The Role of Exchange Rate Movements for Prices in the Euro Area

This study provides new evidence on the degree of exchange rate pass-through (ERPT) within the euro area after the launch of the euro up to the end of 2007. ERPT to import, producer, and consumer prices is estimated within a simple vector auto regression (VAR) framework. ERPT in the euro area is found to be broadly consistent with earlier studies in that it exhibits the following properties: ERPT (a) is incomplete; (b) decreases along the distribution chain; (c) might have slightly decreased; and (d) varies significantly across individual EMU member countries.

Paul Gaggl[1]

Both inflation and exchange rates within the EMU and its member states have been subject to significant volatility in the recent past. After the launch of the EMU in 1999, the euro depreciated constantly until 2001. Since then, it has appreciated continuously to reach its all-time high in early July 2008, most remarkably relative to the U.S. dollar. At the same time euro area inflation remained rather stable around the ECB's operating target of 2% until 2006, when prices in the euro area started to hike, peaking at an annual inflation rate of roughly 4%. Former ECB president, Willem F. Duisenberg, said in May 2000 that "... the depreciation of the exchange rate of the euro, until it is reversed, will increase the risks to price stability in the medium term. These risks have to be taken seriously in the light of the current strong upswing." Despite these exchange rate risks, euro area inflation remained stable until major energy price shocks in 2006 started pushing inflation to extreme heights. However, the euro was constantly appreciating during that time. A number of empirical studies tried to address President Duisenberg's concerns by investigating the so-called exchange rate "pass-through" to aggregate euro area prices, i.e. the percentage change of prices in response to a 1% change in the exchange rate (Landolfo, 2007; Hahn, 2003; Anderton, 2003; Hüfner and Schröder, 2002). However, all of these studies mainly analyzed the era prior to the formation of the EMU and, therefore, only captured the relationship of the former euro area currency exchange rates with respect to aggregate prices of the corresponding member states.

The purpose of this study is to amend the existing literature and investigate the ERPT relationship of the euro area and some of its member countries after the launch of the euro, up to the end of 2007. Moreover, I want to highlight the influence of regional differences within the euro area by also quantifying the ERPT for a number of EMU member countries individually. This will allow me to relate my empirical results to various theories trying to explain cross country differences in the ERPT relationship.

The study is organized as follows: Section 1 outlines various theoretic explanations for the ERPT relation, section 2 summarizes existing empirical studies, section 3 presents the current empirical study, and, finally, section 4 concludes.

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1 Theoretic Explanations for ERPT

Since the breakdown of the Bretton Woods fixed exchange rate system in the 1970s, economists have eagerly searched for the implications of floating exchange rates for the conduct of monetary policy, the degree of macroeconomic stability, the transmission of international shocks, and the international balance of trade and capital flows. Among the most heated debates in the recent past is the degree of pass-through of exchange rate movements to goods prices in local currency. The earlier literature on ERPT during the 1980s focused mainly on cross-sectional evidence for particular industries or even product groups and was based on theoretic models of industrial organization and optimal price-setting of firms in the presence of at least some degree of market power.[2] This study focuses on the younger literature that specifically investigates the relevance of ERPT for the optimal conduct of monetary policy, which is best analyzed in open-economy stochastic dynamic general equilibrium (DSGE) models, often referred to as the so-called "New Open Economy Macroeconomics", initiated by the seminal work of Obstfeld and Rogoff (1995).[3]

Among others, two of the most interesting stylized facts about ERPT worth investigating are first, incomplete, i.e. less than one for one, pass-through to import prices; and second, even lower degrees of ERPT to producer and consumer prices. Further, there seems to be evidence not only for incompleteness but also for a further decline in ERPT over time; and, at the same time, significant differences across countries in the response of price levels to exchange rate movements.[4] In the basic Obstfeld and Rogoff (1995) setup, firms set their prices in their home currency (producer currency pricing – PCP) but cannot change their prices at every point in time.[5] Therefore, at least in the short run, the import prices in the buyer's currency have to absorb the exchange rate movements, since export prices in the producer currency remain fixed even in the presence of exchange rate movements. Hence, in the basic Obstfeld and Rogoff (1995) setup there is complete ERPT. Devereux and Engel (2002), however, show that this tight link can be broken by considering that exporting firms set their prices in the local currency of the buyer (local currency pricing – LCP). In their model, prices are rigid in the local currency of the buyer, which has the effect that exchange rate movements do not affect goods prices in the importing country in the short run. This model is the other extreme, where ERPT is not present at all. Devereux et al. (2004) combine the two specifications and allow firms to choose the currency in which they want to price their products. Not only is their model able to explain low degrees of ERPT, but it also establishes an interesting prediction about the relation between the stability of monetary policy and the

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[2] See surveys by Goldberg and Knetter (1997) and Menon (1995) on the theory and empirics of ERPT with a focus on industry and product level studies.

[3] See Lane (2001) for a recent survey on new open economy macroeconomics.

[4] Empirical evidence for these stylized facts is discussed in section 2 as well as section 3.

[5] The assumption of so-called sticky prices is based on strong empirical evidence that firms do not change their prices very frequently. See Bils and Klenow (2004) for the United States and Fabiani et al. (2006) for European evidence.

degree of ERPT: Countries with relatively stable money growth will have relatively low pass-through rates. This highlights a link between ERPT and monetary policy, which is analyzed by Corsetti and Pesenti (2005). They find that the degree of ERPT is key in the design of optimal monetary policy. While countries with low as well as very high ERPT are best off conducting a monetary policy that aims at stabilizing the home economy, countries with intermediate degrees of ERPT would gain from international policy coordination, i.e. a monetary policy that focuses not only on stabilizing the domestic economy but one that also takes into account the trading partners' economic stability. Similarly, Sutherland (2005) shows that in the presence of incomplete ERPT the coordinated policy outcome, as advocated by Corsetti and Pesenti (2005), can be supported by individual monetary policy based on maximization of an appropriately defined welfare function. This welfare criterion is shown to depend on the second moments of home and foreign producer prices as well as the nominal exchange rate. The weight on the exchange rate depends on the degree of pass-through, the size of the economy and the elasticity of labor supply. Therefore, the degree of ERPT is potentially relevant for the optimal conduct of monetary policy, independent of the degree of international policy coordination.

While the models discussed above provide a theoretical foundation for the low degree of ERPT to aggregate prices in the importing country, they cannot explain why consumer prices react a lot less to exchange rate fluctuations than

producer or import prices at the border. However, the class of PCP models, as advocated by Obstfeld and Rogoff (2000a), in combination with either some degree of "local value added," such as local retail services, shipping etc., or the assumption that only intermediate goods are imported can also explain low rates of ERPT. An additional advantage, though, is that this strand of PCP models can also account for different degrees of pass-through at different stages of the distribution chain.[6] The former approach is proposed by Obstfeld and Rogoff (2000b), who model transportation and local distribution services as an additional cost for imported goods. This has the effect that even when imported and locally produced goods are virtually perfect substitutes, individuals will choose to consume fewer foreign goods, which introduces a bias to locally produced goods. This market segmentation has the effect that imported goods do not play that much of a role for the local CPI, and hence, fluctuations in exchange rates do not fully pass through to consumer prices. Similarly, Burstein et al. (2003) as well as Hellerstein (2008) explain declining ERPT along the distribution chain by explicitly considering a local distribution sector which optimally adjusts markups in response to changes in its cost structure.

McCallum and Nelson (1999) as well as Bacchetta and van Wincoop (2003) take the alternative approach and assume that imported goods are intermediate goods. The motivation for this approach is that most of the goods sold in a particular country are a combination of imported intermediate

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[6] Further, Obstfeld and Rogoff (2000a) argue that LCP models are not consistent with stylized facts about the relation between the terms of trade and exchange rates.

goods and locally produced goods. As soon as the proportion of imported intermediate goods within a final consumer good is low, exchange rate fluctuations, which only influence the import price for intermediate inputs, are not fully passed through to consumer prices. In particular, Bacchetta and van Wincoop (2003) assume that only intermediate goods are traded and final consumption goods are not traded at all. They show that a likely equilibrium is one where firms exporting intermediate inputs set their prices in producer currency (PCP), and the final goods producers post their prices in local currency (LCP). Hence, in their model, the existence of a large enough nontraded goods sector plays a crucial role for achieving complete pass-through to import prices but incomplete pass-through to final goods prices.

A last piece of evidence with respect to ERPT that economists try to explain is a possible decline over time in the pass-through relation. Jeanfils (2008) combines the assumptions of nontraded goods, staggered price-setting, a local distribution sector, and an endogenous variable demand elasticity, to explain all of the above-mentioned stylized facts in one model. The crucial additional assumption is a variable demand elasticity. Bergin and Feenstra (2001) show that a model with staggered price-setting and translog preferences (variable demand elasticity) can account for incomplete ERPT and a significant degree of persistence in the real exchange rate. A variable demand elasticity gives firms the possibility to conduct optimal price discrimination by varying their markups instead of prices, when exchange rate shocks hit the economy.

2 ERPT prior to the EMU

ERPT for EMU member countries and the euro area prior to the introduction of the euro has been analyzed in multiple studies. The results of these studies are summarized in the top panel of table 1. Hüfner and Schröder (2002) are the first to explicitly analyze ERPT in the euro area by estimating ERPT for France, Germany, Italy, the Netherlands, and Spain individually and then aggregate the coefficients to receive a crude proxy of euro area ERPT. They use cointegration analysis and a vector error correction model (VECM) to capture the dynamic component of ERPT and to account for the non-stationarity of several variables. In a similar study Hahn (2003) employs a vector auto regression (VAR) model similar to McCarthy (2000, 2007); however, she is the first to use aggregate euro area data. Anderton (2003) conducts time series and panel regressions for the euro area's most important import suppliers (U.S.A, Japan, the non-Japan Asia region, U.K., Sweden, Denmark and Switzerland). The most recent study of aggregate ERPT to euro area prices is the structural analysis by Landolfo (2007). He estimates various specifications of dynamic simultaneous equation models, which differ from VAR analysis in that they explicitly include exogenously given relations between some of the endogenous and additional exogenous variables.

The bottom panel of table 1 shows previous estimates of ERPT to import and consumer prices for individual countries. The differences for the individual estimates can mainly be attributed to different econometric methodology. The biggest difference can be seen between studies using panel and cross-section regressions (Campa and Goldberg, 2005 and 2006) and those applying VAR or VECM specifications

Table 1

Euro Area Exchange Rate Pass-Through Prior to EMU

Euro Area

	Hüfner and Schröder (2002)		Hahn (2003)		Anderton (2003)		Landolfo (2007)	
	short-run	long-run	short-run	long-run	short-run	long-run	short-run	long-run
Import Prices[1]	×	×	0.700	0.690	0.50−0.70	×	0.580	0.670
Consumer Prices[1]	0.040	0.080	0.087	0.212	×	×	0.086	0.148

Country Comparison

	Hüfner and Schröder (2002)		McCarthy (2007)		Campa and Goldberg (2006)		Campa and Goldberg (2005)	
	short-run	long-run	short-run	long-run	short-run	long-run	short-run	long-run
Import Prices[2]								
Germany	×	×	~0.8	~1.0	0.66	0.76	0.55	0.80
France	×	×	~0.8	~0.8	0.68	0.83	0.53	0.98
Italy	×	×	×	×	0.74	0.94	0.35	0.35
Netherlands	×	×	~1.1	~2.1	0.69	0.79	0.79	0.84
Austria	×	×	×	×	0.37	0.46	0.21	0.10
Consumer Prices[1]								
Germany	0.07	0.10	~0.1	~0.2	×	×	×	×
France	0.01	0.16	~−0.1	~−0.2	×	×	×	×
Italy	0.06	0.18	×	×	×	×	×	×
Netherlands	0.12	0.11	~0.3	~0.4	×	×	×	×

Source: Cited studies.

[1] For euro area comparisons and consumer prices in the bottom panel (country comparison), short-run refers to the response after one year and long-run to the response after three years.

[2] For import prices in the bottom panel (country comparison), short-run refers to the response after one quarter and long(er)-run to the response after four quarters since Campa and Goldberg (2005) only include four lagged variables in their estimation.

(McCarthy, 2007; Hüfner and Schröder, 2002).

Even though the individual estimates vary slightly across studies, one can summarize the following general patterns: Exchange rate pass-through is (a) incomplete, (b) significantly decreases along the distribution chain, and (c) varies significantly across EMU member states.

3 ERPT in the EMU

The main goal of this paper is to explain the effect of exchange rate movements on aggregate import, wholesale and consumer prices within the EMU. Since I focus on magnitude and speed of price adjustment in response to exchange rate shocks, I employ VAR techniques following Christiano et al. (1996), first used in the context of ERPT by McCarthy (2000 and 2007).[7] In particular, I specify the model

$$y_{i,t} = E_{t-1} y_{i,t} + \Gamma_i \varepsilon_{i,t} \qquad (1)$$

where $y_{i,t}$ is a 7×1 vector of endogenous variables, $(\pi_{i,t}^{oil}, \tilde{y}_{i,t}, \Delta e_{i,t}, \pi_{i,t}^m, \pi_{i,t}^w, \pi_{i,t}^c, r_{i,t})'$; the $k \times 1$ vector $\varepsilon_{i,t}$ consists of exogenous shocks; and Γ_i is a $k \times k$ coefficient matrix capturing the contemporaneous rela-

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[7] Christiano et al. (1996) discuss a VAR model's ability to identify a causal relation between a monetary policy shock (an exogenous shock to the U.S. federal funds rate) and main U.S. economic indicators. The same discussion applies here, for the case of an exogenous exchange rate shock and its impact on various price measures. In particular, this approach critically hinges on assumptions about the contemporaneous relations between the endogenous variables included in the VAR, which are discussed below.

tions between the endogenous variables. The variables of prime interest are $\pi_{i,t}^m$, $\pi_{i,t}^w$, and $\pi_{i,t}^c$, which correspond to import, wholesale, and consumer price inflation in country i at time t, respectively. I consider the following $k = 7$ exogenous shocks for each country i: A supply shock, $\varepsilon_{i,t}^s$; a demand shock, $\varepsilon_{i,t}^d$; an exchange rate shock, $\varepsilon_{i,t}^e$; as well as direct shocks to each set of prices, $\varepsilon_{i,t}^m$, $\varepsilon_{i,t}^w$, and $\varepsilon_{i,t}^c$; and finally, a monetary policy shock, $\varepsilon_{i,t}^{mp}$. In order to identify all these exogenous disturbances, I add the following endogenous variables: Oil price inflation, $\pi_{i,t}^{oil}$, to identify supply shocks; output gaps, $\tilde{y}_{i,t}$, to account for demand shocks; exchange rate changes, $\Delta e_{i,t}$, to pin down exchange rate shocks; and, finally, interest rates, $r_{i,t}$, to capture monetary policy reactions. The symbol E_{t-1} represents expectations conditional on information up to the end of period $t-1$.

The simple econometric specification in equation (1) expresses the idea that today's economic indicators, $y_{i,t}$, are people's expectations based on information available last period, $E_{t-1}y_{i,t}$, disturbed by random exogenous innovations, $\varepsilon_{i,t}$, which were unpredictable given the information at time $t-1$. Assuming that agents form their expectations using a vector auto regression, I can proxy the system (1) by the recursive reduced form $VAR(q_i)$

$$y_{i,t}^* = A_i y_{i,t}^* + \Gamma_i^* \varepsilon_{i,t}^* \qquad (2)$$

where A_i is the companion coefficient matrix of the $VAR(q_i)$; and variables with a superscript asterisk, x^*, are appropriate transformations of the corresponding variable $x \epsilon \{y_{i,t}, \Gamma_i, \varepsilon_{i,t}\}$ in order to represent the system as a companion

VAR(1). In what follows I will use impulse response functions to capture the effect of exchange rate changes, $\Delta e_{i,t}$, on the various price indices, $\pi_{i,t}^m$, $\pi_{i,t}^w$, and $\pi_{i,t}^c$. Exchange rate shocks are identified using a Cholesky decomposition of the estimated variance covariance matrix $\hat{\Omega}_i = \hat{\varepsilon}_{i,t}\hat{\varepsilon}_{i,t}'$ in combination with the specific Wold ordering $\{\pi_{i,t}^{oil}, \tilde{y}_{i,t}, \Delta e_{i,t}, \pi_{i,t}^m, \pi_{i,t}^w, \pi_{i,t}^c, r_{i,t}\}$. As long as exchange rates cannot contemporaneously influence supply and demand and the various price indices and short-term interest rates cannot instantaneously affect exchange rates, the chosen recursive ordering uniquely identifies exogenous exchange rate innovations, $\varepsilon_{i,t}^e$, (Keating, 1996).

3.1 Data

To quantify the degree of exchange rate pass-through for the euro area, I use a sample of five EMU member countries: Austria, Germany, France, Italy and the Netherlands, as well as the euro area (12 countries) in the aggregate. All variables are measured at monthly frequency ranging from January 2000 to December 2007.[8] Exchange rates, $e_{i,t}$, are represented by nominal effective exchange rate indices provided by Eurostat (trade weighted for 41 trade partners including the 27 EU countries and 14 extra-EU countries). Import price inflation, $\pi_{i,t}^m$, is proxied by the percentage change in import unit values (trade value divided by trade volume) provided by the OeNB. For Germany and the Netherlands I use import price indices provided by Germany's Federal Statistical Office and by Eurostat, respectively, which are a less noisy measure of import

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[8] *While all price and exchange rate measures are available for the time period January 1995 to December 2007, my measure of industrial production for Austria is only available from January 2000 onward. Therefore, for consistency reasons, I start my VAR analysis in January 2000 rather than January 1999, when the euro was introduced. Table 2 in the annex includes a detailed list of all the data sources used in this study.*

prices than unit values.[9] Producer price indices provided by the OECD are employed to compute inflation of wholesale prices, $\pi_{i,t}^w$. Consumer price inflation, $\pi_{i,t}^c$, is represented by percentage changes in the HICP, provided by Eurostat. I compute output gaps, $\tilde{y}_{i,t}$, by taking the difference between the index of monthly industrial production provided by Eurostat and an HP-filtered trend ($\lambda = 14{,}400$). The oil price measure, $\pi_{i,t}^{oil}$, is the crude oil price in USD/barrel provided by the IMF. Finally, I use monthly averages of day-to-day money market interest rates for the euro area provided by Eurostat as the measure of the monetary policy instrument, $r_{i,t}$. If necessary the series are seasonally adjusted using the U.S. census bureau X12 procedure as implemented in the computer software *EViews*.

Chart 1 shows the nominal effective exchange rate for the euro area and the selected five member countries.

One can see that after the launch of the euro in 1999 the euro strongly de-preciated until the end of 2000 and appreciated on average thereafter. All the individual effective exchange rates closely follow the euro area exchange rate and mainly differ in terms of magnitude but not in terms of volatility.

Chart 2 shows the price indices at the different stages of distribution.

One can see that import prices vary the most, followed by producer prices and consumer prices. This is a first indicator that the effect of exogenous shocks decreases along the distribution chain of prices. Moreover, one can see in chart 2 that the ranking among EMU member countries in terms of average price level changes along the distribution chain. France, for instance, appears to have the second-lowest import prices on average, the lowest producer prices but the third-lowest consumer prices. This already suggests that differences in industrial composition and organization across EMU member states seem to matter for the effect of exogenous disturbances to prices at the different stages of the pricing chain. For Germany

Chart 1

Nominal Effective Exchange Rate
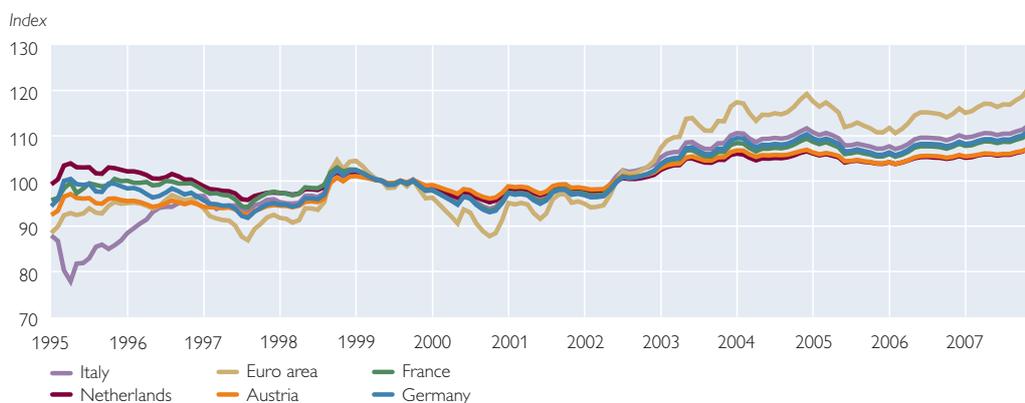
Source: Eurostat.

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[9] *See a report by the General Accounting Office (1995), which illustrates how both measurement and aggregation errors contribute to significant noise in unit value measures in the United States. Also Hallak and Schott (2008) provide a detailed discussion of differences between import price indices and unit values.*

Chart 2
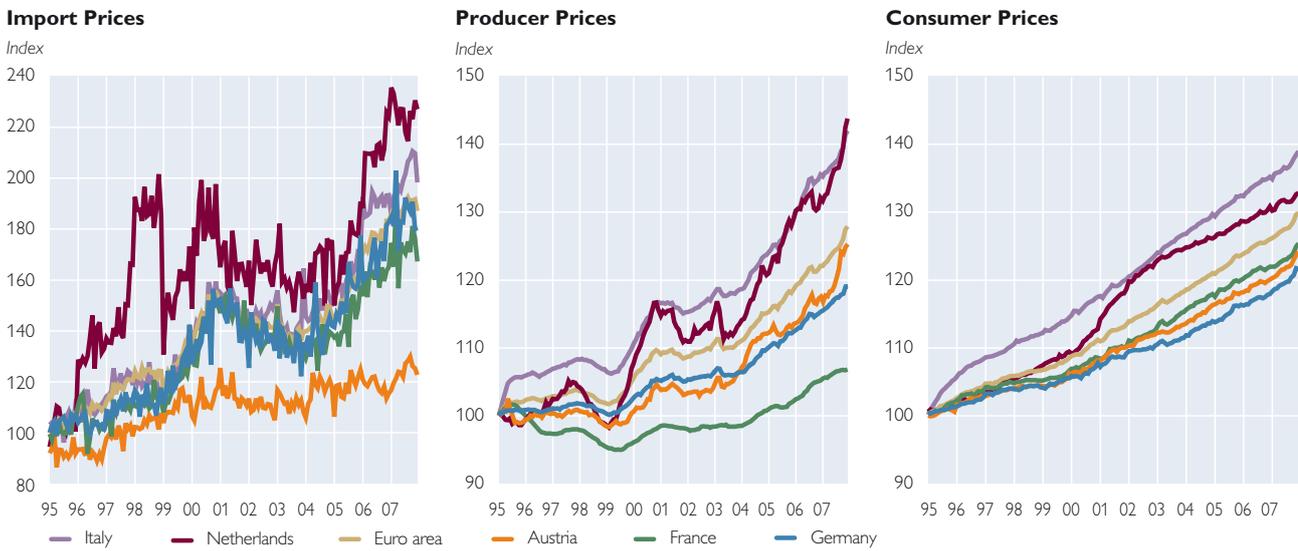
Price Measures − Country Comparison

Import Prices

Index

Producer Prices

Index

Consumer Prices

Index

Italy   Netherlands   Euro area   Austria   France   Germany

Source: Eurostat, OECD, OeNB.

Chart 3

Import Price Measures − Unit Values versus Import Price Index

Germany

Index

Netherlands

Index

Import unit values   Import price index

Source: Eurostat, Federal Statistical Office, OeNB.

and the Netherlands there are import price indices available which, compared to the unit values, are a lot smoother, as can be seen in chart 3. However, the less volatile price indices display the same general pattern over time, as unit values and also preserve the decrease in volatility of prices along the distribution chain, as mentioned above. In principle, it would be preferable to have import price indices for all countries, but the import unit values used for the remaining countries in my sample are the only data on import prices for EMU

member countries available in monthly frequency for the time period past 2002.[10]

3.2 Empirical Results

The results presented in this section were computed using the model described at the beginning of section 3. The sample period is January 2000 to December 2007. All countries are estimated as VAR(1) models in accordance with the AIC_c lag length criterion.[11] Exchange rate pass-through is illustrated by impulse response functions, displaying the response of prices over three years (36 months) following a 1% permanent nominal effective appreciation.[12] The solid line in each chart represents the estimated impulse response, while the dashed lines correspond to two standard error confidence intervals around each point forecast.

3.2.1 Import Prices

Like in earlier studies, the ERPT in the euro area is incomplete on every stage of the price chain (Landolfo, 2007; Hahn, 2003; Anderton, 2003; Hüfner and Schröder, 2002). Chart 4 shows that exchange rate movements are significantly passed through to import prices within the first year after an exchange rate shock, peaking after about one quarter. In the short run about 60% and in the long run about 30% of an exchange rate shock are passed through to euro area import prices. Taking into account the considerable uncertainty associated with the estimated responses, this is consistent with the only euro area evidence by

Hahn (2003), Anderton (2003) and Landolfo (2007), who estimate short-run ERPT to import prices of 50% to 70%. In the long run, my estimates are slightly lower, which suggests a mild reduction in the degree of euro area ERPT relative to the pre-EMU era.

Looking at cross-country comparisons, for Germany and the Netherlands – whose estimates are based on import price indices rather than unit values – one can see a significant pass-through within one year, peaking during the first two quarters after the shock. The estimated degrees of ERPT are broadly consistent with previous studies (McCarthy, 2007; Campa and Goldberg, 2005 and 2006). Notice however, that, in the long run, my estimates seem to be significantly lower than those estimated by McCarthy (2007), who uses the same econometric methodology. Further, it is worth noting that the larger of the two countries, Germany, exhibits degrees of ERPT more similar to the euro area average while the Netherlands are far above average. The impulse responses for all the remaining countries (Austria, France and Italy) should be interpreted with caution. Their respective response coefficients are very imprecisely estimated, most likely due to the considerable noise in the highly volatile unit value measures.

Overall, the observation that my more recent estimates seem to reveal slightly lower pass-through than earlier studies is in line with the theory advocated by Taylor (2000), who argues that in the presence of a more stable monetary environment, like EMU,

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[10] As of 2009, Statistics Austria has been publishing an import price index for Austria (www.statistik.at/web_en/statistics/Prices/import_price_index/index.html). At the cutoff date for this study, however, this index was not yet available.

[11] This information criterion is a small sample correction of Akaike's information criterion (AIC) as suggested by Hurvich and Tsai (1993).
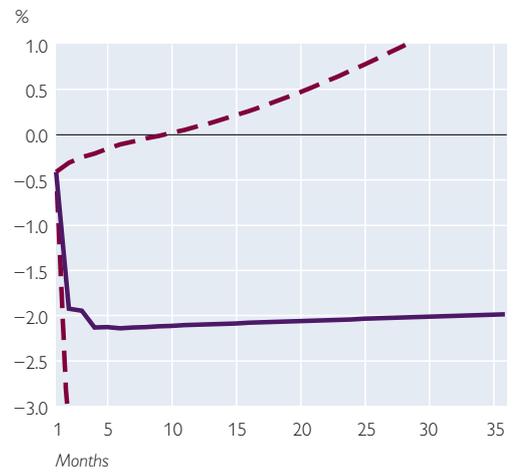
[12] Technically, this is accomplished by plotting the accumulated response of import, producer, and consumer price inflation to a temporary (one-period) 1% innovation to the change in exchange rates.
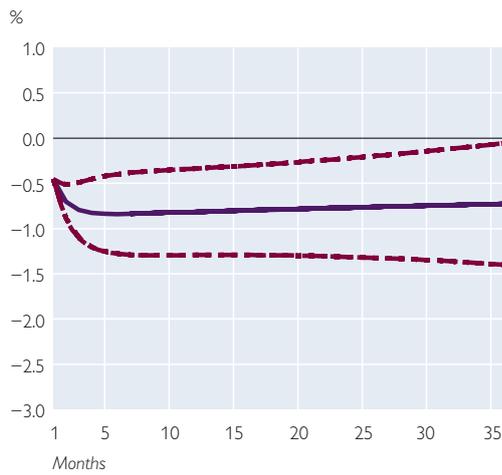
Chart 4

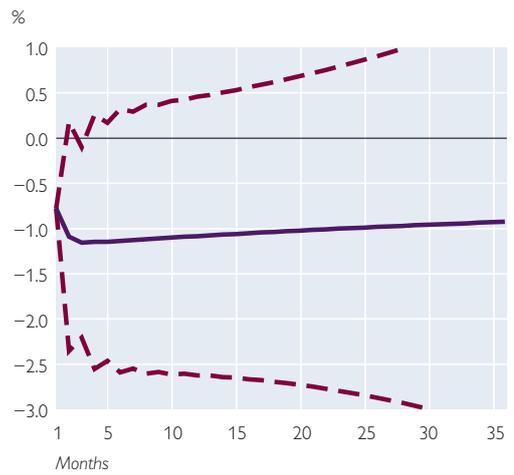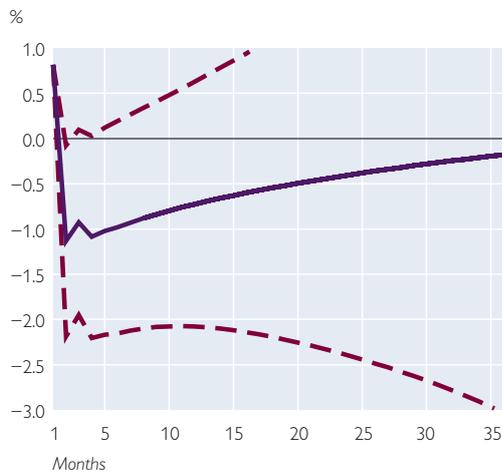## Exchange Rate Shock − Import Prices

Euro area
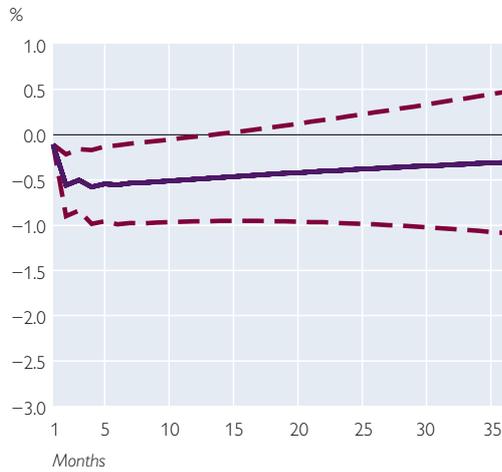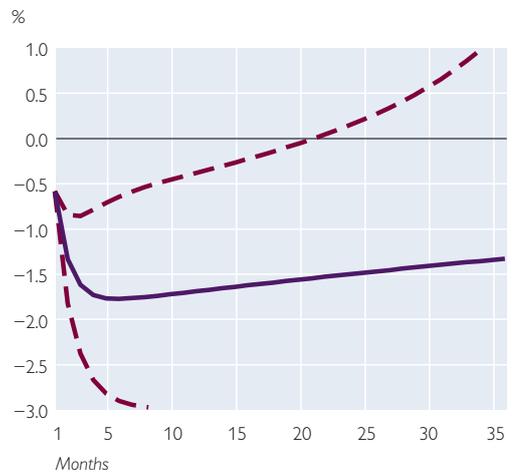
Austria

Germany

France

Italy

Netherlands

- - - Standard error confidence   ——— Impulse response

Source: Author's calculations.

Note: The chart illustrates the accumulated response of $\pi_{i,t}^{m}$ to 1% innovations to $\Delta e_{i,t}$. The dashed lines represent two standard error confidence bands computed with 5,000 residual bootstrap replications.

there should be a lower degree of ERPT. This finding is also consistent with Marazzi et al. (2005), who find a strong decline of ERPT to U.S. import prices over the last 20 years. They attribute the U.S. evidence of a declining ERPT mainly to two possible explanations: First, there seems to be evidence for a shift in demand toward goods that are less commodity-intensive and hence less sensitive to exchange rate movements. Second, China's fixed exchange rate policy together with an increased presence of China's exporters in the U.S. market appears to have played a role. Since the current study is based on aggregate data only, I cannot directly address these conjectures. However, it is likely that, on top of the more stable monetary environment in EMU, forces similar to the ones discussed by Marazzi et al. (2005) contribute to the decline in ERPT in the euro area.

3.2.2 Producer Prices

Chart 5 illustrates that the pass-through of exchange rate shocks to producer prices is considerably less significant than ERPT to import prices. ERPT for the euro area is significant for about half a year and reaches its maximum after about six months. This indicates that pass-through to producer prices is slower than for import prices, which show the strongest reaction within the first quarter. Further, the maximum pass-through is about 10% after six months and only about 5% in the long run, while import prices showed a long-run pass-through of roughly 30% and peaked at about 60%.

ERPT in the individual EMU member countries varies considerably. While there is no significant pass-through to Austrian, German, French and Italian producer prices after one month, there is a significant effect on the producer price index (PPI) in the

Netherlands for about half a year. The maximum degree of pass-through in the Netherlands is about 80% after half a year, while all the other countries (except for France) show ERPT between 3% and 7% in the first month but no statistically significant pass-through after one month. Furthermore, France shows the wrong sign, which is also the case in McCarthy (2007). The findings for producer prices, again, are consistent with the theory that ERPT in (economically) larger countries, like Germany, is closer to the euro area average. Smaller countries, like the Netherlands, appear to exhibit more than (euro area) average ERPT.

3.2.3 Consumer Prices

Statistically, consumer prices in the euro area, as well as in all of the individual EMU member countries investigated, do not respond to an effective exchange rate appreciation of the euro, as highlighted in chart 6. This result is consistent with most of the existing VAR-based ERPT studies, which observe either very small or no significant ERPT to consumer prices (McCarthy, 2007; Hahn, 2003; Anderton, 2003; Hüfner and Schröder, 2002). For consumer prices, the Netherlands deliver the odd result that an effective appreciation results in a slight increase in prices during the first month, which is a phenomenon that McCarthy (2007) also observes for some OECD countries.

4 Conclusion and Discussion

This study provides new evidence for exchange rate pass-through in the euro area since the introduction of the euro up to the end of 2007. The empirical results are broadly consistent with the existing empirical evidence, which is a sign for a rather stable relationship between exchange rate movements and
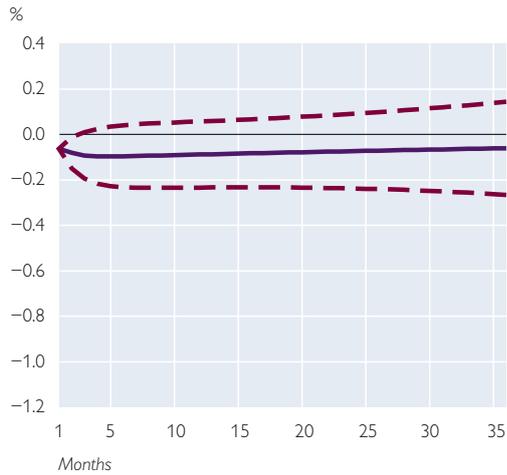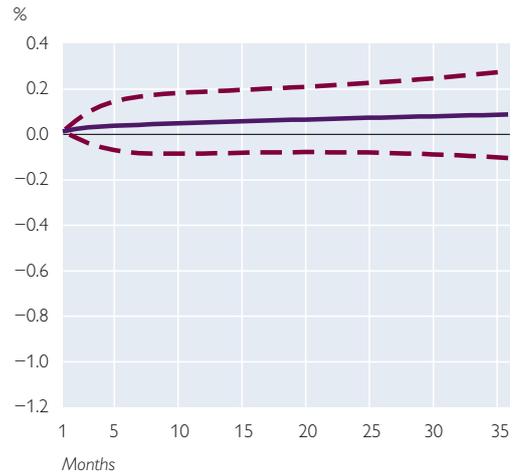
Chart 5

Exchange Rate Shock − Producer Prices

Euro area
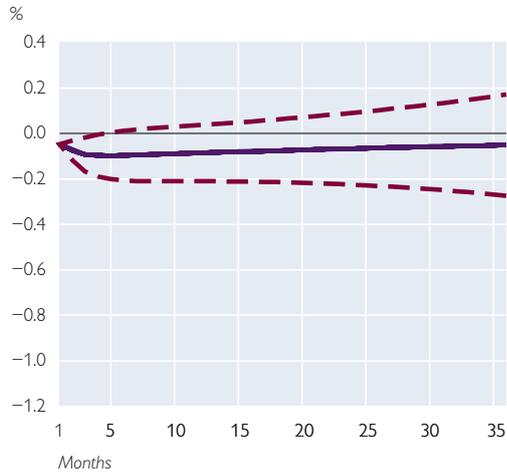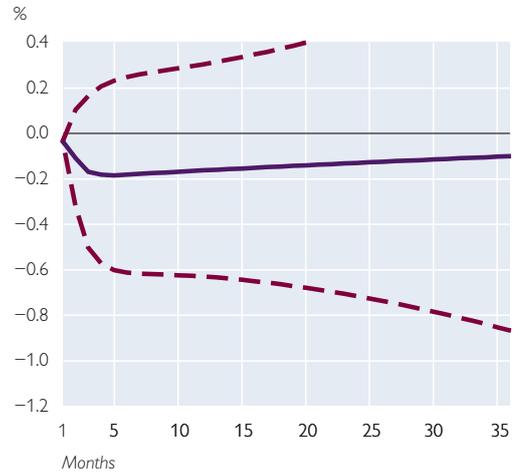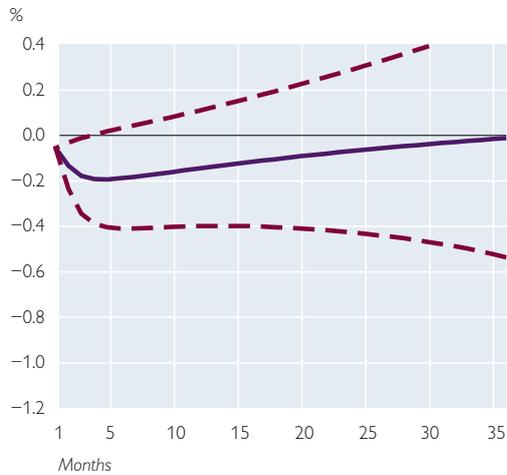

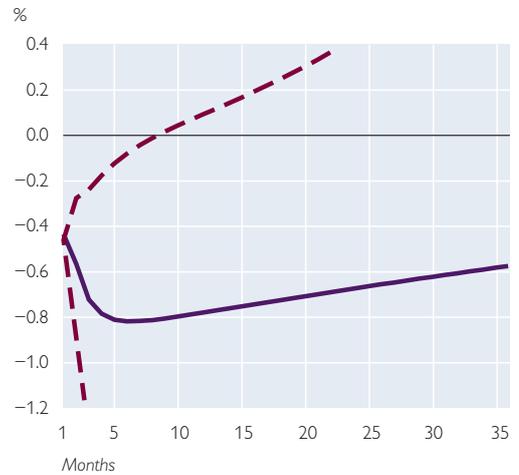**Austria**

Germany

France

Italy

Netherlands

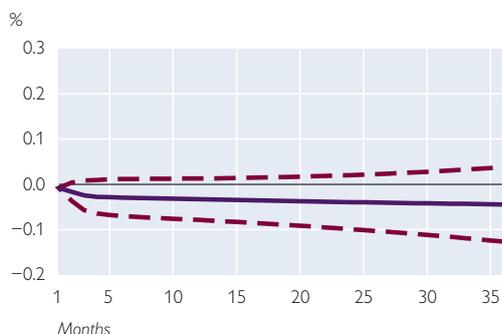- - Standard error confidence   —— Impulse response

Source: Author's calculations.

Note: The chart illustrates the accumulated response of $\pi_{i,t}^{w}$ to 1% innovations to $\Delta e_{i,t}$. The dashed lines represent two standard error confidence bands computed with 5,000 residual bootstrap replications.
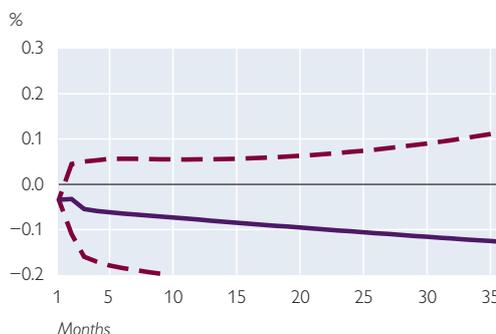
Chart 6
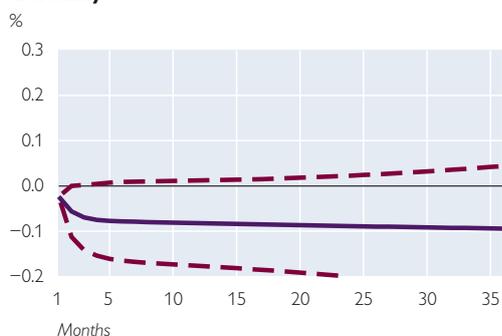
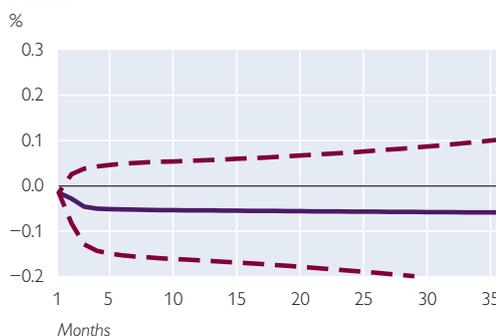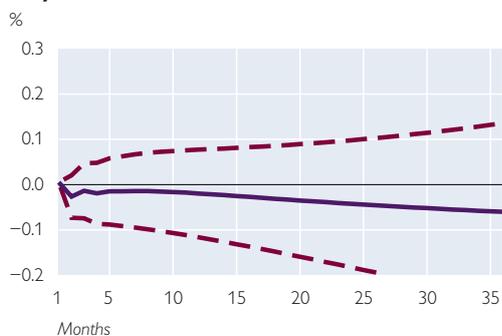## Exchange Rate Shock – Consumer Prices

Euro area

%

Austria

%

Germany

%

France
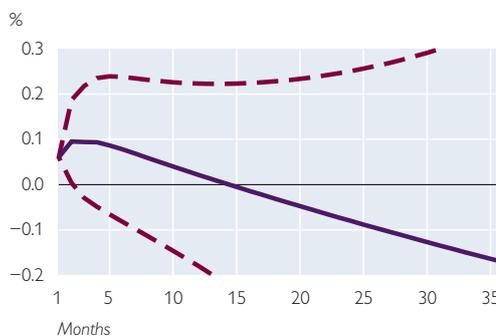
%

Italy

%

Netherlands

%

- - - Standard error confidence   ——— Impulse response

Source: Author's calculations.

Note: The chart illustrates the accumulated response of $\pi^{c}_{i,t}$ to 1% innovations to $\Delta e_{i,t}$. The dashed lines represent two standard error confidence bands computed with 5,000 residual bootstrap replications.

price adjustment in the euro area. Even though all the estimates are very imprecisely estimated, one can see a very mild decline in ERPT in the euro area relative to earlier studies. Taylor (2000) argues that such a decline could be explained by a more stable monetary environment, such as provided by the euro. Apart from the slight decline, the

qualitative findings are identical to the earlier empirical literature. ERPT is strong (up to 60% in the euro area) for import prices, rather weak for producer prices, and barely noticeable for consumer prices. There are various theories that can explain this phenomenon, among them the existence of a large nontraded sector or a large degree

of local value added through retail and distribution services. Looking at the euro area as a whole, one could argue that the large proportion of intra euro area trade serves as a large nontraded sector.

Cross-country comparisons reveal that there is a significant degree of heterogeneity among EMU member countries, which results in quite different degrees of ERPT. There are various reasons which could lead to those differences, such as country size, the degree of openness, or sectoral composition of individual EMU member states. The cross-country comparisons in this study have to be treated with caution, though. First, the strongest ERPT is observed for import prices, which for most countries were proxied with import unit values. These unit values are a very noisy measure and hence produce very imprecise results. Second, all the price indices used incorporate goods that are traded both within and outside of the euro area. On the one hand, this is a possible theoretical explanation for very low degrees of ERPT, especially at the consumer level. On the other hand, the estimates incorporate two distinct effects which cannot be separately identified. First, a direct effect from trade with a particular currency area and second, an indirect effect through intra-euro area

trade at a one-to-one exchange rate with countries that are again trading partners with the same country. It would be interesting to isolate the two effects to investigate the cross-country differences in the importance of the direct and the indirect effect.

This study is a first attempt to quantify the ERPT in the euro area on a purely empirical basis. As a next step, it would be interesting to test particular open-economy DSGE models against the VAR evidence and estimate structural parameters of such a model. For the euro area in the aggregate one could use impulse response matching à la Christiano et al. (2005) to estimate the structural parameters of the model within standard open-economy models. However, for cross-country comparisons within the euro area, the existing two country open economy DSGE models are not suitable. One needs to modify the models to account for the fact that individual member countries take monetary policy as given but share it with all intra-euro area trading partners. That way one could potentially estimate interesting structural parameters such as the degree of openness (i.e. size of the traded goods sector), the degree of price rigidities, etc., which are crucial in theory for the level and dynamics of ERPT for individual EMU member countries.

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Annex

A – Data Sources
Table 2 summarizes the detailed data sources.

Data Sources

Variable	Measured by	Unit	Source	Database/Table/Series	Links
Oil prices	Crude oil price	USD/Barrel	IMF	OeNB database based on IMF data	
Industrial production	Industrial production	Index		Industry and services – monthly data (is_m); industrial production – total industry (excluding construction) – seasonally adjusted (is080idx)	http://epp. eurostat. ec.europa.eu/
Exchange rates	Effective exchange rates	Index	Eurostat	Industrial countries' effective exchange rates including the new EU Member States – monthly data (ert_eff_ic_m); nominal effective exchange rate – 41 trading partners (neer41)	http://epp. eurostat. ec.europa.eu/
Import prices					
Germany	Import price index	Index	Federal Statistical Office	Import prices	http://www. destatis.de/
Netherlands	Import price index	Index	Eurostat	Industry – monthly indices of import prices (ebt_inpi_m); import price index (impr); total industry (excluding construction) (c_d_e); gross data (gross)	http://epp. eurostat. ec.europa.eu/
All other countries	Unit values	Index	OeNB	OeNB computations based on Eurostat import values and volumes	
Producer prices	Producer prices	Index	OECD	Price indices (Main Economic Indicators – MEI); manufacturing products	http://www. oecd.org/ statsportal/
Consumer prices	HICP	Index	Eurostat	Harmonized consumer prices – monthly data (cp_m); harmonized consumer prices – monthly data (cp000idx)	http://epp. eurostat. ec.europa.eu/
Interest rates	Day-to-day money market interest rate		Eurostat	Monetary and financial indicators – monthly data (mf_m); day-to-day money market interest rates – monthly average – not seasonally adjusted (mf100rt)	http://epp. eurostat. ec.europa.eu/

Source: Author's compilation.

B – Alternative Estimation Technique
This section illustrates an alternative empirical approach based on Jordà (2008), which yields qualitatively comparable results. Here, I abstract from the assumption that agents use a VAR to form their expectations and instead assume that the expectations in (1) are computed by direct forecasts using local linear projections. In addition, I do not report the conventional two standard error confidence bands around each single impulse response coefficient but, rather, confidence regions based on the joint test of the whole impulse response path against the alternative constant

path at zero (Jordà, 2008). Section B.1 briefly illustrates the estimation and testing strategy, and section B.2 reports the empirical results.

B.1 Estimation and Inference by Local Projections

Following Jordà (2008) I use local projections to compute the $h = 1, ..., H$ structural impulse response coefficients, $\hat{\Phi}_h$, associated with the 7×1 vector time series $y_{i,t}$ and stack them to the impulse response path

$$\hat{\Phi}(1,H) = \begin{bmatrix} \hat{\Phi}_1 \\ \vdots \\ \hat{\Phi}_H \end{bmatrix} \quad (3)$$

where $\hat{\Phi}(1,H)$ is a $7 \cdot H \times 7$ matrix. The estimated impulse response of the ith variable to a shock in the jth variable at horizon h is given by the (i,j) element of the 7×7 matrix $\hat{\Phi}_h$. The accumulated responses reported in charts 7 through 9 in section B.2 are then constructed as

$$\hat{\phi}_{i,j} = LS_{i,j} vec\left(\hat{\Phi}(1,H)\right) \quad (4)$$

where $S_{i,j} \equiv e'_j \otimes (I_H \otimes e_i)'$, with e_ℓ representing the ℓth column of I_7, is a selector matrix that picks the $(i,j)^{th}$ impulse response and L is an $H \times H$ matrix with ones in the main diagonal and below, which sums up the response coefficients. The associated variance covariance matrix is $\hat{\Omega}_{i,j} = LS_{i,j}\hat{\Omega}_\phi S'_{i,j} L'$, where $\hat{\Omega}_\phi$ is a consistent estimator of the variance covariance matrix of

$vec\left(\hat{\Phi}(1,H)\right)$ (see Jordà, 2008 for details of the computation of $\hat{\Omega}_\phi$).

To compute confidence regions for the $(i,j)^{th}$ impulse response function I construct the Wald statistic

$$\hat{W}(i,j) = T\hat{\phi}'_{i,j} \hat{\Omega}^{-1}_{i,j} \hat{\phi}_{i,j} \xrightarrow{d} \chi^2_H \quad (5)$$

which allows me to test the null hypothesis $H_0 : \phi(i,j) = 0_{H \times 1}$. This is nothing else than testing for *joint significance* of the $(i,j)^{th}$ impulse response path. Each figure in the subsequent section reports the value of the Wald statistic, $\hat{W}(i,j)$, and the associated χ^2_H critical values and p-values for a significance level of $\alpha = 0.05$. Following Jordà (2008) I also compute two-dimensional approximations of the 95%, 75%, 50%, and 25% confidence regions and plot them as *fan charts*.
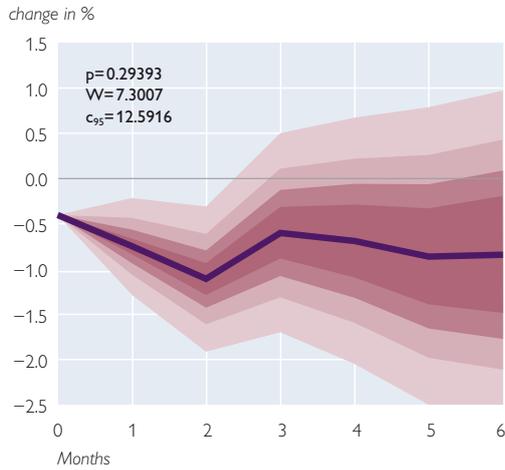
B.2 Empirical Results

Charts 7 through 9 plot accumulated impulse responses for a horizon $H = 6$ (half a year) of $\pi^m_{i,t}$, $\pi^w_{i,t}$, and $\pi^c_{i,t}$, in response to shocks to $\Delta e_{i,t}$ estimated with local projections as outlined in the previous section. Qualitatively, the pictures convey the same information as the pictures in the main text. Notice that the joint Wald tests at a 95% confidence level for import prices suggest that only Germany and the Netherlands experience significant ERPT. Again, that suggests that the unit value measures used for the remaining countries are a poor measure for import prices.
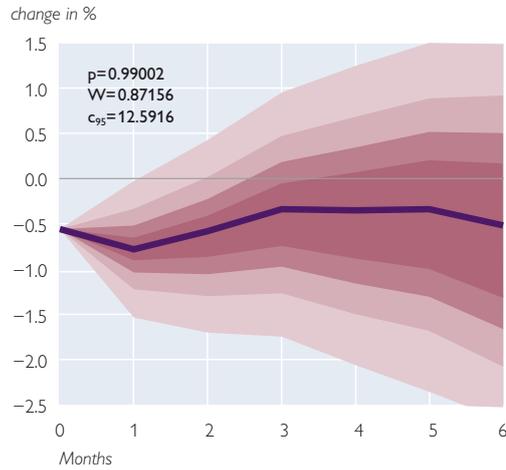
Chart 7

Exchange Rate Shock − Local Projections for Import Prices
(accumulated response of $\pi_{i,t}^{m}$ to a 1% change in $\Delta e_{i,t}$)
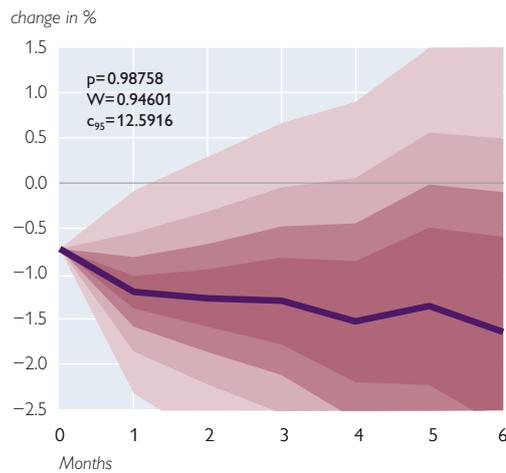
Import Prices − Euro area

change in %

p=0.29393
W=7.3007
c₉₅=12.5916

p=0.29393
W=7.3007
c_{95}=12.5916

Import Prices − Austria

change in %

p=0.99002
W=0.87156
c_{95}=12.5916

Import Prices − Germany

change in %

p=$8.3493e\text{-}07$
W=38.6586
c_{95}=12.5916

Import Prices − France

change in %

p=0.98758
W=0.94601
c_{95}=12.5916

Import Prices − Italy

change in %

p=0.86005
W=2.5744
c_{95}=12.5916

Import Prices − Netherlands
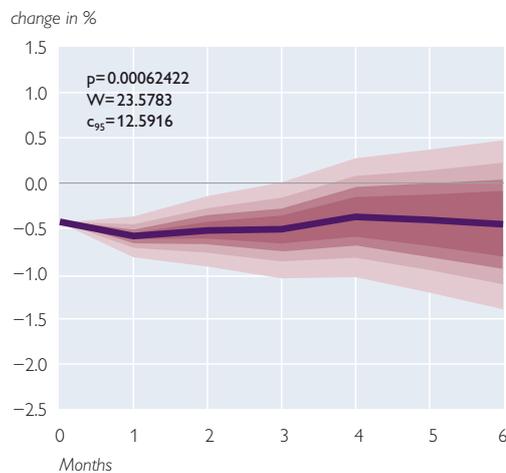
change in %

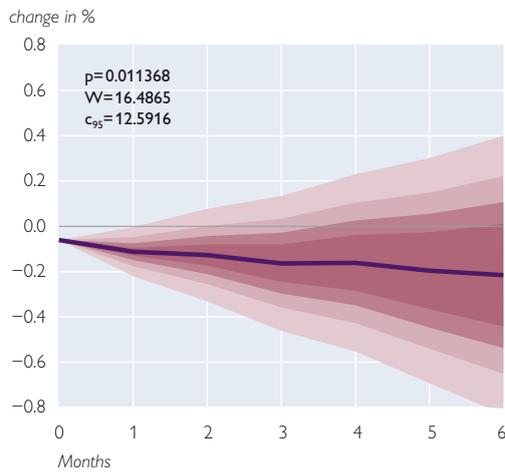p=0.00062422
W=23.5783
c_{95}=12.5916

Impulse response ▪ 95% confidence ▪ 75% confidence ▪ 50% confidence ▪ 25% confidence

Source: Author's calculations.

Note: The asymptotic 95%, 75%, 50%, and 25% confidence regions are based on methods developed by Jordà (2008). In each graph the p-values, the Wald statistic, and the critical value for the 95% confidence level are denoted by W, p, and c₉₅, respectively.

Chart 8

Exchange Rate Shock − Local Projections for Producer Prices
(accumulated response of $\pi_{i,t}^{w}$ to a 1% change in $\Delta e_{i,t}$)
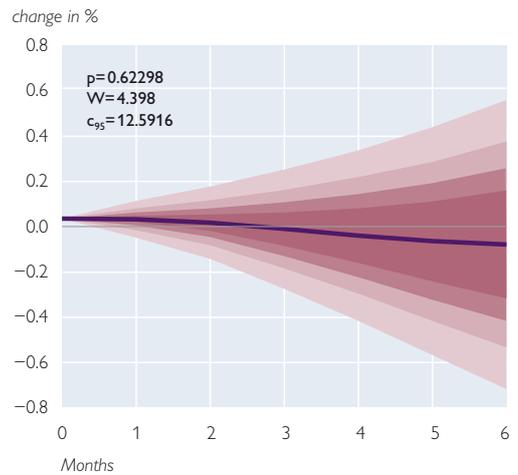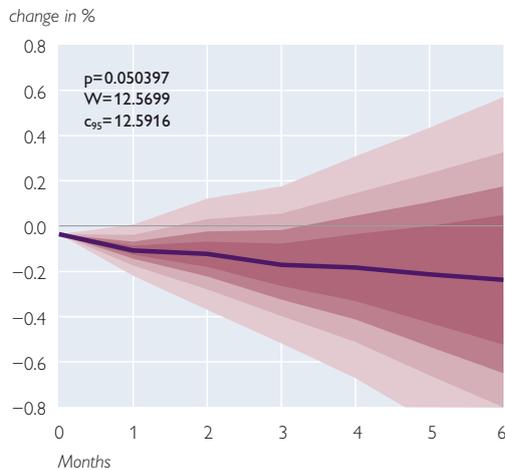

Producer Prices − Euro area

change in %

p=0.011368
W=16.4865
c$_{95}$=12.5916

Months

Producer Prices − Austria

change in %

p=0.55186
W=4.9374
c$_{95}$=12.5916

Months

Producer Prices − Germany

change in %

p=0.12981
W=9.8797
c$_{95}$=12.5916

Months

Producer Prices − France

change in %

p=0.62298
W=4.398
c$_{95}$=12.5916

Months

Producer Prices − Italy

change in %

p=0.050397
W=12.5699
c$_{95}$=12.5916

Months

Producer Prices − Netherlands
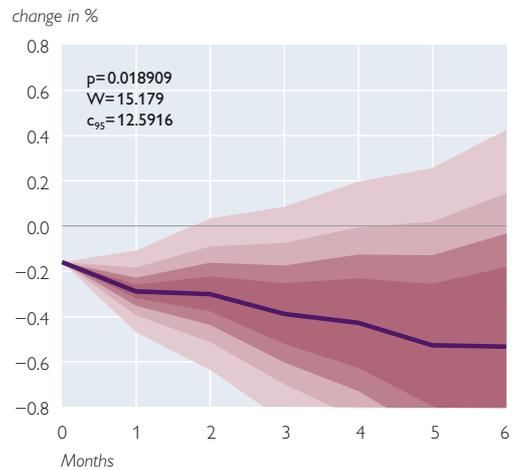
change in %

p=0.018909
W=15.179
c$_{95}$=12.5916

Months

Impulse response   95% confidence   75% confidence   50% confidence   25% confidence
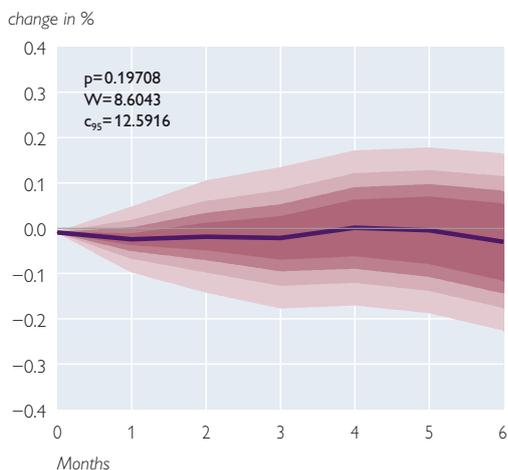
Source: Author's calculations.

Note: The asymptotic 95%, 75%, 50%, and 25% confidence regions are based on methods developed by Jordà (2008). In each graph the p-values, the Wald statistic, and the critical value for the 95% confidence level are denoted by W, p, and c$_{95}$, respectively.
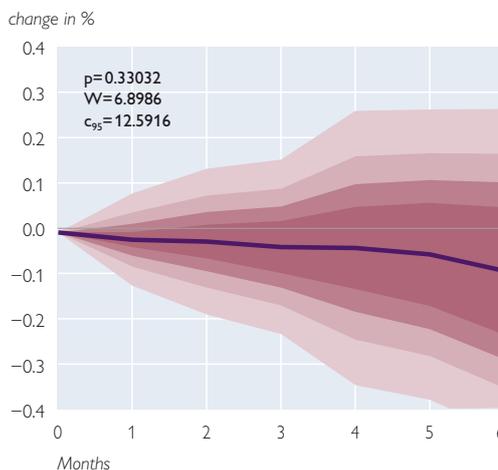
Chart 9

Exchange Rate Shock − Local Projections for Consumer Prices
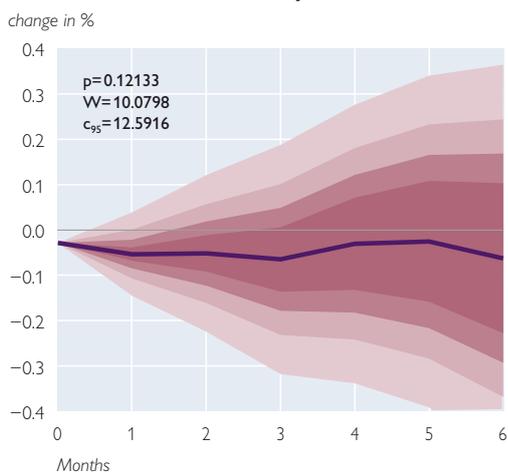### (accumulated response of $\pi_{i,t}^{c}$ to a 1% change in $\Delta e_{i,t}$)
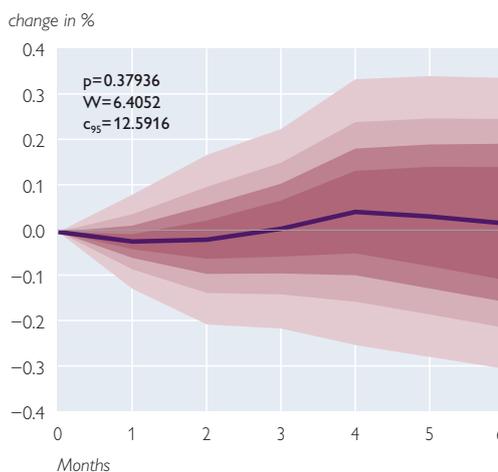
Consumer Prices − Euro area

change in %
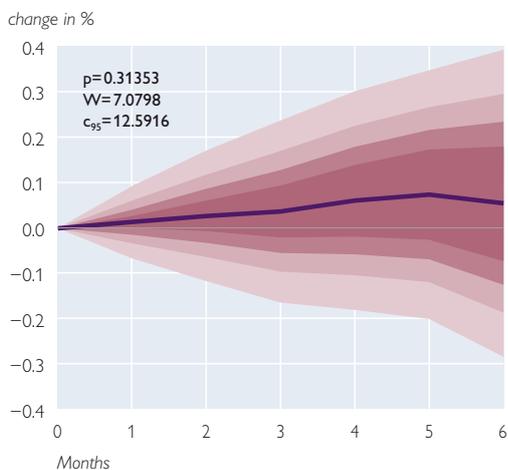
p=0.19708
W=8.6043
c_{95}=12.5916

Months

Consumer Prices − Austria

change in %

p=0.33032
W=6.8986
c_{95}=12.5916

Months

Consumer Prices − Germany

change in %

p=0.12133
W=10.0798
c_{95}=12.5916

Months

Consumer Prices − France

change in %

p=0.37936
W=6.4052
c_{95}=12.5916

Months

Consumer Prices − Italy

change in %

p=0.31353
W=7.0798
c_{95}=12.5916

Months

Consumer Prices − Netherlands

change in %

p=0.62557
W=4.3787
c_{95}=12.5916

Months

— Impulse response   95% confidence   75% confidence   50% confidence   25% confidence

Source: Author's calculations.

Note: The asymptotic 95%, 75%, 50%, and 25% confidence regions are based on methods developed by Jordà (2008). In each graph the p-values, the Wald statistic, and the critical value for the 95% confidence level are denoted by W, p, and c_{95}, respectively.