country's markets.

4. Estimation results for the big-5 countries

4.1 Data and estimation issues

The data base used for this exercise is currently based on ESA79[5] definitions, and updated from 1997 with growth rates from ESA95 data. Country-specific forecast experiences indicated that a shift in the intercept is sufficient to account for this change in the accounting framework. The estimation of the import price equations takes account of the impact of the data revisions on the long- and short-run specification of these equations. In addition, there have been further potential sources for structural change in recent years. One relates to data issues, as monetary unification brought about some further harmonisation in definitions for a number of key variables. The other potential source for structural change relates to monetary union itself, when behavioural relationships may have changed as a result of a new economic framework. Furthermore, as argued above, the increasing integration of Europe may have led to increased PTM behaviour. As the effects of structural change are of particular policy relevance, stability of the estimated import price equations will be tested. Apart from the direct evidence of stability in the values of estimated coefficients, OLS-CUSUM tests are performed to test stability more formally.

4.2 Long-run import price equations

The traditional two-step approach, used in such large structural macro-econometric models, entails a co-integrating long-term relationship and dynamic short-term equations. The long-term equation must form part of a stable and well defined long-run equilibrium. The stationary residual of this long-run equation enters the short-run equation, where the prime objective is to achieve a good fit to the data. The short-term dynamic equation then allows for different adjustments of import prices to changes in foreign competitors' prices $p^{comp,\,US}$ and the exchange rate *er*.

The coefficients of the long-run equations are estimated using the fully-modified estimation method (FME, Phillips *et al.* 1990, Phillips 1990). The advantage of this estimation method is that FME applies corrections to OLS to take care of endogeneity and serial correlation problems. This is appropriate if there is a single cointegrating relationship between I(1) variables[6] (Phillips 1995). The estimation is based on the sample period 1980Q1 to 1999Q2. The table below shows the estimated coefficients of the long-run equations in the big-5 euro area countries. The t-values are given in small print under the estimated coefficients.

[5] European System of national Accounts.

[6] Stationarity tests have shown that all variables in question are I(1), although there are some borderline cases between I(1) and I(2).

Table 1: Long-run import price equations in the big-5 countries[7]

MCM-5	DE	FR	IT	ES	NL
c	-0.557	-1.379	-3.674	-2.961	-0.782
p^{comp}	0.476 7.95	0.731 9.49	0.532 10.94	0.651 11.13	0.929 87.95
p	0.439	0.155 2.64	0.261 7.00	0.176 4.01	-
p^{en}	0.085 4.93	0.115	0.207	0.173	0.071
D901p	-	-	-0.063 -7.17	-	-
D911p	-0.050 -11.63	-	-	-	-
D921p	-	-	-	-0.067 -5.86	-
D971p	-0.082 -11.63	-0.045 -4.21	-	-0.047 -3.67	-0.014 -1.00
ADF crit. val. 3.06 /2.77 (5% / 10 %)	-3.42	-3.11	-2.87	-4.10	-3.67

Estimation sample period: 1980Q1 to 1999Q2

A step dummy from 1997Q1 (D971p) is included in the estimation to take account of the change in the data series from that date. It proves significant in all countries but Italy. A step dummy is also needed for German unification from 1991Q1 (D911p) and for Italy and Spain in order to obtain a stationary residual (D901p from 1990q1 and D921p from 1992q1).

The table shows the results of an augmented Dickey-Fuller test for stationarity of the residual. The critical values are -3.06 and -2.77 at 5% and 10% significance levels respectively. All residuals from the long-run equations pass this stationarity test at 5% significance, except for the Italian residual, which only passes at the 10% significance level. In order to use the results of this estimation for aggregation in the later part of this paper, all 5 countries had to be dealt with in a homogeneous manner. It is in this sense a satisfactory result, as it was possible to formulate stable and homogeneous long-term relations for all 5 countries under consideration.

Consistent with the hypothesis that PTM effects are more pronounced in larger countries, Germany exhibits the largest PTM effect. For the Netherlands, the smallest of the five countries, domestic prices do not co-integrate with the other variables and have therefore been left out.

[7] The missing t-statistics are due to the homogeneity restriction.

PTM effects in France are found to be smaller than in Italy and Spain. Energy prices play a more important role in Italy and Spain.

The order of magnitude of the PTM effects is quite high for Germany, where even in the long run less than 60 % of foreign and energy price developments and changes in the exchange rate are passed onto German import prices. The second largest economy in the euro area, France, exhibits at first sight substantially smaller PTM effects. However, this conclusion is drawn on the basis of the coefficients on domestic prices in the import price equations. There are of course other elements in PTM behaviour, such as the impact of import prices on domestic prices, but these elements lie outside the scope of this part of the analysis.

4.3 Short-run dynamic equations

The short-run ECM equations are given as

$$\Delta p^{im} = c + \sum_{i=-1 to -3} \alpha_1 \Delta p_i^{im} + \sum_{i=0 to -3} \alpha_2 \Delta p_i^{comp,US} + \sum_{i=0 to -3} \alpha_3 \Delta er_i + \sum_{i=0 to -3} \alpha_4 \Delta p_i + \sum_{i=0 to -3} \alpha_5 \Delta p_i^{en} + \alpha_6 ect_{-1} \quad (3)$$

where *ect* is the residual from the long-run equation, i.e. the error-correction term. Competitors' prices in domestic currency p^{comp} are divided into two components: Competitors' prices in US-Dollar $p^{comp,\ US}$ and the exchange rate *er*. In the short-term analysis it is therefore possible to have different dynamic adjustments to long-term equilibrium, since it is conceivable that cost developments abroad and exchange-rate movements are passed on differently to import prices, or that there are generally non-common factors in both components. The significance of the difference in $p^{comp,\ US}$ and *er* is tested. The set of variables entering the short-run dynamic equation is not restricted to be the same in all countries.

Moving on to the results of this model, the coefficient of the error-correction term is found to be significant in all countries[8]. Adjustment to long-run equilibrium, as measured by this coefficient, is fastest in Germany, but there are also other factors that will influence the adjustment time which are discussed in the simulation analysis below. The distinction between changes in actual cost effects and the exchange rate turned out to be significant in all countries but Italy[9]. The pass-through of foreign prices in Germany, France and the Netherlands is stronger than the pass-through of changes in the exchange rate. In Spain no short-term impact of foreign prices is revealed and a relatively small impact of the exchange rate can be identified. Instead, domestic

[8] This should not be misinterpreted in a sense of testing for co-integration, as different critical values would be applicable for that (see Banerjee *et al.* 1998). Testing for Co-integration has already been done in the framework of the long-run equations, where stationarity of the residual term has been formally checked.

[9] An F-test on the coefficients of $\Delta\ p^{comp,\ US}$ and Δ er being equal for lags 0 and 1 resulted in F(2,68) = 0.15, i.e. the hypothesis is accepted at all conventional significance levels.

prices *p* are found to have a stronger impact than in other countries with a coefficient of 0.678 (first lag), i.e. PTM effects in Spain are particularly strong in the short run. In Germany, France and Italy PTM effects have the same order of magnitude in the short run as in the long-run equations. For the Netherlands, as in the long run, we find no PTM effects in the short run.

Table 2: Short-run dynamic equations in the big-5 countries

MCM-5	DE	FR	IT	ES	NL
constant	-0.004 -2.48	-0.002 -1.66	-0.003 -1.33	-0.003 -1.12	-0.000 -0.04
ect_{-1}	-0.388 -4.43	-0.109 -2.01	-0.159 -2.44	-0.219 -3.32	-0.117 -1.95
$\Delta p^{im}{}_{-2}$	0.329 4.29	0	0	0	0
$\Delta p^{comp, US}$	0	0.624 4.93	0.363 8.49	0	0.729 3.88
$\Delta p^{comp, US}{}_{-1}$	0.700 5.47	0.363 3.07	0.141 3.26	0	0
Δer	0.235 10.37	0.492 6.83	0.363 (8.49)[10]	0.147 4.40	0.523 5.33
Δer_{-1}	0.356 5.70	0.237 3.72	0.141 (3.26)	0.109 3.28	0
Δp	0.448 2.71	0.172 1.67	0.328 3.11	0	0
Δp_{-1}	0	0	0	0.678 4.07	0
$\Delta \ln p^{en}$		0.112 10.46	0.159 11.87	0.100 5.63	0.106 8.10
$\Delta p^{en}{}_{-1}$	0.035 2.30	0	0	0.043 2.37	0
$\Delta p^{en}{}_{-2}$	-0.083 -4.93	0	0	0	0
D971	-0.052 -4.79	0	0	0	0
R^2	0.80	0.88	0.88	0.74	0.71
DW	1.97	1.55	1.89	0.88	1.78

Estimation sample period: 1980Q2 to 1999Q2 (NL), 1980Q3 to 1999Q2 (FR, IT, ES), 1980Q4 to 1999Q2 (DE)

[10] The difference in the coefficients on $\Delta p^{comp, US}$ and Δer are insignificant in Italy.

4.4 Test of stability

Both statistical and economic factors suggest that there may have been a structural break in the sample. Economically, structural change might have occurred in the run-up and in the implementation of monetary union. The issue of structural change in the context of monetary union is further elaborated in Fagan *et al.* (2001) and Henry (1999). Moreover, as described above, the data set used in this paper is based on ESA79 data until 1996Q4, supplemented until the end of the sample period with ESA95 growth rates. The break in the data in 1997 has been taken account of by inclusion of a dummy variable. However, in order to test for stability more formally, OLS-CUSUM tests (Ploberger *et al.* 1992) were performed in the dynamic short-run equations. As compared to the standard CUSUM test based on recursive residuals, neither version is uniformly superior to the other. In case of structural shifts which occur late in the sample, however, OLS-CUSUM performs better. Given the late break in the data in 1997, OLS-CUSUM will thus be reported here. Standard CUSUM tests have nevertheless been performed, and all the results from OLS-CUSUM were confirmed. The graphical result of the OLS-CUSUM tests is shown in the appendix. It shows that if there was any structural break in the parameters it has been sufficiently accounted for by inclusion of a dummy variable.

5. Euro area

5.1 Intra- and extra-area components

For analysis of the euro area as a whole, it is necessary to introduce a distinction, which will be important in determining PTM effects in the euro area. The import price, as well as its key explanatory variable, i.e. the competitors' price on the import side, now have an intra and an extra euro area component. The average import price takes the prices of imports from within and from outside the area into account, whereas the consolidated import price refers only to the price of imports from outside. Similarly, the competitors' price on the import side has an intra and extra area dimension. Sufficiently long time series data are currently only available for average euro area import deflators, whereas competitors' price indices can be constructed based on intra or extra area definitions.

5.2 Aggregation of country results and PTM effects in the euro area

When looking at the euro area as a whole, the intra-area effect from competitors' prices p^{comp} can be attributed to the pricing-to-market effect, as extra-area exporters have to align the prices of their products to domestic prices in individual countries, but also to trade prices between

countries. The intra-area import prices form, in that sense, part of euro area domestic prices. Undoubtedly, this can only be seen as an accounting measure, a second best to a complete data set including import prices for both intra- and extra-area components. The long-run equations estimated for the individual countries above were given as

$$p^{im} = \beta_1 p^{comp} + \beta_2 p + \beta_3 p^{en} \quad (4)$$

A simple aggregation of the country coefficients across the big-5 countries using GDP weights[11] would result in

$$p^{im} = 0.60\, p^{comp} + 0.27\, p + 0.13\, p^{en} \quad (5)$$

This should not be interpreted in the same way as an estimated equation, because, for example, the country coefficients do not result from a simultaneous estimation. However, the focus is here on the PTM effects. Decomposing therefore the competitors' prices into their intra and extra component, using the share of intra euro area imports s_j in total imports for each country j in the euro area,

$$p^{comp}{}_j = s_j\, p^{comp,\, intra}{}_j + (1-s_j)\, p^{comp,\, extra}{}_j \quad (6)$$

allows then to approximate PTM effects on an area-wide level as follows.

$$p^{im} = \sum_j \omega_j (s_j \beta_{1j} + \beta_{2j})\; p + \sum_j \omega_j (1-s_j) \beta_{1j}\; p^{comp} + \sum_j \omega_j \beta_{3j}\; p^{en}, \quad j = DE, ES, FR, IT, NL \quad (7)$$

where ω_j are the GDP weights and s_j the shares[12] of intra-area imports of each country. The result of this aggregation is

$$p^{im} = 0.565\, p + 0.305\, p^{comp,\, extra} + 0.129\, p^{en} \quad (8)$$

The euro area as a whole thus exhibits PTM effects of 0.57, larger than in any individual country effect. It is important to note that this result comes out of a long-run set-up where, as detailed above, fluctuations in the exchange rate are transmitted in the same way as changes in production costs. In other words there is a constant mark-up on production costs, determined in the producing country, and represented through the coefficient on p^{comp} in the model. In contrast, the extent of the pass-through, i.e. the PTM effects, are determined in the importing country and are a function of the competitive conditions that prevail in that country. The latter is represented in the model through the coefficient on domestic prices p, which is thus independent from that distinction between productions costs and exchange rate movements. The equal treatment of the pass-through of exchange rate fluctuations and producers' costs is particularly important when adding the intra-area competitors' prices to the domestic price

[11] Using 1999 country weights based on PPP exchange rate conversions and re-scaling the 5 countries under consideration to 100%.

[12] Average import shares 1995-1997.

component in the euro area, because the exchange rate movements that are entailed in the intra-area competitors' price for the estimation period play obviously no more part in monetary union. Moreover, the stability tests reported above indicate that historic events like e.g. the exchange rate movements in the 1992 ERM crises did not have an impact on the coefficients of the equations.

5.3 Area-wide model (AWM)

The evidence on PTM effects from the ECB's AWM (Fagan *et al.*, 2001) are taken as a reference point. The model is estimated on aggregate data for the euro area. Irrespective of any PTM effects, both import and export deflators in the AWM include some intra-area effect already by construction. The import deflator in the AWM is, in the long run, given as (all variables in logs)

$$p^{im} = 0.65\, p^{ex} + 0.1\, p^{f} + 0.25\, p^{com} \tag{9}$$

where p^{ex} is the export deflator, p^{f} the foreign deflator, and p^{com} is a commodity price index which contains the price of energy. p^{ex} refers to both intra and extra area export prices, i.e.

$$p^{ex} = 0.7\,p + 0.3\,p^{f} \tag{10}$$

The PTM effect for import prices in the euro area is represented by intra-area export prices. A reduced-form equation for import prices which shows PTM effects can thus be derived as

$$p^{im} = 0.52\,p + 0.25\,p^{com} + 0.23\,p^{f} \tag{11}$$

The PTM effect as measured by the coefficient on domestic prices *p* is here slightly lower than the one found through aggregation of single-country equations above, but still higher than in any individual country. There is, however, a substantial difference in the impact of energy prices, which is found in the AWM to be about twice as large as in the aggregated single countries equation. This can possibly be attributed to a different definition of the energy variable. A further potential source for differences is that the AWM encases all euro area countries, whereas the big-5 only account for a GDP share of about 85 %.

5.4 Euro area estimation

The coefficients of the import equation in the AWM are not directly comparable to those in the individual country equations, as different explanatory variables are included in both. It is therefore necessary to complete the analysis with an estimation of area-wide import price equations which are analogous to the single-country analysis. The estimation method for the long-run equations is also FME.

For better comparison, the coefficients from the aggregation of single country results and the AWM are also shown in the table below. The last column shows the results of the estimation of the following model:

$$p^{im} = \beta_0 + \beta_1 p^{comp} + \beta_2 p + \beta_3 p^{com} + \beta_4 D911p + \beta_5 D971p \qquad (12)$$

Table 3: Long-run import price equations and PTM effects in the euro area

EA	Country aggregation	AWM	FME
β_0	-	-	-0.284 -3.81
β_1	0.60	-	0.732 13.45
β_2	0.27	-	0.185 4.88
β_3	0.13	0.25	0.084[13]
β_4	-	-	-0.020 -3.72
β_5	-	-	-0.014 -3.03
PTM	0.56	0.52	0.55
$p^{comp,extra}$	0.31	0.23	0.37
ADF crit. val. 3.06 /2.77 (5% / 10 %)	-	-	-4.79

Sample period 1980q1 to 1999q2.

The residual from the estimated long-run euro-area import prices equation passes the Dickey-Fuller test for stationarity. According to this estimation, import prices in the euro area are mainly explained by competitors' prices p^{comp}. However, as p^{comp} refers to the intra- and extra- area definition, the intra-area share is again added to domestic prices p in order to obtain a measure

[13] T-statistic missing due to homogeneity restriction.

for PTM effects. The intra-area share of euro area imports is 0.5. PTM effects according to this measure are thus 0.55. The three measures for PTM effects are therefore found to be in a very narrow range of 0.52 to 0.56. Noteworthy is also the proximity of the PTM effects resulting from the aggregation of country coefficients and the estimated coefficients from the area-wide, which are 0.56 and 0.55. This is a very remarkable result, given the difficulties in aggregating the intra- and extra-components, and also the fact that the country analysis comprised only of the big-5 euro area countries.

5.5 Short-run dynamic equation

For completeness, the short-run dynamic equation is also included in the analysis. After dropping the insignificant variables, the following short-run dynamic equation results:

sample period: 1980q2 to 1999q2

$$\Delta \ln p^{im} = -0.003_{-2.06} - 0.275_{-3.53}\, ect + 0.743_{5.71}\, \Delta \ln p^{comp,\,US} + 0.643_{7.33}\, \Delta \ln er + 0.432_{3.67}\, \Delta \ln p$$
$$+ 0.049_{4.43}\, \Delta \ln p^{com} + 0.051_{4.62}\, \Delta \ln p^{com}{}_{-1} \qquad (13)$$

$R^2 = 0.91$ DW = 1.14

The hypothesis that the coefficients of $p^{comp,US}$ and *er* are the same can be rejected at the 5 % significance level[14]. We find that, as in the country analysis, the adjustment to changes in competitors' prices $p^{comp,US}$ is slightly stronger in the short run than the adjustment to changes in the exchange rate. PTM effects are very high in the short run. Using the same accounting measure again, and interpret the intra-area share of competitors' prices as domestic prices, we obtain PTM effects of 0.80.

5.6 Test of stability: OLS-CUSUM

Similarly to the single-country analysis an OLS-CUSUM test was applied to the residuals from both short-run dynamic equations above. The Null Hypothesis of stability cannot be rejected (See graph in the appendix).

6. Simulation analysis

In this section, two diagnostic shocks, an exchange rate and an oil-price shock, are simulated in order to evaluate the overall effect of such shocks as well as the adjustment path of import prices. The data used for these simulations comprises of the historical data as well as the

[14] F(1, 69) = 4.63, significance level 0.03.

forecast data until 2002q4. The simulations are run in isolated mode, which means that all variables on the right hand side (except any lagged endogenous) are treated as exogenous. Additionally, the simulations were also run in a mode in which domestic prices p are themselves a function of the import price. This has been implemented in a very stylised way by using the following calibrated equations

$$\Delta p = \lambda \Delta p_{-1} + (1 - \lambda)\, \mu\, \Delta p^{im} + \varepsilon \qquad (14)$$

where λ is the adjustment parameter which is arbitrarily set at 0.8, μ is the import share in each country[15], and ε is a residual term fitting the equation to the data. This equation ensures that a change in the import price will eventually be passed onto the domestic price to the extent of the import share in that country.

This type of simulation exercise shows the adjustment of the endogenous variable, in this case the import price, to a change in its explanatory variable. The graphs in the appendix show the effect of the shocks on 5 variables for each country as a percentage deviation from baseline. The dotted line shows the effect on prices resulting from the above equation. The two horizontal lines show the long-run effect on the import price for both cases, i.e. with and without inclusion of a price effect. The remaining two lines show the actual effect on the import price for both cases. As there are no PTM effects in the Netherlands, there are only three lines in the graph.

6.1 10 % increase in the price of energy

The table provided in the appendix shows the impact of this shock on import prices as a percentage deviation from baseline. The last row shows the long-term impact, as determined by the long-run equation. For ease of illustration graphs of these impacts are also presented in the appendix.

The long-term impact is given by the estimated coefficient on p^{en} (euro area: p^{com}) in the long-run equation. The speed of adjustment to long-run equilibrium is mainly determined by the coefficients of the error-correction-term, but also by the coefficient on p^{en} (p^{com}) in the short-run dynamic equation. The coefficients on the error-correction term are highest in Germany (-0.39) and the euro area (-0.27), whereas the other countries exhibit a larger short-term coefficient on p^{en}. From the coefficients, there are thus no obvious differences in the speed of adjustment. For the Netherlands, independently from this being the only country with no PTM effects, adjustment to the new long-run equilibrium is from above, i.e. there is some overshooting in the short run. In Germany there is also an overshooting effect, although very small and with a few quarters delay. In France the adjustment to long-run equilibrium takes place almost instantly. In Spain, Italy and the euro area adjustment is a bit smoother, and import prices are close to their

[15] As an average from 1980-1996, which are DE 0.26, FR 0.25, IT 0.17, ES 0.23, NL 0.47 and euro area 0.25.

new long-run equilibrium within 3-4 years. The inclusion of the price equation has no significant effect on the adjustment pattern. Only in Germany, where PTM effects are relatively high, inclusion of the price equation has a noticeable effect[16]. The overall impact on import prices ranges from 0.7 % to 2.5 %.

6.2 10 % depreciation of the euro

The main difference to the previous simulation is the scale of the effect. The long-run impact on import prices ranges here between 4.6 % and 9.3 %. In this scenario there is an overshooting effect in Germany and the euro area, and some minor overshooting also in France. Again, the adjustment paths are fairly independent of whether price effects are included or not. However, the inclusion of price effects accelerates the otherwise rather slow adjustment to long-run equilibrium in Spain.

6.3 Interpretation of the simulation results

The simulation results have an interesting interpretation in the context of the depreciation of the Euro and the rise in the oil price at the beginning of monetary union. The commodity price index used in the AWM increased in the first two years of monetary union by about 35%, whilst the Euro depreciated against the US-Dollar by more than 20% in the same period. Using the simulation results for the two shocks, i.e. a rise in the import deflator after two years of 1.6% following a 10% increase in the price of energy, and a 5.6% rise in the import deflator following a 10% depreciation of the Euro, and multiplying these numbers by 3.5 and 2, respectively, in order to mimic the actual developments in the first two years of monetary union, adds up to an increase in the import deflator of 17%. Calculating the impact on domestic prices using the calibrated equation would imply an increase of 3.4%. The actual increase in the GDP deflator at factor cost was 2.4% in that period, i.e. the simulation results exhibit a slightly exaggerated effect on prices. The difference between actual and simulated price effects is however certainly small enough to attribute it to factors that have not been taken into account in the simulations. Overall, the simulation results suggest that the rise in inflation in the euro area in 2000 can be largely explained by the external factors of oil-price and exchange rate.

7. Conclusions

The analysis undertaken within this paper reveals evidence for PTM effects in Germany, France, Italy and Spain, but not in the Netherlands. Stable long-run cointegrating relationships are found for all five countries in a harmonised way in the sense of resulting from an identical

[16] The euro area results are based on the estimated equation, not the accounting equation with higher PTM effects.

model. This was a prerequisite for the aggregation of country results. Using this harmonised approach, PTM effects in individual countries are the largest, at 0.44 in Germany and for the other countries of a magnitude of around 0.2.

The analysis of PTM effects in the euro area can not be derived from a straightforward aggregation of country results, as the impact from competitors' prices within the euro area forms part of the aggregate PTM effects. Data restrictions preclude a separate treatment of intra and extra area import prices. The paper shows that the use of a simple accounting measure allows the estimation of PTM effects. The evidence from country aggregation, the area-wide model and some new estimates for the euro area point towards PTM effects in the euro area in the order of magnitude of 0.55 in the long run. In the short run PTM effects are as high as 0.80.

Simulation analyses undertaken on the basis of the estimated equations for the import deflator provide insights into the price developments in the early stages of monetary union. The results suggest that the increase in euro-area inflation during the first two years of monetary union can be largely attributed to oil price and exchange rate developments.

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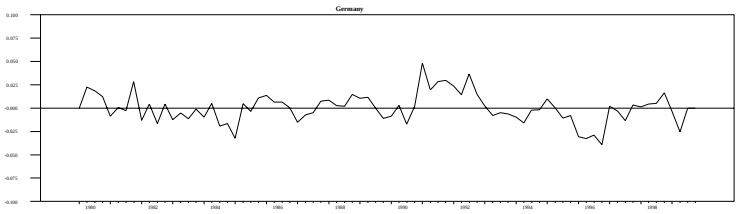
Appendix 1: Residuals from the long-run equations

Long-run residuals

DE



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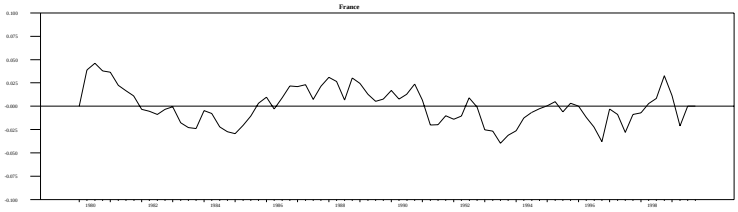

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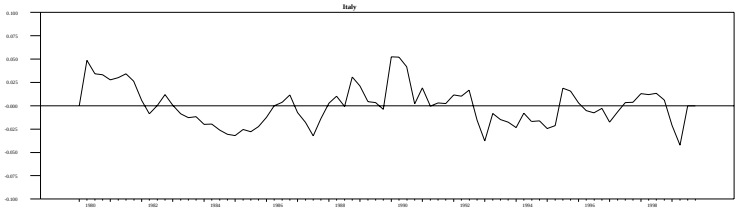

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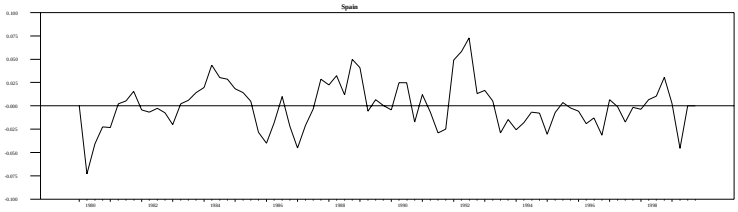

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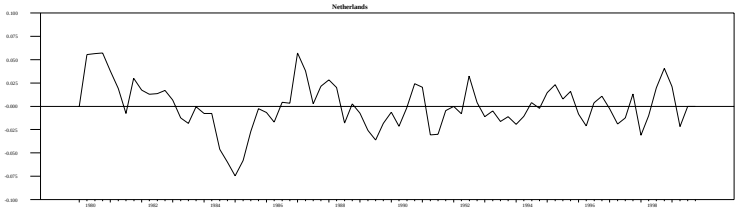

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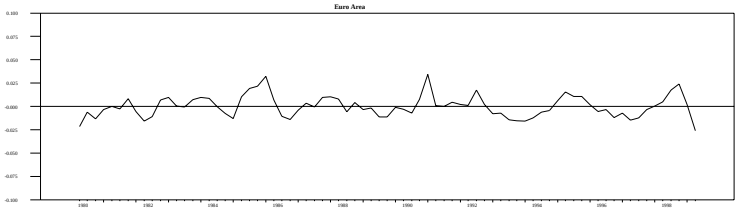

Appendix 2: OLS-CUSUM tests

OLS-CUSUM Tests

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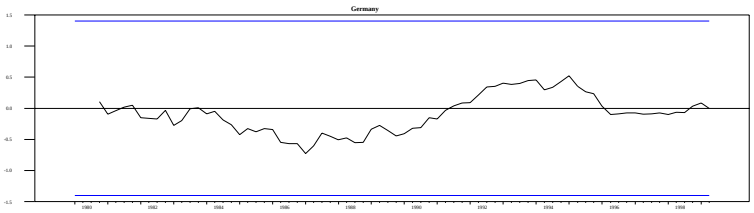

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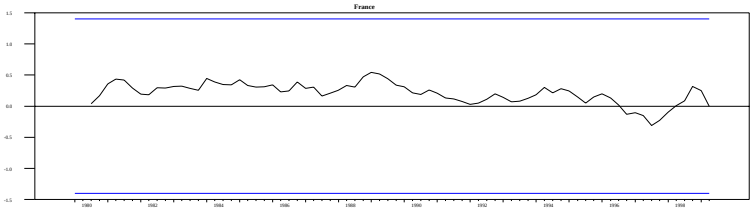

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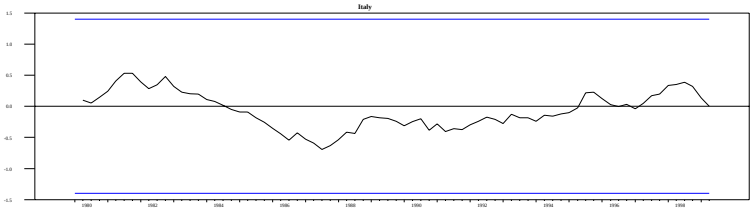

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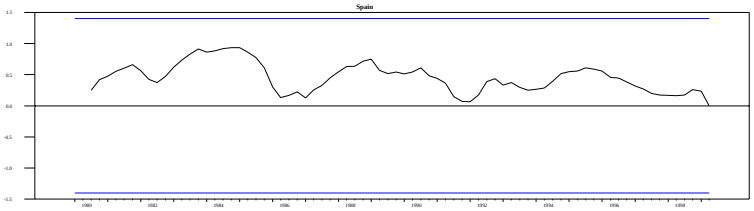

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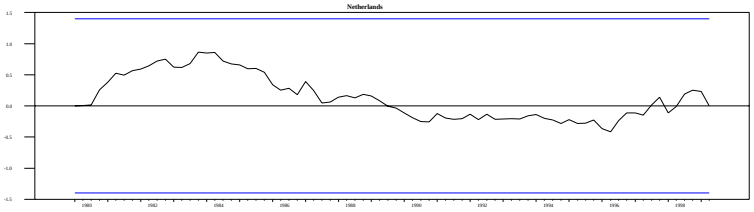

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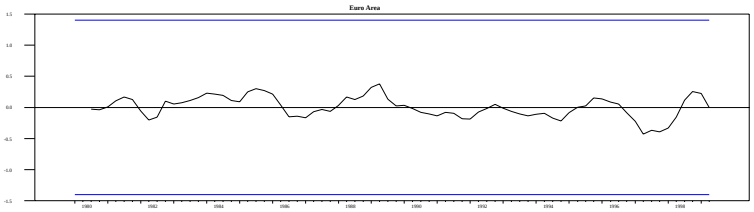
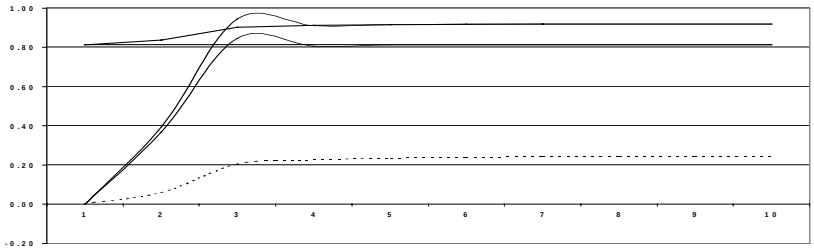


Appendix 3: Simulation analysis

Table 4: Impact on import prices of a 10% increase in the price of energy.

Time	*DE*	*ES*	*FR*	*IT*	*NL*	*EA*	*DE*	*ES*	*FR*	*IT*	*NL*	*EA*
	without price effect						*with price effect*					
Q1	0.00	0.96	1.07	1.58	1.02	0.56	0.00	0.96	1.08	1.61	1.02	0.57
Q2	0.65	1.53	1.08	1.67	0.98	1.22	0.67	1.56	1.09	1.72	0.98	1.25
Q3	-0.08	1.58	1.08	1.75	0.94	1.33	-0.07	1.66	1.10	1.81	0.94	1.37
Year 1	0.48	1.63	1.08	1.82	0.91	1.40	0.51	1.74	1.11	1.89	0.91	1.46
Q1	0.37	1.67	1.08	1.88	0.88	1.46	0.40	1.81	1.12	1.96	0.88	1.53
Q2	0.73	1.71	1.09	1.94	0.86	1.50	0.77	1.86	1.12	2.03	0.86	1.58
Q3	0.72	1.73	1.09	1.99	0.84	1.53	0.78	1.90	1.12	2.08	0.84	1.61
Year 2	0.88	1.76	1.09	2.03	0.82	1.55	0.95	1.93	1.13	2.13	0.82	1.64
3	0.85	1.83	1.09	2.16	0.76	1.59	0.95	1.98	1.14	2.27	0.76	1.71
4	0.81	1.86	1.10	2.24	0.73	1.60	0.91	1.99	1.14	2.36	0.73	1.73
5	0.81	1.88	1.10	2.29	0.71	1.60	0.92	1.99	1.14	2.40	0.71	1.74
6	0.81	1.89	1.10	2.33	0.70	1.60	0.92	1.98	1.15	2.43	0.70	1.74
7	0.81	1.90	1.10	2.35	0.69	1.60	0.92	1.97	1.15	2.45	0.69	1.74
8	0.81	1.90	1.10	2.36	0.69	1.60	0.92	1.96	1.15	2.46	0.69	1.74
9	0.81	1.90	1.10	2.37	0.68	1.60	0.92	1.96	1.15	2.47	0.68	1.74
10	0.81	1.90	1.10	2.37	0.68	1.60	0.92	1.96	1.15	2.47	0.68	1.74
Long run	0.81	1.91	1.10	2.38	0.68	1.60	0.92	1.96	1.15	2.48	0.68	1.74

DE



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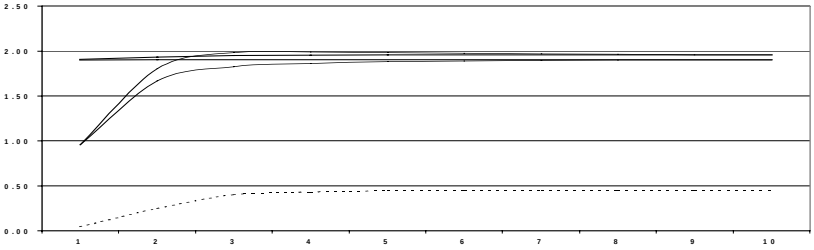

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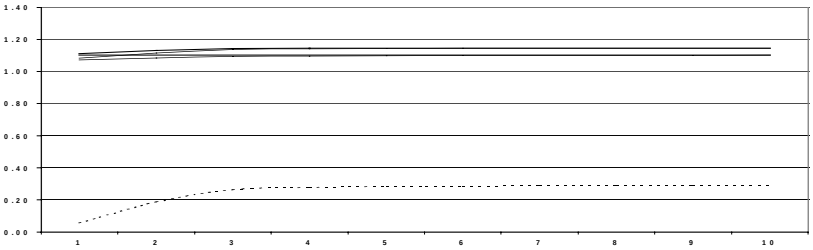

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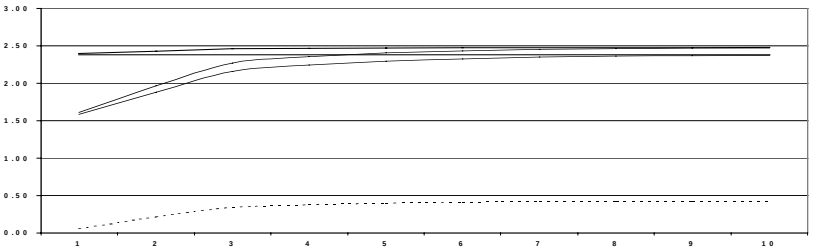

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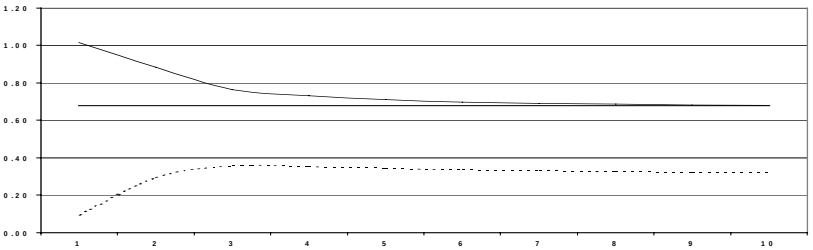

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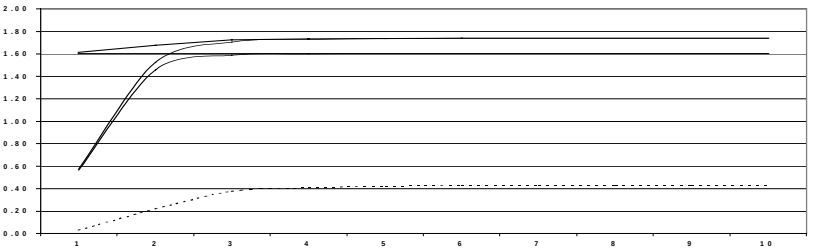
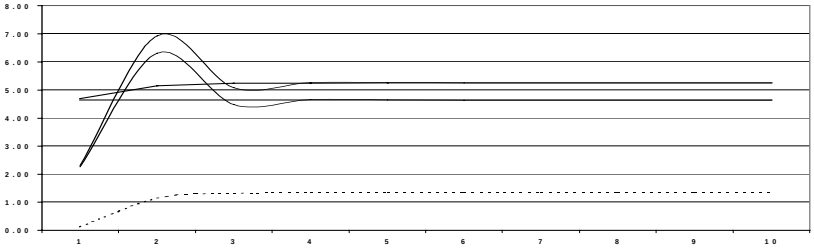


Table 5: Impact on import prices of a 10% depreciation of the euro against the US-Dollar.

Time	*DE*	*ES*	*FR*	*IT*	*NL*	*EA*	*DE*	*ES*	*FR*	*IT*	*NL*	*EA*
	without price effects						*with price effects*					
Q1	2.27	1.21	4.80	3.85	5.11	6.24	2.32	1.21	4.84	3.91	5.11	6.34
Q2	6.74	3.00	7.46	4.00	5.59	5.93	6.96	3.04	7.56	4.10	5.59	6.10
Q3	6.71	3.53	7.43	4.13	6.01	5.71	7.07	3.67	7.58	4.27	6.01	5.94
Year 1	7.40	3.99	7.41	4.25	6.39	5.54	7.93	4.21	7.60	4.42	6.39	5.82
Q1	6.31	4.38	7.39	4.35	6.72	5.42	6.93	4.68	7.60	4.55	6.72	5.74
Q2	5.89	4.71	7.37	4.45	7.01	5.34	6.58	5.08	7.61	4.66	7.01	5.68
Q3	5.05	5.00	7.35	4.53	7.27	5.28	5.74	5.42	7.61	4.76	7.27	5.64
Year 2	4.75	5.25	7.34	4.61	7.50	5.23	5.44	5.70	7.61	4.84	7.50	5.61
3	4.49	5.92	7.29	4.83	8.19	5.14	5.09	6.44	7.59	5.08	8.19	5.56
4	4.66	6.28	7.26	4.97	8.61	5.12	5.27	6.76	7.57	5.22	8.61	5.55
5	4.65	6.48	7.25	5.06	8.86	5.11	5.27	6.89	7.55	5.31	8.86	5.55
6	4.64	6.58	7.24	5.12	9.02	5.11	5.26	6.92	7.54	5.35	9.02	5.55
7	4.64	6.63	7.23	5.15	9.11	5.11	5.26	6.92	7.53	5.38	9.11	5.55
8	4.64	6.66	7.22	5.17	9.17	5.11	5.26	6.92	7.53	5.40	9.17	5.55
9	4.64	6.68	7.22	5.19	9.20	5.11	5.26	6.91	7.53	5.41	9.20	5.55
10	4.64	6.69	7.22	5.20	9.23	5.11	5.26	6.90	7.52	5.41	9.23	5.55
Long run	4.64	6.70	7.22	5.21	9.26	5.11	5.26	6.89	7.52	5.42	9.26	5.55

DE



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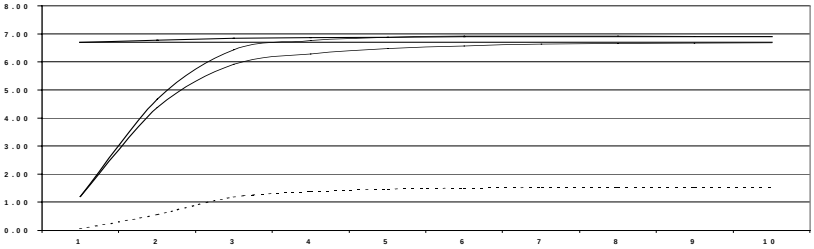

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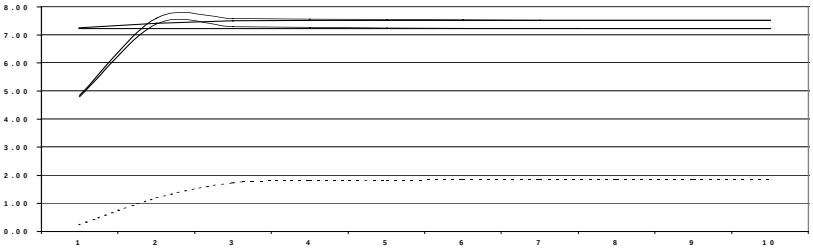

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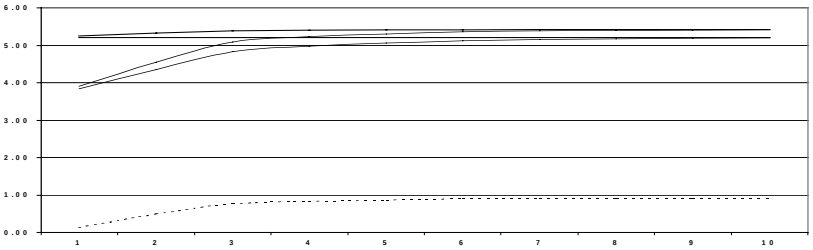

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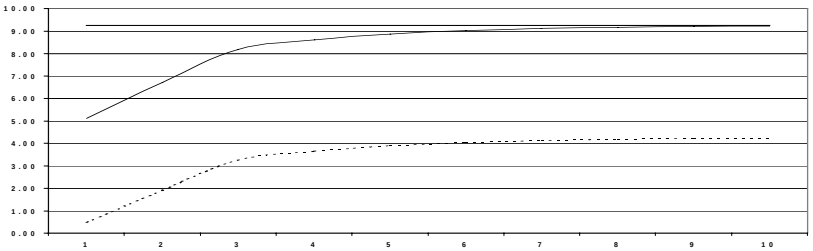

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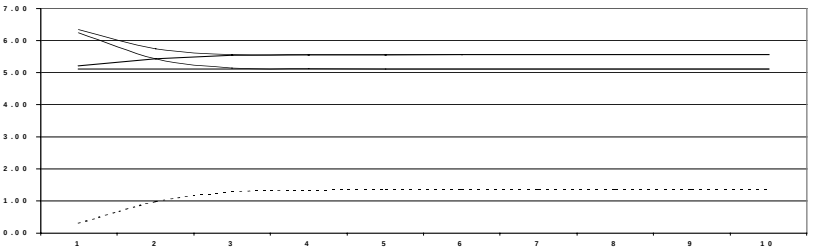

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