

Articles

1 Exchange rate pass-through into euro area inflation

Exchange rate movements are one factor affecting inflation in the euro area. The exchange rate can influence euro area inflation both directly via the price of imported final consumer goods, and indirectly via the price of imported intermediate goods used in euro area domestic production. Empirical studies have shown that exchange rates have a stronger and more immediate effect on import prices than on final consumer prices. Moreover, the size and speed of the exchange rate effects differ across product categories. The macroeconomic environment, factors affecting pricing decisions at the firm level and the shocks driving the exchange rate movements determine the strength of the exchange rate effects on inflation. Over time, the size of exchange rate pass-through is documented to have declined in the euro area and other advanced economies. This decline can be attributed to several factors, including the low inflation environment prevailing in many economies over the past two decades and the changing composition of imports.

Introduction

The degree to which exchange rate changes are transmitted to import prices and subsequently to final consumer prices is commonly referred to as the “exchange rate pass-through”. Understanding the role of exchange rates in shaping economic outcomes is important from a monetary policy perspective. In particular, assessing the degree of pass-through of exchange rate movements to import or domestic prices is essential for monitoring and forecasting domestic inflation.

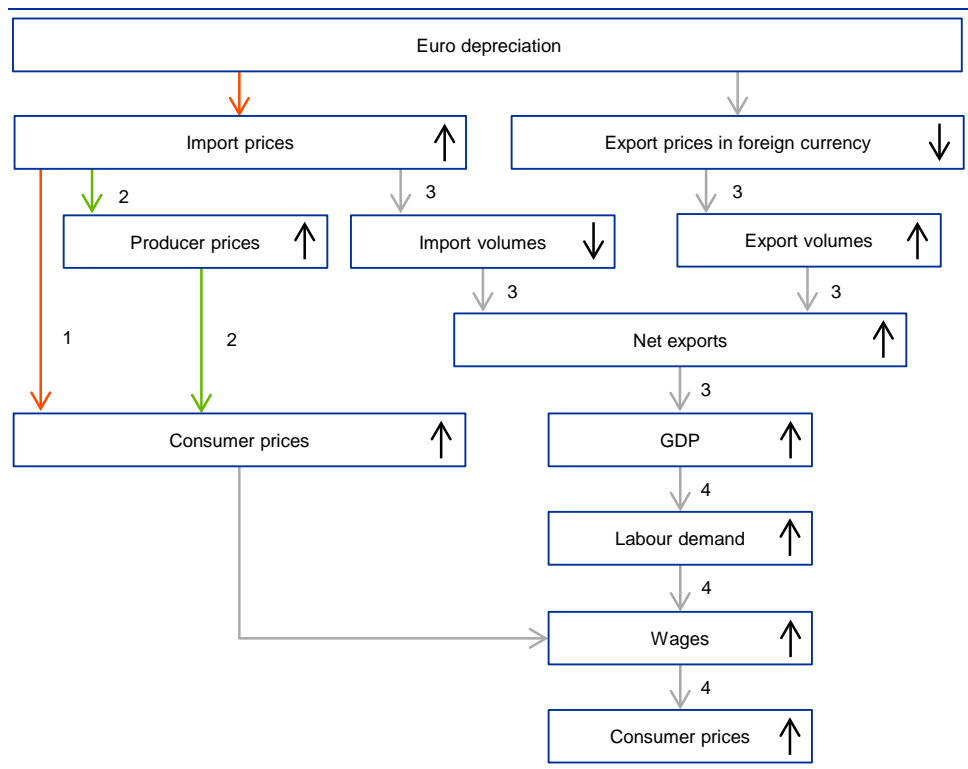
Exchange rate changes are transmitted to HICP inflation via a number of channels, both direct and indirect. Exchange rate movements are passed on directly to consumer prices via their impact on the import prices of final consumer goods. Following an exchange rate depreciation, imported final consumer goods become more expensive (“first stage pass-through”), pushing up overall HICP inflation. Figure 1 provides an overview of the direct and indirect effects of a depreciation in the euro nominal effective exchange rate (NEER). The direct channel is depicted by the arrow labelled “1”, which joins import prices directly with consumer prices and depends on the pricing decisions of foreign producers exporting to the euro area.

Indirect effects, which can take longer to trickle through the economy, work via production costs and real channels. The euro depreciation translates into higher production costs due to more expensive imported inputs, and these feed through the different stages of domestic intermediate and final goods production (“second stage pass-through”), with an inflationary impact on domestic consumer prices. This channel is depicted by the arrows labelled “2”, which connect import prices with

producer prices and then consumer prices, and depends, inter alia, on the pricing behaviour of domestic firms. The latter might pass on the increase in costs resulting from the euro depreciation in order to keep mark-ups and profits constant, or they might keep prices constant and accept lower profits, thus dampening the pass-through to final consumer prices.

As regards the real channels, the euro depreciation decreases euro area export prices denominated in foreign currency and increases import prices in euro. This, in turn, leads to an increase in net exports and higher GDP growth (indicated by the arrows labelled “3”). As the increase in real GDP growth leads to higher labour demand and higher wages, this puts upward pressure on consumer prices (indicated by the arrows labelled “4”). These indirect effects can be reinforced by expectations of a positive loop of future higher growth and inflation.

Figure 1
Schematic overview of direct and indirect effects of a depreciation in the NEER



Note: The arrows connecting the boxes indicate causality, while the arrows inside the boxes refer to the direction of movement of the variable.

The composition of the consumption basket is also relevant for understanding how exchange rate changes affect HICP inflation. The harmonised index of consumer prices (HICP) is a weighted average of a representative basket of goods and services consumed by households in the euro area. This basket covers a wide range of items, from food and clothing to accommodation services, which have different shares of imported inputs in their production structure.¹ The aggregate

¹ An [overview](#) of the product categories included in the HICP basket is available on the ECB’s website.

effect depends on the composition of the consumption basket, which can change over time.

Exchange rate pass-through also depends on what shocks drive exchange rates and inflation at each point in time. The exchange rate pass-through is usually understood as a correlation between exchange rate changes and inflation, without any meaningful economic interpretation. However, from an economic point of view, the pass-through is related to the nature of the shocks driving the exchange rate and prices, as this is one of the factors that affect how firms react and adjust their prices.

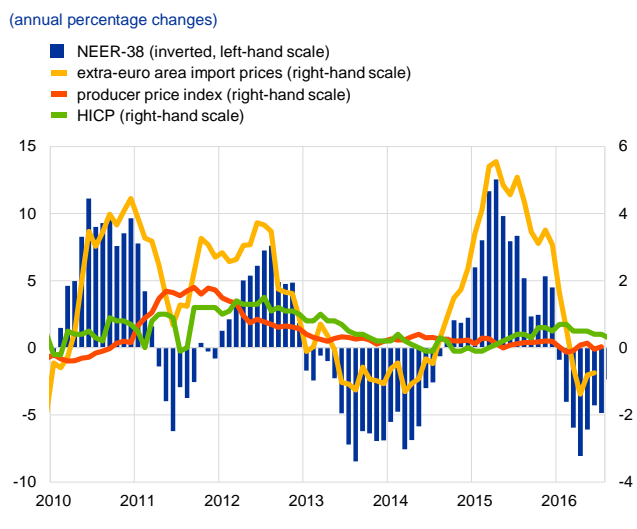
The article is structured as follows: The next section illustrates the responsiveness of various prices to exchange rate changes and shows how sequences of appreciations and depreciations highly complicate the dynamics of the exchange rate-price relation. The third section discusses determinants of exchange rate pass-through in the theoretical literature and their empirical relevance for the euro area. The fourth section presents estimates of pass-through to import and consumer prices in the euro area across various studies and discusses the importance of looking at underlying macroeconomic shocks when assessing exchange rate impacts. The last section concludes.

Exchange rate movements and inflation along the pricing chain

Changes in the exchange rate of the euro against its trading partners are reflected more quickly and more sizeably in movements in import price inflation, and less so in producer and consumer price inflation. The nominal effective exchange rate of the euro against 38 of its main trading partners (NEER-38) has depreciated by around 4% since the second quarter of 2014 (i.e. when the period of depreciation started). This depreciation, the combined result of an initial 10% depreciation (up to mid-2015) and a smaller subsequent appreciation, put substantial upward pressure on import prices for consumer goods excluding energy and food. The price of these goods increased by roughly 3.5% over the same period and has, in recent years, displayed a strong contemporaneous correlation with the NEER-38 (see Chart 1). Recent movements in the NEER-38 have also lifted domestic inflation somewhat. The effects of exchange rate developments on inflation are expected to remain positive for a while longer because changes in the exchange rate take around two years to fully pass through (see Box 1 in this article).

Chart 1

Prices and the exchange rate in the euro area



Sources: Eurostat, ECB and ECB staff calculations.
Note: The latest observation is for June 2016 for import prices of non-food and non-energy consumer goods, and July 2016 for the NEER-38, producer prices and the HICP of non-energy industrial goods.

The strong correlation of euro exchange rate changes with import price inflation reflects the direct effects of movements in the exchange rate, while the weaker relation with producer prices and HICP reflects indirect effects that take time to materialise, as well as dampening effects along the pricing chain. Producer price inflation is expected to react more and faster than consumer price inflation after an exchange rate change. An exchange rate depreciation will directly affect the price of imported goods, both intermediate and final. More expensive imported final goods put direct upward pressure on HICP inflation (indicated by the arrow labelled “1” in Figure 1).² However, a larger share of the imported goods is used as inputs by euro area producers than is directly consumed. Euro area producers combine the imported inputs with domestic inputs to deliver domestic intermediate and final consumption goods (arrows labelled “2”). They also charge a mark-up in the final price of the goods they sell. This indirect effect on the

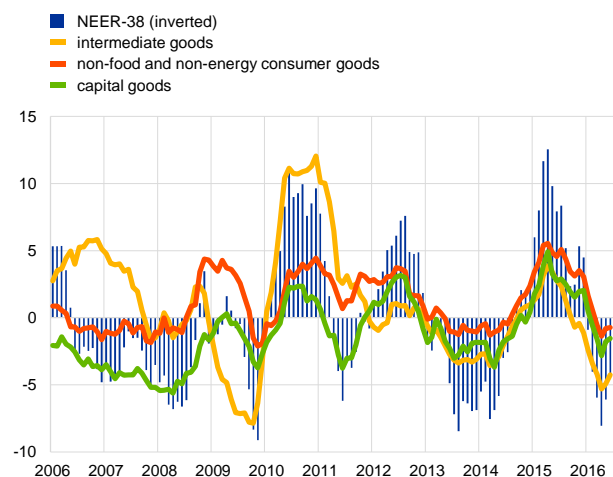
HICP via domestic production takes more time to materialise compared with the effect on producer price inflation. Besides the exchange rate movements, other factors play an important role in driving domestic inflation, such as the amount of slack in the economy.

Simple correlations reveal that import prices tend to be more volatile and more closely related to exchange rate movements than producer prices (see Charts 2 and 3). The correlation between the annual growth rates of the NEER-38 and import prices across product categories is quite strong, ranging from 0.6 to 0.8 over the past ten years. Where domestic producer price indices are concerned, the correlation with the exchange rate is strongest for the producer price index (PPI) of intermediate goods, and weaker for capital and consumer goods. For the period 1997-2006, the correlation between the annual growth rates of the NEER-38 and the producer prices for intermediate goods is 0.21, whereas it is almost zero for consumer and capital goods.

² The size of the direct effect is small, as the imported goods used directly for consumption represent around 15% of the overall HICP (5% from the non-energy industrial goods component and almost 10% from energy).

Chart 2**Extra-euro area import prices for different categories of goods**

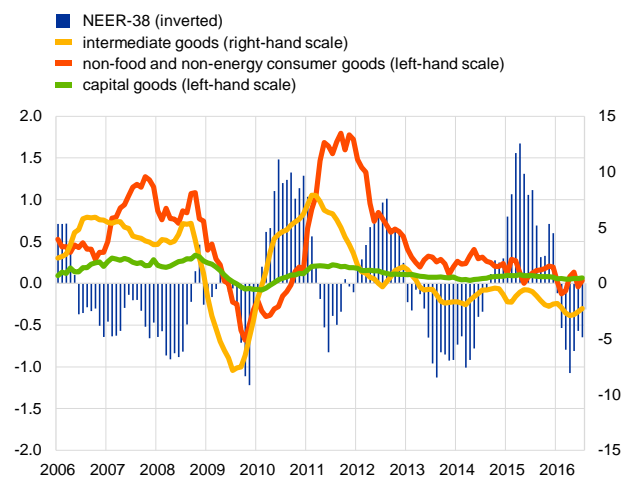
(annual percentage changes)



Sources: Eurostat, ECB and ECB staff calculations.
 Note: The latest observation is for June 2016.

Chart 3**Domestic producer prices for different categories of goods**

(annual percentage changes)



Sources: Eurostat, ECB and ECB staff calculations.
 Note: The latest observation is for July 2016.

The empirical literature has shown that the observed relationship between the exchange rate and producer prices depends on sector and product characteristics.

Intermediate goods tend to be more homogeneous, with more elastic demand and a higher share of imported inputs than capital goods. Homogeneous products can easily be substituted if they become relatively more expensive and this implicit higher degree of competition means that their price tends to be common across markets. As a consequence, exchange rate changes are more directly reflected in euro prices for intermediate goods. In the case of capital goods, exchange rate pressures feeding into PPI inflation can be expected to be negligible, as their cost is not immediately reflected in the prices set by firms but is amortised over several time periods. Finally, the pass-through to the PPI for consumer goods is found to lie between that for intermediate and capital goods. Consumer goods markets tend to be less competitive than those for intermediates because consumer goods are less homogeneous, for example because of the importance of branding. Furthermore, pass-through can differ between sub-categories of consumer goods, as these contain different shares of imported inputs. For instance, the item “jewellery and watches” embodies a larger share of imported inputs (gold) in production compared with the item “newspapers”, which depends more on domestic production costs. This translates into a higher pass-through for “jewellery and watches” compared with “newspapers”.³

The long time lags involved in the transmission of an exchange rate change to HICP inflation via the pricing chain imply that, at each point in time, the net effect reflects a combination of lagged effects from past exchange rate movements. For instance, the recent impact of the exchange rate on inflation

³ For more details, see the section entitled “Determinants of exchange rate pass-through”.

reflects a combination of the boosting effects from the strong euro depreciation in 2014/15, and the dampening effects of the recent appreciation as illustrated in Box 1 of this article. This dynamic overlap of the effects of past and current exchange rate movements makes it difficult to quantify the pass-through to HICP inflation.

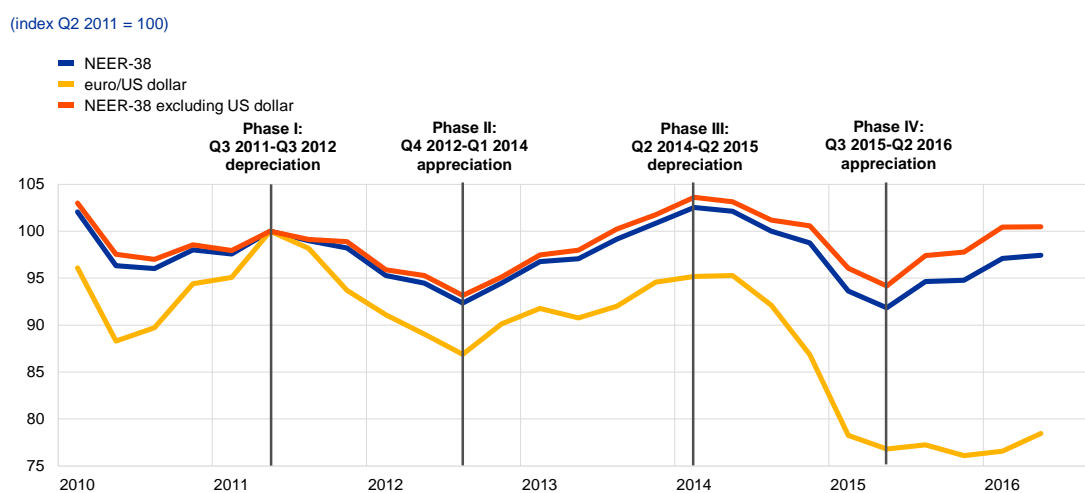
Box 1

Overlapping dynamics of euro/US dollar exchange rate changes from 2010-16 and the effects on HICP inflation

Given delays in pass-through, volatile exchange rate movements generate overlapping lagged upward and downward impacts. This box presents a mechanical estimate of the impact of this dynamic overlap on inflation, based on the euro/US dollar exchange rate developments of the last six years. Looking at quarterly averages since 2011, it is possible to identify four clear phases of appreciation and depreciation in the euro NEER, which were mainly driven by the US dollar (see Chart A). The euro/US dollar exchange rate is particularly relevant for euro area inflation compared with other currencies because commodity prices are set in dollars. As a consequence, large swings in the euro/US dollar exchange rate affect headline inflation directly via imports of energy and other commodities. This box therefore focuses on the overlapping effects of successive waves of appreciation and depreciation of the euro against the US dollar.

Chart A

NEER-38 and euro/US dollar exchange rate changes



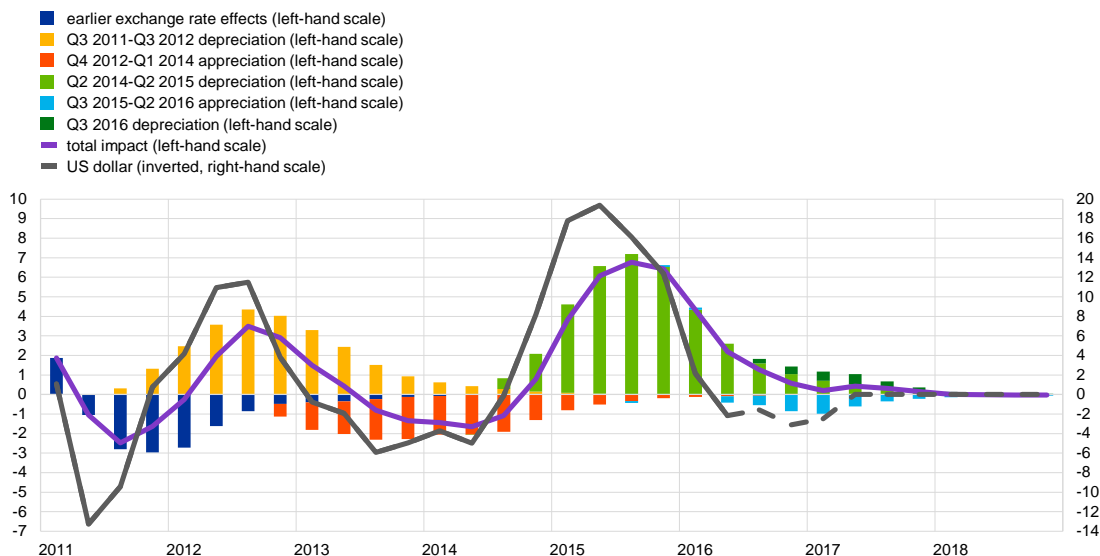
Sources: ECB and ECB staff calculations.

From mid-2011 to the third quarter of 2012, the euro depreciated by around 13% against the US dollar and by around 7.6% in nominal effective terms vis-à-vis 38 trading partners (NEER-38). Subsequently, the euro appreciated by 9.5% against the US dollar, from the end of 2012 to the first quarter of 2014 (11% in NEER-38 terms). After peaking in the period between the second quarter of 2014 and mid-2015, it depreciated by 19% against the US dollar (-10.4% in NEER-38 terms). That decline was partially reabsorbed from mid-2015 to mid-2016 as the euro appreciated again by around 2% against the US dollar, and even more strongly, by 6%, in effective terms. As a result, the euro/US dollar exchange rate, which has a weight of around 12% in the NEER-38, has contributed almost entirely to the lower level of the NEER-38 so far in the third quarter of 2016 compared with five years earlier.

Chart B

Exchange rate pass-through of US dollar to import prices

(percentage points)



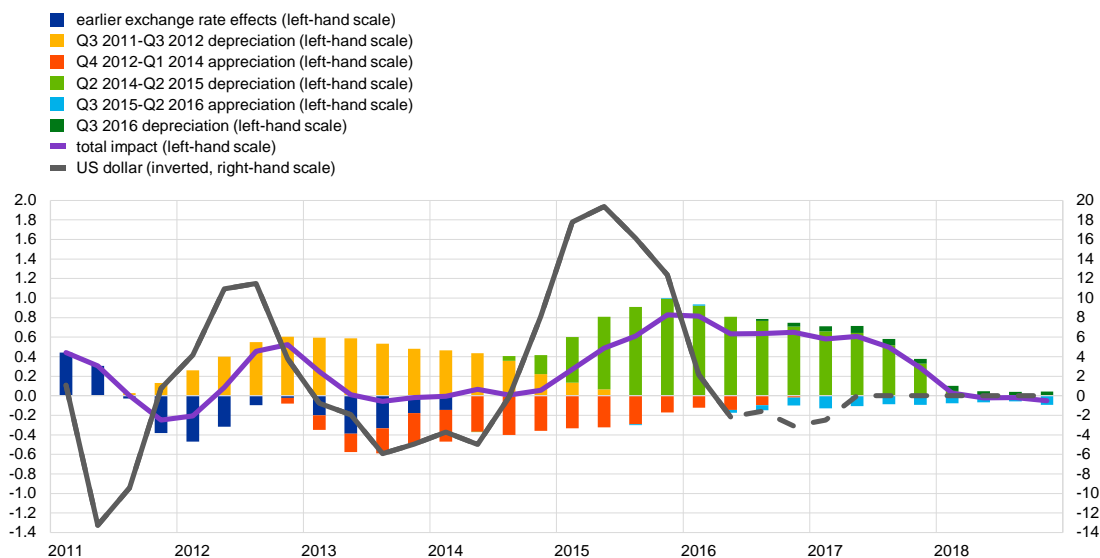
Sources: Eurostat, ECB and ECB staff calculations.

Notes: Calculations are based on an updated version of the model presented in ECB Working Paper No 243. The latest observation for the US dollar for the third quarter of 2016 is 28 August. The US dollar is assumed to remain at the same level recorded for the third quarter of 2016 until 2018.

Chart C

Exchange rate pass-through of US dollar to HICP inflation

(percentage points)



Sources: Eurostat, ECB and ECB staff calculations.

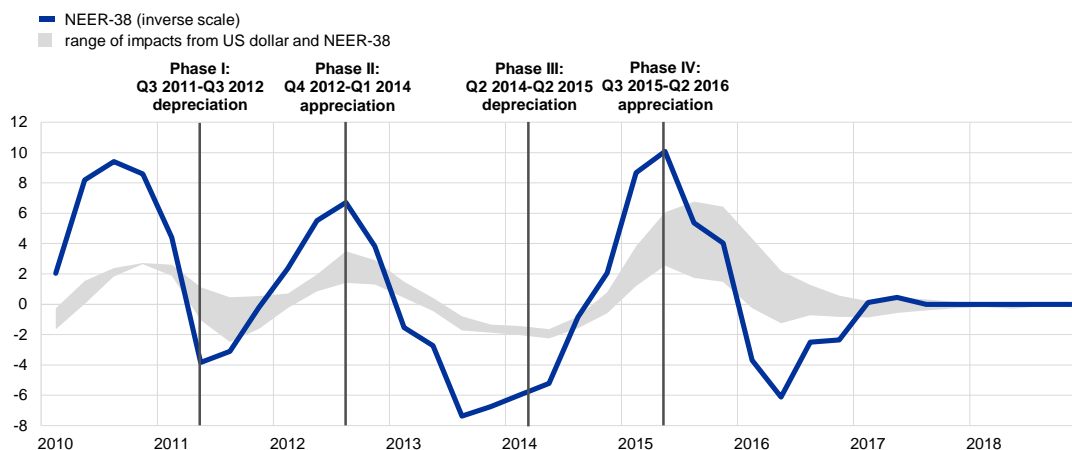
Notes: Calculations are based on an updated version of the model presented in ECB Working Paper No 243. The latest observation for the US dollar for the third quarter of 2016 is 28 August. The US dollar is assumed to remain at the same level recorded for the third quarter of 2016 until 2018.

The compound effects of successive euro/US dollar exchange rate movements can be estimated based on the results of the model presented in Hahn⁴, modified by substituting the NEER with the euro/US dollar exchange rate. HICP inflation continues to be positively affected by the large depreciation of the euro against the US dollar that began in 2014. According to this mechanical calculation, the contribution of the euro/US dollar exchange rate to headline inflation reached an initial peak of 0.5 percentage point in the last quarter of 2012 as a result of the first depreciation phase mentioned above. The following appreciation phase led to an overall neutral impact in 2013 and 2014, which was offset in 2015 and 2016 by the 19% depreciation that took place between the second half of 2014 and the first half of 2015. The lagged effect of this depreciation phase is also expected to positively affect inflation in 2017. With the fading-out of the past depreciation, if the euro/US dollar exchange rate remains constant at the level recorded so far for the third quarter of 2016, it should stop supporting inflation at the beginning of 2018.

Chart D

Exchange rate pass-through to euro area import prices

(percentage points)



Sources: Eurostat, ECB and ECB staff calculations.

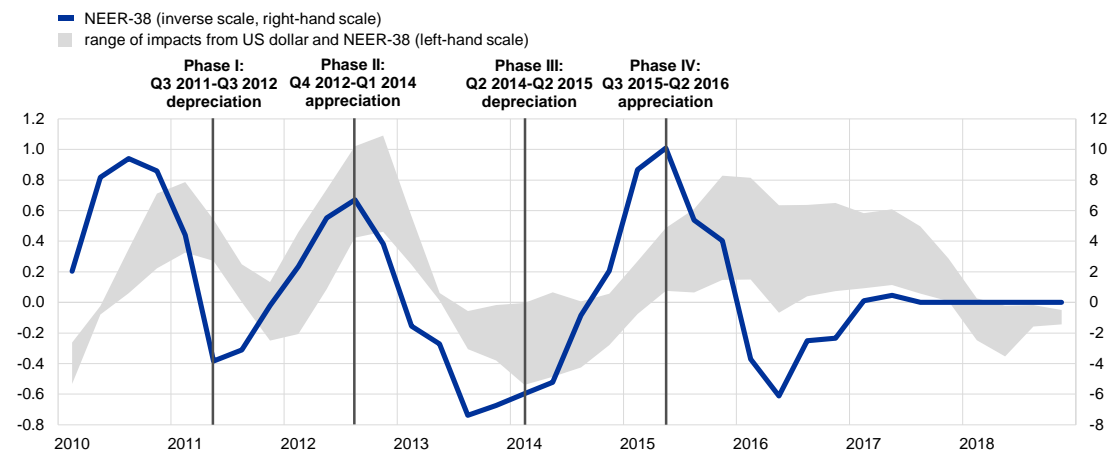
The final effect of the exchange rate movements on import prices and HICP inflation depends on both the exchange rate index and the model used. As can be observed in Charts D and E, there is a wide range of estimates of exchange rate pass-through to import prices and euro area inflation across models, indicating some degree of uncertainty in pinning down an exact number for this estimate.

⁴ Hahn, E., "Pass-through of external shocks to euro area inflation", *Working Paper Series*, No 243, ECB, July 2003.

Chart E

Exchange rate pass-through to euro area HICP

(percentage points)



Sources: Eurostat, ECB and ECB staff calculations.

Determinants of exchange rate pass-through

There are many reasons why exchange rate pass-through is incomplete, i.e. less than proportional, at the level of import prices and, to a greater extent, at the level of consumer prices. Some of these reasons relate to the microeconomic structure and behaviour of firms while others concern the general macroeconomic environment. Exporting firms' decisions as to how they price their exports to the euro area are affected by structural conditions, such as the currency in which they invoice, the degree of competition in the euro area market and the costs resulting from changing prices. Macroeconomic factors involve changes in the degree of openness, the structure of imports and the expected persistence of the exchange rate change. Some sources of incomplete pass-through correspond to the import price stage; others can be traced to the behaviour of firms at successive stages in the pricing chain.

At the import price stage, the exchange rate pass-through is related to the degree of competition across industries. Following a euro depreciation, foreign products mechanically become relatively more expensive in euro. This is referred to as producer currency pricing and corresponds to full pass-through to import prices in euro. In a competitive market, where the number of domestic and foreign producers is relatively high, foreign firms tend to lose market share in the euro area following a depreciation of the euro; to retain this share, they need to keep their prices in euro as stable as possible, thus reducing their margins. This can go as far as local currency pricing, i.e. zero pass-through to euro area import prices. In a market with low competition, firms that export to the euro area can more easily adjust their prices in euro and nevertheless keep their market share. Indeed, the theoretical literature has shown that the degree to which firms can adjust their mark-up in response to an exchange rate change depends on (i) their pricing power, which is a function of how easily their product can be substituted with other similar ones, and (ii) the degree of

market concentration, namely the number of firms present in the industry.⁵ As a consequence, the greater the capacity for substitution between domestic and imported products and the higher the number of producers servicing the euro area market, the lower the pass-through to import prices in euro. Furthermore, pricing decisions on the part of exporters to the euro area can interact with distribution margins set by euro area local distributors in the supply chain. Regardless of the strength of sensitivity of euro area import prices to exchange rates, if local distributors absorb exchange rate fluctuations in their own margins, consumer prices will experience less pass-through than those at the border.⁶

Empirical research for the euro area has confirmed diverse impacts on prices at the industrial sector level. Differences in exchange rate pass-through can be explained by the import structure, as discussed in Box 2 of this article. Osbat and Wagner⁷ report wide ranges of exchange rate pass-through across manufacturing sectors that can be explained by sectoral variables such as import penetration and firm concentration. Campa and Goldberg⁸ show that pass-through to import prices is found to be higher in energy and lower in manufacturing across several euro area countries and the United States. Campa et al.⁹ also find that exporters price discriminate to a larger extent between markets for manufacturing goods than between those for commodities. Hahn¹⁰ similarly reports that, among the sub-sectors of industry (excluding construction), the exchange rate pass-through is highest in electricity, gas and water supply, as well as in the energy sector. The lowest pass-through is found for capital goods. As mentioned in the previous section, the reason lies with the product characteristics: energy products are more homogeneous, entailing a higher degree of competition, and their price is set in international markets. By contrast, capital goods are less homogeneous and less substitutable, leading to less competition; hence they are priced more locally.

The currency of invoice for imports of goods and services also determines the degree and speed of pass-through and can depend on many structural factors. Foreign producers that export to the euro area might sell their products by charging one common price across all customers in their own currency. Under this scenario, movements in the exchange rate pass directly into euro area import prices and the pass-through is complete. If, instead, foreign producers charge a different price in

⁵ See Dornbusch, R., "Exchange rates and prices", *The American Economic Review*, Vol. 77, No 1, March 1987, pp. 93-106.

⁶ See Burstein, A.T., and Gopinath, G., "International prices and exchange rates", *NBER Working Paper Series*, No 18829, February 2013; Burstein, A.T., Neves, J.C. and Rebelo, S., "Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations", *Journal of Monetary Economics*, Vol. 50, Issue 6, September 2003, pp. 1189-1214; and Campa, J.M. and Goldberg, L.S., "Distribution margins, imported inputs, and the sensitivity of the CPI to exchange rates", *NBER Working Paper Series*, No 12121, March 2006.

⁷ See Osbat, C. and Wagner, M., "Sectoral exchange rate pass-through in the euro area", ECB, 2006.

⁸ See Campa, J.M. and Goldberg, L.S., "Pass-through of exchange rates to consumption prices: what has changed and why?", in Ito, T. and Rose, A.K. (eds.), *International Financial Issues in the Pacific Rim: Global Imbalances, Financial Liberalization, and Exchange Rate Policy*, University of Chicago Press, Chicago, 2008, pp. 139-176.

⁹ Campa, J.M., Goldberg, L.S. and González-Mínguez, J.M., "Exchange-rate pass-through to import prices in the euro area", *NBER Working Paper Series*, No 11632, September 2005.

¹⁰ Hahn, E., "The impact of exchange rate shocks on sectoral activity and prices in the euro area", *ECB Working Paper Series*, No 796, August 2007.

each export market, the effect of the exchange rate on import prices in euro may be incomplete. The decision to price imports in producer or local currency depends primarily on the state of local competition.¹¹ It can also depend on the existence of strategic complementarities, as exporters tend to use the currency of the country that dominates their industry or that their main competitors use.¹² More homogeneous goods, meanwhile, are priced in US dollars.¹³

The role of the euro as a currency of invoice has increased in the 21st century.

The introduction of the euro resulted in a larger share of euro area imports denominated in euro; consequently, foreign producers exporting to the euro area have been using the euro (local currency) more actively in their transactions with euro area importers. The expected result would be a lower exchange rate pass-through to domestic euro area prices.¹⁴ Indeed, in 2013, 52% of extra-euro area imports in goods were settled in euro, compared with 49% in 2006; the same figures for extra-euro area imports in services are 62% and 54% respectively.¹⁵ The results presented in Box 2 support the conclusion that Member States with a higher share of extra-euro area imports invoiced in euro experience a lower degree of exchange rate pass-through.

The extent to which firms hedge themselves against exchange rate movements also determines the degree of exchange rate pass-through to import prices.

Hedging against exchange rate movements can take place in two ways: one occurs naturally via the increased integration of firms into global value chains and the growing use of imported inputs from various source countries¹⁶; the other is a specifically financial strategy. Larger firms with access to hedging are more likely to invoice in the importer's currency and pass through the changes in the exchange rate to a lesser extent.¹⁷

¹¹ See Bacchetta, P. and van Wincoop, E., "A theory of the currency denomination of international trade", *Journal of International Economics*, Vol. 67, Issue 2, December 2005, pp. 295-319. The authors give prominence to the role of price elasticity of demand.

¹² See Goldberg, L.S. and Tille, C., "Vehicle currency use in international trade", *Journal of International Economics*, Vol. 76, Issue 2, December 2008, pp.177-192; Goldberg, L.S. and Tille, C., "Micro, macro, and strategic forces in international trade invoicing", *NBER Working Paper Series*, No 15470, November 2009; Bacchetta, P. and van Wincoop, E., *op. cit.*; Gopinath, G., Itskhoki, O. and Rigobon, R., "Currency choice and exchange rate pass-through", *American Economic Review*, Vol. 100, No 1, March 2010, pp. 304-336; Devereux, M.B., Engel, C. and Storgaard, P.E., "Endogenous exchange rate pass-through when nominal prices are set in advance", *Journal of International Economics*, Vol. 63, Issue 2, July 2004, pp. 263-291.

¹³ See Goldberg, L.S. and Tille, C., "Vehicle currency use in international trade", *op. cit.*

¹⁴ Evidence supporting this hypothesis is provided by Campa, J.M., Goldberg, L.S. and González Mínguez, J.M., *op. cit.* However, there are also forces that might work in the opposite direction: the share of euro area imports as a percentage of GDP has increased enormously since 1970, which could have led to an increase in the exchange rate pass-through over time due to the increased share of imports in consumption.

¹⁵ See *The international role of the euro*, ECB, July 2014.

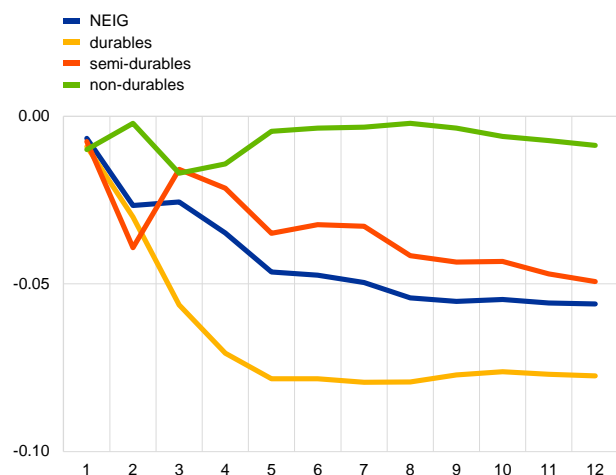
¹⁶ See di Mauro, F. and Ronchi, M., *Assessing European competitiveness: the contribution of CompNet research*, ECB, June 2015.

¹⁷ Martin, J., and Mejean, I., "Invoicing currency, firm size, and hedging", *CEPII Working Paper*, No 2012-28, 2012.

Chart 4

Impact of a 1% NEER appreciation on NEIG and sub-components

(deviation from baseline level, percentage points)



Sources: Eurostat and ECB staff calculations.

Note: Estimates are based on an amended version of the VAR model by Hahn (see footnote 4).

Focusing on the last stage of the pricing chain, namely consumer prices, pass-through tends to be higher for durable goods and lower for non-durable goods.

The impact of an exchange rate change on non-energy industrial goods (NEIG) inflation is, to a large extent, transmitted via the prices of durable NEIG (see Chart 4).¹⁸ In response to a 1% appreciation of the NEER, the inflation rate of durable NEIG is estimated to decline by about 0.08 percentage point. This pass-through is relatively quick, with the full effect expected to materialise after about a year. Semi-durable NEIG prices are affected as well, but these effects are significant only in the short term. The percentage point estimates show a smaller response for semi-durable prices than for durable NEIG prices, with a more protracted pass-through. Semi-durable NEIG prices are estimated to decrease by 0.05 percentage point following a 1% appreciation, with the full effect passed through only after about three years. The prices of non-durable NEIG, by contrast, seem hardly to respond to

an exchange rate shock at all (about 0.01 percentage point). For semi-durable NEIG prices, the exchange rate pass-through is significant only in the short term; for non-durable NEIG prices, it is insignificant.

Wider macroeconomic factors, such as the degree of openness, affect the impact of exchange rates on consumer prices.

The more open an economy or a sector, the higher the degree of pass-through. Imported foreign inputs need to be combined with domestic inputs to produce final domestic consumption goods. A higher share of imported inputs or final goods relative to domestically produced ones amplifies the impact of exchange rate movements on domestic prices, and open economies tend to experience a higher and quicker pass-through. This is supported by evidence that pass-through in the euro area is found to be higher compared with that in the United States, as the share of imported inputs across industries tends to be higher in the euro area.¹⁹ Naturally, this share tends to be higher in euro area small economies such as Austria, Ireland and Belgium than in larger economies, for example France. However, the analysis in Box 2 finds only a small role for the degree of openness in explaining differences in exchange rate pass-through across euro area countries.

Finally, the size of exchange rate pass-through is affected by price rigidities and by the perceived persistence of shocks.²⁰

If there are “menu” costs to

¹⁸ The applied vector autoregression (VAR) model is an adjusted, smaller version of the VAR model of the pricing chain applied in Hahn, E., “Pass-through of external shocks to euro area inflation”, op. cit. The model is estimated in turn for the different price variables of interest, namely total NEIG and its sub-components, based on quarterly data over the period 2001-15.

¹⁹ See Campa, J.M. and Goldberg, L.S., “Pass-through of exchange rates to consumption prices: what has changed and why?”, op. cit.

²⁰ Burstein, A.T. and Gopinath, G., op. cit.

adjusting prices, then it might not make sense for importers and exporters to change their prices in response to small currency movements. If firms perceive the exchange rate shock as non-lasting, they will adjust prices only partially. Therefore, a lower (perceived) persistence of exchange rate shocks can result in low pass-through. Indeed, the stable inflation environment that has been achieved in many euro area economies has reduced the persistence of price and exchange rate shocks, thus also reducing the frequency of price changes and the degree of exchange rate pass-through.²¹ As with openness, however, the regression analysis in Box 2 indicates that, once many other factors are taken into account, the inflation rate explains only a small part of the differences in the degree of exchange rate pass-through across euro area countries.

Box 2

Currency invoicing and exchange rate pass-through

This box looks at the role of currency invoicing in exchange rate pass-through.²² Recent empirical studies based on micro-level (i.e. goods-level) data have found that the transmission of exchange rate movements to import prices differs sizeably depending on the currency chosen to invoice import transactions, and that the pass-through is lower when a higher share of local currency is used to invoice imports.²³ Translating this finding to the macro level, this box relates differences in country-specific degrees of long-run exchange rate pass-through across euro area economies to the relative use of the euro as an invoicing currency.

Estimated degrees of exchange rate pass-through vary markedly across euro area economies.²⁴ According to pass-through estimates based on a standard log-linear regression model, for the euro area aggregate a 1% nominal effective appreciation of the euro has, on average, resulted in a 0.51% decline in aggregate import prices. However, this finding masks substantial heterogeneity in exchange rate pass-through across euro area economies. Indeed, long-run exchange rate pass-through is estimated to range from 0.29% in Austria to 0.75% in Ireland.

²¹ Taylor, J.B., "Low inflation, pass-through, and the pricing power of firms", *European Economic Review*, Vol. 44, Issue 7, June 2000, pp. 1389-1408.

²² This box is based on special feature article A in *The international role of the euro*, ECB, July 2015.

²³ Gopinath, G., Itskhoki, O. and Rigobon, R., op. cit.

²⁴ Following the literature, country-specific degrees of long-run exchange rate pass-through for euro area countries are estimated using a standard log-linear regression model:

$$\Delta p_{it} = \alpha + \sum_{j=0}^4 \beta_{ij} \Delta e_{t-j} + \sum_{j=0}^4 \gamma_{ij} \Delta \text{Cost}_{t-j} + \delta_{ij} \Delta \text{IP}_{it} + \varepsilon_{it} \quad (1)$$

where Δp is the quarterly log change in import price unit values of euro area economy i , Δe is the quarterly change of the standard broad measure of the NEER-38 of the euro, ΔCost is a quarterly effective measure of inflation in production costs of the euro area's major trading partners and ΔIP is the quarterly log change in industrial production (excluding construction) of euro area economy i . The estimation sample has a quarterly frequency, spans the time period from the first quarter of 2000 to the last quarter of 2014, and covers 17 euro area countries. It is also possible to use NEERs calculated with country-specific weights instead of the standard NEER-38. In this case, the estimates remain qualitatively unchanged, which is unsurprising given the high and statistically significant correlation (around 80%) in log differences between the standard and country-specific NEERs.

Standard determinants of exchange rate pass-through explain only a fraction of the total variation in pass-through across euro area economies.²⁵ The existing literature that aims to explain cross-country differences in pass-through focuses on a combination of macroeconomic and microeconomic structural determinants, including the level of inflation, the degree of openness and the micro-structure of imports.²⁶ Following the standard regression approach, results suggest that inflation and openness, the standard macroeconomic determinants, explain around only 4% of the pass-through heterogeneity across euro area economies. The R-squared increases to 24% when agricultural and raw material imports are included in total imports, suggesting that the import structure of an economy is an important determinant of cross-country differences in pass-through.

The cross-country variation in the use of the euro as an invoicing currency for extra-euro area imports is substantial. The role of local currency invoicing is a determinant that has received little attention in existing studies on cross-country differences in pass-through. Table A displays the share of the euro as an invoicing currency or settlement currency for the extra-euro area imports of 15 Member States. Euro invoicing shares in extra-euro area imports range from just over 20% in Greece to more than 70% in Estonia. The variation in the use of the euro may mainly reflect different ratios of intra-euro area exports to total exports. Euro area economies tend to invoice a larger share of their extra-euro area imports in euro if they export mainly to other euro area countries, partly reflecting the need for foreign exchange hedging, along with other motives such as reducing transaction costs. Since balancing costs and revenues in the same currency is a cost-efficient way to hedge against exchange rate risk, euro area economies that predominantly rely on intra-euro area exports, and whose revenues are hence mainly denominated in euro, can be expected to be more likely to invoice extra-euro area imports in euro.

Table A

The share of the euro as an invoicing or settlement currency in extra-euro area imports

BE	DE	EE	IE	GR	ES	FR	IT	CY	LU	NL	AT	PT	SI	SK
57%	57%	72%	33%	23%	48%	54%	46%	12%	44%	37%	55%	36%	59%	67%

Source: *The international role of the euro*, ECB, July 2015.

Notes: The latest available data are for 2012 for Belgium, Germany, Ireland, Italy, Luxembourg, the Netherlands and Austria, 2010 for Cyprus and 2013 for the remaining countries. Malta and Finland do not report data.

Estimated degrees of exchange rate pass-through are closely correlated with the relative use of the euro as an invoicing currency. Chart A plots the relative use of the euro as an invoicing currency for extra-euro area imports against the estimated degree of long-run pass-through. The results show that Member States with a larger share of extra-euro area imports invoiced in euro typically have a substantially lower degree of exchange rate pass-through.

²⁵ Following the literature, the estimated exchange rate pass-through β_i is related to a set of macro and micro variables:

$$\beta_i = \alpha + \gamma_1 \text{Openness}_{it} + \gamma_2 \text{HICP}_{it} + \gamma_3 \text{LowTech}_{it} + \varepsilon_{it} \quad (2)$$

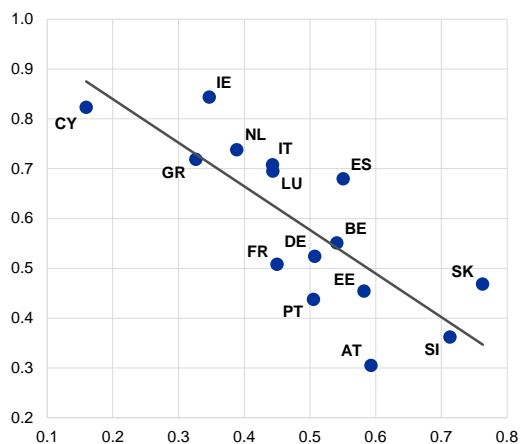
where Openness of euro area economy i is measured as the ratio of imports to GDP, HICP is the logarithm of annualised HICP inflation, and LowTech is the ratio of agricultural and raw material imports to total imports, which is a proxy for the degree of product differentiation. The estimation sample has an annual frequency, spans the time period 2000-13, and covers the 15 euro area countries for which data on currency invoicing is available.

²⁶ See Campa, J.M. and González Mínguez, J.M., "Differences in exchange rate pass-through in the euro area," *European Economic Review*, Vol. 50, Issue 1, 2006, pp. 121-145.

Chart A

Relation between estimated long-run exchange rate pass-through and share of local currency invoicing

(x-axis: local currency share; y-axis: long-run exchange rate pass-through)



Source: *The international role of the euro*, ECB, July 2015.

Note: The share of local currency invoicing reported on the x-axis is the average over the sample period.

imports tend to experience a significantly higher degree of exchange rate pass-through to import prices.

Euro invoicing shares explain a large part of the cross-country variation in pass-through, including when controlling for standard determinants of pass-through.

In order to control for other factors that affect the choice of invoicing currency, equation (1) (reported in footnote 24) is modified to include the share of local currency invoicing of extra-euro area imports in the euro area economy. The share of local currency invoicing strongly correlates with long-run pass-through and is statistically highly significant, even when controlling for standard determinants of pass-through heterogeneity. Moreover, the R-squared increases markedly, by more than 30 percentage points.²⁷

In sum, the results suggest a strong link between invoicing currency choice and exchange rate pass-through. Euro area economies with a smaller share of the euro as an invoicing currency for extra-euro area

Estimates of the aggregate exchange rate pass-through in the euro area

The previous sections described the mechanisms whereby movements in exchange rates affect import prices and the HICP, and the factors that determine the magnitude and the speed of this effect. This section presents empirical evidence on the size and speed of the exchange rate pass-through to import and consumer prices for the euro area and euro area Member States.

Aggregate exchange rate pass-through estimates for the euro area vary depending on the models and samples used in the analysis. Given that the size of the exchange rate pass-through depends on sectoral and firm-level factors, which vary over time, and on aggregates, which change their composition, it comes as no surprise that ad hoc specifications using country-level aggregates yield different estimates – according to country and time. Hahn²⁸ estimated a vector autoregression (VAR) including the NEER of the euro and the pricing chain. Updated estimates of

²⁷ If country-specific NEERs are used to estimate equation (1), the coefficient estimate for local currency invoicing increases further (from 0.7 to 1.4), which points to an even stronger relation between invoicing and pass-through. Moreover, even after controlling for extra-euro area import shares, the increase in R-squared is larger when local currency invoicing is included in the regression.

²⁸ See footnote 4.

this model show that a 1% depreciation of the euro increases HICP inflation by 0.10% after one year and 0.23% after three years (see Table 1). Other models tend to report similar results for the HICP.²⁹ More recently, Comunale and Kunovac³⁰ have used a Bayesian VAR and a different approach to identify an exchange rate shock. They found that, after a one-year period following a 1% depreciation in the NEER of the euro, import prices in the euro area would rise by 0.50%, producer prices by 0.37% and consumer prices by 0.11%. Regarding the four largest euro area economies, they found that an exchange rate shock would have a similar impact on HICP inflation in Germany, France and Italy to HICP inflation in the euro area, whereas they estimated a much greater effect for Spain (see Table 2). Studies focusing only on import prices produce a range of estimates across countries.³¹

Table 1
Exchange rate pass-through estimates in the euro area after a 1% depreciation in the exchange rate

Author	Price variable	one year	three years
Hahn (2003) update	Import prices	0.71%	0.81%
	Producer prices	0.27%	0.39%
	HICP	0.10%	0.23%
Comunale and Kunovac (forthcoming)	Import prices	0.50%	0.46%
	Producer prices	0.37%	0.36%
	HICP	0.11%	0.12%
New area-wide model (NAWM)	Import prices	0.55%	0.89%
	HICP	0.02%	0.20%
New multi-country model (NMCM)	Import prices	0.30%	0.44%
	HICP	0.09%	0.25%

Notes: "Hahn (2003) update" refers to updated estimates using the 2003 Hahn model with data from the first quarter of 1980 to the first quarter of 2016; it reports cumulated impulse responses to a 1% depreciation in the NEER of the euro. Comunale and Kunovac (forthcoming) report the ratios of cumulated impulse responses of each price indicator to the cumulated impulse response of the exchange rate. The estimation uses data from the first quarter of 1992 to the second quarter of 2016. The NAWM and NMCM results are generated under a scenario where the interest rates are assumed to stay unchanged. In the case of the NAWM, the import deflator effects refer to extra-euro area imports. For more details on the NAWM and NMCM, see footnote 29.

²⁹ For the NAWM, see Christoffel, K., Coenen, G. and Warne, A., "The new area-wide model of the euro area: a micro-founded open-economy model for forecasting and policy analysis", *Working Paper Series*, No 944, ECB, October 2008; for the NMCM, see Dieppe, A., Pandiella, A.G., Hall, S. and Willman, A., "Limited information minimal state variable learning in a medium-scale multi-country model", *Economic Modelling*, Vol. 33, Issue C, 2013, pp. 808-825.

³⁰ Comunale, M. and Kunovac, D., "Exchange rate pass-through in the euro area", forthcoming.

³¹ See An, L. and Wang, J., "Exchange rate pass-through: evidence based on vector autoregression with sign restrictions", *Federal Reserve Bank of Dallas Working Paper*, No 70, 2011; Campa, J.M. and Goldberg, L.S., "Pass-through of exchange rates to consumption prices: what has changed and why?", op. cit.; Campa, J.M. and González Mínguez, J.M., "Differences in exchange rate pass-through in the euro area", op. cit.

Table 2

Exchange rate pass-through estimates in euro area countries after a 1% depreciation in the exchange rate

Author	Price variable	Germany	France	Spain	Italy
Comunale and Kunovac (forthcoming)	Import prices	0.74%	0.58%	1.00%	1.00%
	PPI	0.54%	0.49%	0.64%	0.64%
	HICP	0.19%	0.15%	0.35%	0.20%
An and Wang (2011)	Import prices			1.00%	0.94%
	PPI			0.44%	0.15%
	HICP			0.02%	0.05%
Campa et al. (2008)	Import prices	0.80%	0.90%	0.70%	0.35%
Campa and González Mínguez (2006)	Import prices	0.66%	0.68%	0.98%	0.74%

Notes: Comunale and Kunovac (forthcoming) and An and Wang (2011) report the ratios of cumulated impulse responses of each price indicator to the cumulated impulse response of the exchange rate after three years. Campa et al. (2008) and Campa and González Mínguez (2006) report the cumulative effect after four quarters.

Estimates of exchange rate pass-through in the euro area based on the NEER tend to be lower than those based on the euro/US dollar bilateral exchange rate.

The bilateral euro/US dollar exchange rate has recently exhibited larger movements compared with the NEER-38 of the euro, as illustrated in Chart A in Box 1. This is because the changes in the euro/US dollar exchange rate are counteracted by changes in other currencies included in the basket of currencies comprising the NEER. Moreover, the US dollar has a strong impact because it is the invoicing currency of commodities; it thus tends to pass through to import prices of food and energy quickly and completely.

Some empirical studies argue that pass-through may have declined in the euro area since the 1990s.

Campa et al.³² investigated changes in the pass-through to import prices in euro area countries based on sectoral data up to 2004. They detected declines in the estimates of the exchange rate pass-through to import prices in around two-thirds of the industries in their sample, but most of this evidence is not statistically significant. Only manufacturing industries present statistically significant effects. ECB researchers³³ found tentative evidence of a decline in the exchange rate pass-through for the euro area based on a panel VAR and the Area Wide Model, with data up to 2007. Clearer evidence of changes in the exchange rate pass-through for several Member States has been reported by the IMF and Sekine.³⁴ Both studies note a substantial decline in the exchange rate pass-through to import prices and consumer prices for a number of advanced economies. When the model proposed by Hahn is estimated over rolling windows of 20 years, a decline in pass-through since 1980 is found for both import prices and HICP inflation. In particular, while the model estimated over the full sample (the first quarter of 1980 to the first

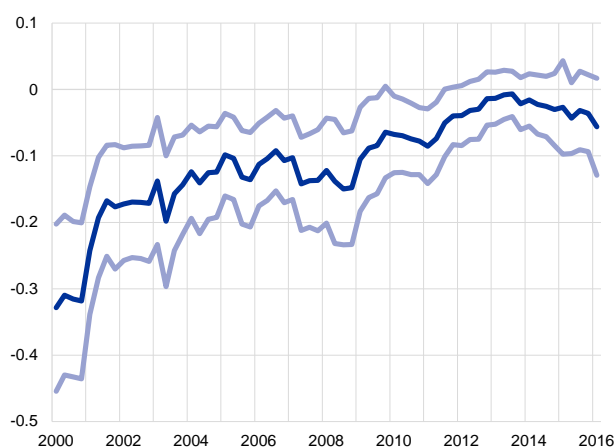
³² See Campa, J.M., Goldberg, L.S. and González Mínguez, J.M., "Exchange-rate pass-through to import prices in the euro area", op. cit.

³³ See di Mauro, F., Ruffer, R. and Bunda, I., "The changing role of the exchange rate in a globalised economy", *Occasional Paper Series*, No 94, ECB, September 2008.

³⁴ See *World Economic Outlook*, IMF, 2006; Sekine, T., "Time-varying exchange rate pass-through: experiences of some industrial countries", *BIS Working Papers*, No 202, March 2006.

quarter of 2016) finds that a 1% appreciation in the NEER would lead to a 0.23% decline in HICP inflation after three years, the same model estimated over a rolling sample finds that this effect would be negligible in the most recent iteration (the second quarter of 1996 to the first quarter of 2016) of the rolling window estimation (see Chart 5).

Chart 5
Exchange rate pass-through to HICP inflation over time



Sources: Eurostat and ECB staff calculations.
Notes: The chart shows the cumulated impulse response (dark blue line) of HICP inflation to a 1% appreciation in the NEER after three years over time and the respective 95% confidence bands (light blue lines). The cumulated impulse response is based on the updated estimation of Hahn (2003) over a 20-year rolling window from the first quarter of 1980 to the first quarter of 2016. Each point on the dark blue line refers to the end point of each 20-year rolling sample, with the first sample referring to the period from the second quarter of 1981 to the first quarter of 2000 and the last sample to the period from the second quarter of 1996 to the first quarter of 2016.

The composition of imports is one factor that has been put forward to explain the potential decline in exchange rate pass-through. Indeed, the

compositional shift from sectors with high pass-through (such as energy) to sectors with lower pass-through, (such as manufacturing and food) has been proposed as one of the reasons for a decline in the pass-through to import prices.³⁵ ECB researchers³⁶ have compared aggregate exchange rate pass-through estimates, computed by aggregating sectoral estimates using the import shares of each sector in 1988 and 2005 as weights, to show that this would mechanically result in a decline in overall import price pass-through from 0.83 to 0.74.

Another proposed explanation for the secular decline in exchange rate pass-through to import prices is globalisation and the emergence of low-cost exporters. Gust, Leduc and Vigfusson³⁷ suggest that part of the decline in the exchange rate pass-through might be related to increased trade integration,

as firms have become more responsive to competitors' prices. This competitive pressure is further increased by the rising prominence of low-cost producers in international trade.

Several factors at the firm level may also have contributed to the declining exchange rate pass-through. First, as illustrated in Box 2 of this article, an increasing share of extra-euro area imports is invoiced in euro, meaning that an increasing proportion of foreign exporters choose to price their exports to the euro area in euro. According to the results shown in the box, this can lead to lower pass-through. The increasing import content of exports and the lower cost of hedging per unit of risk may also have dampened the response of import prices to exchange rate movements.³⁸

An influential explanation for the decline of exchange rate pass-through at both the import price and final consumer price stages is that the low inflation

³⁵ See also footnotes 7, 8 and 31.

³⁶ See footnote 33.

³⁷ See Gust, C., Leduc, S. and Vigfusson, R., "Trade integration, competition, and the decline in exchange-rate pass-through", *Journal of Monetary Economics*, Vol. 57, Issue 3, April 2010, pp. 309-324.

³⁸ See footnote 33.

environment supported by credible monetary policy has led to a reduction in the perceived persistence of shocks and that, as a result, firms have tended to adjust prices less frequently. Taylor³⁹ notes that the low inflation environment achieved in many countries has resulted in lower pass-through. Lower inflation leads to a reduction in the expected persistence of cost and price shocks and consequently to lower exchange rate pass-through to prices, as producers have less incentive to change their prices in the face of less persistent shocks.

A way to reconcile the different estimates presented so far across models, countries and samples is to recognise that, far from being a structural parameter at the macroeconomic level, exchange rate pass-through depends on the nature of the shocks driving exchange rates. This has been shown in theoretical models where exchange rate pass-through is a function of the underlying shocks in the economy and the competitive structures of the industries involved.⁴⁰ Empirically, however, most approaches are based either on simple regressions or on identifying exchange rate shocks in a manner that does not take into account the full economic structure and consequently the most important shocks that drive the economy.⁴¹

A more economically meaningful approach to study the impact of the exchange rate on inflation would be to employ a method similar to that used when looking at the impact of other variables (for example, oil prices), in order to determine what shocks move exchange rates in the first place. In reality, the exchange rate does not move as a consequence of one particular shock, but is instead influenced by various driving forces. The entire constellation of macroeconomic shocks affecting the exchange rate at each point in time should be considered. The fact that pass-through can be shock-dependent has long been discussed in the literature.⁴² However, in empirical terms, disentangling the underlying economic forces driving the exchange rate is difficult, as this is a highly endogenous variable. The key question revolves around what moves exchange rates. Is it a domestic supply shock? Could it be global demand? Or is it monetary policy, either domestic or foreign?

Depending on the shock, the response of consumer prices to an exchange rate movement will be different. For instance, an expansionary domestic monetary policy shock will be followed by a euro depreciation, with a direct inflationary effect on import prices. This direct effect will feed into consumer prices and be amplified by

³⁹ Taylor, J.B., op. cit.

⁴⁰ These are micro-based open-economy general equilibrium models. See, for instance, Corsetti, G. and Dedola, L., "A macroeconomic model of international price discrimination", *Journal of International Economics*, Vol. 67, Issue 1, September 2005, pp. 129-155; Corsetti, G., Dedola, L. and Leduc, S., "High exchange-rate volatility and low pass-through", *Journal of Monetary Economics*, Vol. 55, Issue 6, September 2008, pp. 1113-1128.

⁴¹ Using a Choleski decomposition as described in e.g. Hahn, E., "Pass-through of external shocks to euro area inflation", op. cit.

⁴² See Klein, M., "Macroeconomic aspects of exchange rate pass-through", *Journal of International Money and Finance*, Vol. 9, Issue 4, December 1990, pp. 376-387; Shambaugh, J., "A new look at pass-through", *Journal of International Money and Finance*, Vol. 27, Issue 4, June 2008, pp. 560-591; Astley, M., Pain, D. and Smith, J., "Interpreting recent movements in sterling", *Quarterly Bulletin*, Bank of England, 2009 Q3, pp. 202-214.

the other transmission channels of monetary policy, leaving “room” for mark-ups to adjust. It could therefore be expected that such a shock would lead to a higher correlation between exchange rate and HICP movements, i.e. to a higher pass-through, than would be observed after a depreciation caused by, for example, a negative domestic supply shock such as lower productivity. Instead of being accompanied by the amplifying effects of an expansionary shock, such a depreciation caused by a negative domestic supply shock would occur in an environment where firms found little space to maintain or increase their mark-ups and the pass-through down the pricing chain would be contained. Similarly, the euro could also depreciate because of a foreign monetary policy tightening; in this case, however, any fall in foreign demand due to the restrictive policy abroad, other things being equal, would be a drag for euro area growth and would not foster a domestic inflationary environment.

In other words, while some shocks lead to self-reinforcing exchange rate and price dynamics, others lead to counterbalancing effects on inflation. In the case of a negative domestic demand shock, which could cause the exchange rate to depreciate, the overall “pass-through” could easily lead to an apparently perverse correlation between exchange rates and consumer price inflation, as found by Comunale and Kunovac⁴³ for the euro area, and Forbes et al.⁴⁴ for the United Kingdom.

A common result from the existing studies that adopt this approach is that the exchange rate pass-through following a monetary shock is relatively high. This is observed by Comunale and Kunovac for the exchange rate pass-through following a monetary policy shock or an exogenous exchange rate shock modelled as a risk premium shock. The exchange rate channel can thus be considered active in the transmission of monetary policy. Bobeica and Jarociński⁴⁵ look at a similar set of shocks for the euro area and disentangle the effects of interest rate shocks and the shocks that affect the spread between short-term and long-term rates.

Research on quantifying exchange rate pass-through based on macroeconomic shocks is still in an incipient phase, as indicated by the wide variations not only in quantification, but also in the perceived contribution of economic shocks to exchange rate movements. A better understanding of the relevance of the prevailing current shocks for quantifying the responsiveness of HICP inflation to exchange rate changes is necessary for understanding the effects of any policy mix.

⁴³ See Comunale, M. and Kunovac, D., op. cit.

⁴⁴ Forbes, K., Hjortsoe, I. and Nenova, T., “The shocks matter: improving our estimates of exchange rate pass-through”, *Bank of England Discussion Paper*, No 43, November 2015.

⁴⁵ Bobeica, E. and Jarociński, M., “‘Missing disinflation’ and ‘missing inflation’ since the Great Recession: a VAR perspective”, forthcoming.

Conclusions

Understanding the way exchange rates shape the outlook for inflation is crucial for conducting monetary policy effectively and understanding the strength of its transmission mechanism. Drawing on evidence from the available data, models and existing literature, this article contributes to a better understanding of the complex role of the exchange rate in affecting prices in the euro area. A number of conclusions can be drawn from this evidence.

First, the effect of the exchange rate is strongest and most immediate for import prices, and declines along the pricing chain. Simple graphical correlations illustrate that import prices tend to correlate with exchange rate movements, whereas this effect is more muted for producer prices and final HICP inflation. The presence of local distribution costs, a lower share of imported inputs in the final HICP, and the relatively long time taken for the indirect effects of exchange rate shocks to feed through the economy are the main factors contributing to this pattern.

Second, the size and speed of the exchange rate pass-through seems to differ across product categories, indicating that cost structures and pricing decisions at the firm level are important for gauging the exchange rate effects at the aggregate price level. Empirical results show that pass-through to producer prices of intermediate goods is higher while pass-through to prices of capital goods is lower. The impact on consumer goods tends to lie somewhere in-between. Within the non-energy industrial goods components, pass-through tends to be highest for durable consumer goods. These differences at the goods category level can be related to different industry characteristics.

Third, estimates of exchange rate pass-through for the euro area vary considerably across models and across time periods. The exchange rate pass-through estimates based on the bilateral euro/US dollar exchange rate are found to be proportionally higher than those based on the NEER against the euro area's 38 main trading partners. Moreover, empirical studies have provided some evidence that, since the 1990s, the sensitivity of import and domestic prices to the nominal exchange rate has declined. Several explanations have been put forward, such as the change in the composition of imports towards less exchange rate-sensitive sectors, more currency invoicing of extra-euro area imports in euro, natural and financial hedging against exchange rates via participation in global value chains and financial instruments, and the contribution of the low inflation environment.

Last, recent studies advocate looking at the underlying economic shocks when analysing the responsiveness of import and domestic prices to exchange rate changes. The studies are far from reaching a consensus on the importance of each shock in driving the exchange rate and on the size of pass-through following each shock. However, they seem to agree that when a monetary policy shock drives the nominal exchange rate, a relatively larger pass-through tends to be generated. The fact that the exchange rate pass-through is shock-dependent can explain why, in some periods, the reaction of final prices to exchange rates is smaller or larger than would be expected based on simple historical regularities.