III. The exchange rate elasticity of import prices across the euro area

By Eric Meyermans

***Abstract**: This section examines the responsiveness of the aggregate price of goods imported from outside the euro area to nominal exchange rate fluctuations across the euro area. It presents estimates of price to exchange rate elasticities disentangling the effects of the bilateral euro exchange rate against the US dollar, and the euro nominal effective exchange rate against a basket of currencies of non-euro EU Member States and a basket of the currencies of a selected group of other countries. The empirical analysis suggests that the overall exchange rate pass-through differs significantly across euro area Member States. As expected, the magnitude of the elasticities is lower in the short term than in the long term for most Member States. In the long term, the point estimates of the production costs of the imported goods and exchange rate are similar in line with economic theory, but in the short term the point estimates for the former tend to be larger than those for the latter. Finally, the US dollar affects the aggregate import price of goods primarily through the import of oil in most Member States ([79]).*

III.1. Introduction

This section examines the impact of euro exchange rate changes on the aggregate price of goods imported from outside the euro area across the euro-area countries. The speed and magnitude of the exchange rate pass-through of a change in a foreign currency is mainly conditioned by market structure, macro-economic conditions and the share of the imports denominated in that currency in total imports. This pass-through has a direct impact on Member States' inflation and external adjustment capacity. It also affects the speed of convergence in the euro area ([80]).

This section is organised as follows. The second subsection presents a brief literature review of the macroeconomic effects of (in)complete exchange rate pass-through to import prices, while the third subsection identifies the factors affecting this pass-through. Building on this literature review, the fourth and fifth subsections provide new empirical estimates of euro-area countries' exchange rate pass-through. The last section draws some conclusions.

International trade takes place in various currencies. However, the volatility of these currencies' exchange rates against the euro may differ, affecting the speed and magnitude of the pass-through ([81]). Moreover, international trade in oil and other commodities is predominantly invoiced in US dollars, reflecting the dollar's strong international currency status.

The empirical analysis in this section therefore adds to the existing empirical literature (to the best of our knowledge) two novel features. First, it makes a distinction between the euro's exchange rate against the US dollar, a basket of non-euro EU Member States' currencies and a basket of the currencies of a selected group of other countries ([82]). Second, the price of oil and non-fuel commodities denominated in US dollars are taken into account as separate channels. The resulting empirical analysis suggests that these two features may help to better understand cross-country differences in exchange rate pass-through ([83]).

([79]) The author wishes to thank an anonymous reviewer for useful comments. This section represents the author's views and not necessarily those of the European Commission.

([80]) Convergence in the euro area is a multi-dimensional process, whereby nominal, real, social, cyclical convergence and convergence towards resilient economic structures are different but relevant and interrelated dimensions. See for instance Berti, K. and E. Meyermans (2017), 'Sustainable convergence in the euro area: A multi-dimensional process', *Quarterly Report on the Euro Area*, Vol. 17, No.3, pp. 9-24.

([81]) See subsection III.3 for more details.

([82]) In the following econometric analysis this level of aggregation helps to avoid problems related to multicollinearity (especially for non-euro area EU exchange rates) and to maintain sufficient degrees of freedom when estimating - which could decrease significantly if a further disaggregation of the basket of the currencies of a selected group of other countries would were considered.

([83]) This section has been prepared against the backdrop of an appreciating US dollar in the wake of the Russian invasion of Ukraine. Various factors may affect the exchange rate pass-through of such a strengthening of the dollar on import prices, including its expected persistence, and changes in the pricing power of importers and in invoice currency composition. However, as the sample of the econometric regression analysis of this section does not cover the first nine months of 2022, inferring the quantitative impact of this strengthening on import prices would be beyond the scope of this section.

III.2. The macroeconomic effects of the exchange rate pass-through to import prices: a short overview

The literature identifies several channels through which the intensity of the exchange rate pass-through to import prices may affect a country's inflation and external adjustment capacity, as well as convergence in a currency union.

III.2.1. Inflation

The exchange rate pass-through to import prices affects consumer price inflation through several channels, including the following.

- *Direct effects:* as some imported products constitute part of the consumption bundle of households, changes in import prices caused by an exchange rate change may have a direct effect on the consumer price index.

- *Input-output effects*: imported goods such as oil may serve as intermediate inputs into the domestic production of products for households so that changes in the prices of imported intermediate inputs (following an exchange rate change) may also affect consumer prices.

- *Substitution/demand effects*: a depreciation may reallocate consumption away from imported products towards domestic products as imported goods become more expensive ([84]). Such increased domestic demand may put additional pressure on consumer prices.

A lower pass-through also allows monetary policy to focus more on domestic sources of inflationary pressures ([85]).

III.2.2. External adjustment capacity

In the case of a full and immediate pass-through, a depreciation will trigger a trade surplus if import and export volumes are very price responsive – so that the Marshall-Lerner conditions hold ([86]).

An incomplete exchange rate pass-through to import prices will also affect a country's external adjustment capacity also through its impact on the relative price of traded and non-traded goods and of exports and imports (denominated in local currency) ([87]).

In an extreme case of no exchange rate pass-through to import or export prices ([88]) there will be no change in imported and exported volumes when the exchange rate changes. However, the terms of trade will be affected as the country's export prices (denominated in local currency) will increase ([89]) while import prices will remain constant, so that the nominal trade balance will improve.

In the case of a partial pass-though to import prices, the impact of an exchange rate change on import volumes will be smaller than in a complete pass-through scenario, as foreign exporters absorb a portion of the shock into their margins. However, trade volumes will change and, depending on the size of trade elasticities, the terms of trade changes ([90]) and links between imports and exports ([91]), impose a heavier adjustment burden on the nominal exchange rate to restore external equilibrium (Gust et al. (2008) and Obstfeld and Rogoff (2004) ([92])).

III.2.3. Speed of convergence

Significant cross-country differences in exchange rate pass-through to import prices within a currency union such as the euro area may also

([84]) Complementarity between imported and domestic goods may have the opposite effect.

([85]) Cœuré, B. (2017), 'The euro's global role in a changing world: a monetary policy perspective', speech delivered at the Council on Foreign Relations, New York City, 15 February 2019.

([86]) Tthe sum of import and export price elasticities (in absolute value) is greater than one. See Grubel, H. (1990), *International Economics*, Richard D. Erwin Inc.

([87]) For a more detailed analysis see Gust, C., Leduc, S. and N. Sheets (2008), 'The Adjustment of Global External Balances: Does Partial Exchange Rate Pass-Through to Trade Prices Matter?', *Federal Reserve Bank of San Francisco Working Paper Series* No. 2008-16, and Tille, C. (2007), 'Box 3.3. Exchange Rate Pass-Through to Trade Prices and External Adjustment' in IMF (2007), *World Economic Outlook, April 2007*.

([88]) Traded goods prices are set in the currency of the buyer, i.e. local currency pricing.

([89]) In line with the depreciation and constant price in foreign currency in the export market.

([90]) Partly conditioned by the pass-through on the export side.

([91]) The adjustment burden may be heavier if imports are required for exports and export demand shows low price elasticity.

([92]) Obstfeld, M. and K. Rogoff (2004), 'The Unsustainable US Current Account Position Revisited', *National Bureau of Economic Research (NBER) Working Paper* No. 1086. Gust et al. (2008), *op. cit.*

deepen divergence between inflation rates in the currency union if hit by a persistent exogenous exchange rate shock ([93]). It may also create a wide gap between Member States' capacity to withstand a common real shock as they may have different needs for a euro exchange rate adjustment, depending on their pass-through intensity ([94]). Such divergent responses may make the common monetary policy less effective.

III.3. Factors affecting the exchange rate elasticity of import prices: a short literature review

In perfectly competitive markets, exchange rate movements are immediately fully passed on to import prices and the law of one price holds. However, depending on market structure and macroeconomic conditions, the literature identifies several channels that may hinder a full exchange rate pass-through to import prices. These channels can be briefly summarised as follows.

III.3.1. Market structure

In imperfect markets several features will affect the exchange rate pass-through, including the following.

- *Substitutability and market integration*: in markets characterised by strong substitutability with domestically produced goods, no barriers to restrict spatial arbitrage and no market entry barriers, the exporters usually act as price takers and set their prices accordingly. If there is imperfect competition in international markets, the exchange rate pass-through is incomplete as companies trade off changes in profits with changes in sales when the exchange rate changes (e.g. Dornbusch (1989) ([95])).

- *Choice of invoice currency:* if the imports are invoiced in the currency of the importer, the importer's price will not be affected by a subsequent exchange rate change, and the exporting producer's profit margin (measured in foreign currency) will shrink (Krugman (1987) ([96])). If imports are invoiced in the producer's currency, the importer has to pay a higher price if the currency depreciates (Obstfeld and Rogoff (1995) ([97])). Similarly, if imports are invoiced in a dominant currency, importers have to bear the burden of the adjustment, even if the exporter's profits do not necessarily increase (Goldberg and Tille (2008) ([98])).

Several factors may affect the choice of the invoice currency. They may also affect the speed and size of the exchange rate pass-through ([99]).

- *Type of good:* when international trade in homogeneous goods whose prices are set in global markets, such as oil and raw materials, or goods produced by specific sectors such as the aircraft and energy sectors, is mainly invoiced and settled in US dollars. In this case the speed and size of the exchange rate pass-through is usually high and its size is large (Tille and Goldberg (2009) ([100]) and Langedijk et al. (2016) ([101])).

- *International trade openness:* a more open economy makes exporters more responsive to their competitors' price-setting. This may delay the pass-through (López-Villavicencio and Mignon (2021) ([102])) and Gust et al. (2008) ([103])). Closely related to this is the stability of the invoice currency, as it may reduce exchange rate risks.

([93]) Leiva-Leon, D., Martínez-Martín, J. and E. Ortega (2020), 'Exchange rate shocks and inflation comovement in the euro area', *ECB Working Paper Series* No.2383, estimate that exogenous shocks to the exchange rate were behind more than 50% of nominal EUR/USD exchange rate fluctuations in more than a third of the quarters between the first quarter of 2013 and second quarter of 2019.

([94]) In addition to other structural factors such as differences in import composition and import price elasticities.

([95]) Dornbusch, R. (1987), 'Exchange rates and prices', *American Economic Review*, Vol. 77, No. 1, pp. 93–106

([96]) Krugman, P (1987), 'Pricing to Market When the Exchange Rate Changes', *NBER Working Paper* No. 1926.

([97]) Obstfeld, M. and K. Rogoff (1995), 'Exchange Rate Dynamics Redux', *Journal of Political Economy*, Vol. 103, pp. 624-660

([98]) Goldberg, L. and C. Tille (2008), 'Vehicle currency use in international trade', *Journal of International Economics*, Vol. 76, No. 2, pp. 177-192.

([99]) Although in the long term (in the absence of any frictions) the law of one price holds so that the exchange rate and import price are simultaneously determined and keep pace with the exporters' production costs.

([100]) Tille, C. and L. Goldberg (2009), 'What drives the invoicing of international trade?, *VoxEU*. 2 Dec 2009.

([101]) Langedijk S., Karagiannis S. and E. Papanagiotou (2016), 'Invoicing Currencies in International Trade - Drivers and Obstacles to the Use of the Euro', *JRC Science for Policy report.*

([102]) López-Villavicencio, A. and V. Mignon (2020), 'On the Seemingly Incompleteness of Exchange Rate Pass-Through to Import Prices: Do Globalization and/or Regional Trade Matter?', in Recent Econometric Techniques for Macroeconomic and Financial Data, Dynamic Modeling and Econometrics in Economics and Finance 27

([103]) Gust, C., Leduc, S. and N. Sheets (2008), *op. cit.*

- *Global value chains:* companies in global value chains may have a strong incentive to settle their imported inputs in dollar when selling in dollars in order to stabilise their margins (Tille et al. (2021) ([104])). In this case, the domestic currency does not play its role as a unit of account or medium of exchange, making the concept of pass-through to import prices redundant.

- *International currency status:* a strong international currency status makes for low transaction costs and a low exchange rate risk for both exporters and importers. This means that the imports of countries with a strong currency stratus are more likely to be invoiced and settled in their own currency, making their import prices less sensitive to exchange rate fluctuations.

- *Company size:* smaller companies are more likely to adopt the invoicing currency of their main competitors (Tille and Goldberg (2009) and Langedijk et al. (2016)). As a result, insofar as a country imports only from small companies it will be able to settle its international trade in local currency, making its imports less sensitive to exchange rate fluctuations.

III.3.2. Macroeconomic conditions

The degree of exchange rate pass-through to import prices may also be affected by macro-economic conditions, including the following.

- *Business cycle:* a booming economy may create more room to increase prices. This may speed up the exchange rate pass-through (Ben Cheikh et al. (2018) ([105])).

- *Nature of the exchange rate shock:* the size and expected duration of the exchange rate change may also affect the pass-through with big changes and depreciations (expected to be persistent) more likely to be passed through (completely) (Bailliu and Bouakez (2004) ([106])). Even so, the origin of the shock is also important. If an exchange rate change is triggered by a shock to domestic demand, then it is less likely to be passed through than when triggered by a shock originating in the rest of the world (Forbes et al. (2017) ([107])). Exchange rate fluctuations caused by financial market shocks ([108]) are also less likely to be passed on to prices (Rogoff (1996) ([109])).

- *Price stability*: when inflation is low, companies tend to change their prices less frequently, leading to a lower pass-through in the short term (but not in the long term to remain profitable) (Bailliu and Bouakez (2004) ([110]) and Taylor (2020) ([111])).

- *Exchange rate volatility*: countries with low exchange rate volatility or stable monetary policies are more likely to have their currencies chosen for invoicing and settling international trade (Bacchetta and van Wincoop (2003) ([112]). This makes them more likely to have a low pass-through (Gopinath (2015) ([113])) ([114]).

- *Menu costs:* the high fixed costs of implementing a price change may also slow down the exchange rate pass-through, possibly leading to strong non-linearities whereby exchange rate changes are only passed through when they reach a certain threshold (Larue et al. (2010) ([115])).

([104]) Tille, C., Mehl, A., Georgiadis, G. and H. Le Mezo (2021), 'Fundamentals vs. policies: can the US dollar's dominance in global trade be dented?', *Centre for Economic Policy Research (CEPR) Discussion Paper DP16303.*

([105]) Ben Cheikh, N, Ben Zaied, Y., Bouzgarrou, H. and P. Nguyen (2018), 'Nonlinear Exchange Rate Pass-Through: Does Business Cycle Matter?', *Journal of Economic Integration*, Vol.33 No.2, pp. 1234-1261. These authors report a higher pass-through for a positive output gap.

([106]) Bailliu, J. and H. Bouakez (2004), *op. cit.*

([107]) Forbes, K., Hjortsoe, I. and T Nenova (2018), 'The shocks matter: Improving our estimates of exchange rate pass-through', *Journal of International Economics*, Vol. 114, pp. 255–275, argue that in this case companies distributing imported products have less of an incentive to reduce prices, because the increase in domestic prices (corresponding to stronger demand) gives them some leeway to increase margins without losing market share.

([108]) I.e. these shocks do not reflect changes in the real economy, but may affect the relative prices of imported and domestic goods.

([109]) Rogoff, K. (1996), 'The Purchasing Power Parity Puzzle' *Journal, Journal of Economic Literature,* Vol. 34, pp. 647-68.

([110]) Bailliu, J. and H. Bouakez (2004), 'Exchange Rate Pass-Through in Industrialized Countries', Bank Of Canada Review, spring 2004.

([111]) Taylor, J. (2000), 'Low inflation, pass-through, and the pricing power of firms', *European Economic Review*, Elsevier, Vol.. 44, No. 7, pp. 1389-1408,

([112]) Bacchetta, P. and E. van Wincoop (2003), 'Why Do Consumer Prices React Less than Import Prices to Exchange Rates?', *Journal of the European Economic Association*, Vol. 1, No. 2-3, pp. 662-670.

([113]) Gopinath, G. (2015), 'The International Price System', *NBER Working Paper* No. 21646.

([114]) Up to 2 years.

([115]) Larue, B.Gervais, J-P and Y. Rancourt (2010), 'Exchange rate pass-through, menu costs and threshold cointegration', *Empirical Economics*, Vol. 38, pp. 71–192.

III.4. Estimates of the exchange rate elasticities of import prices

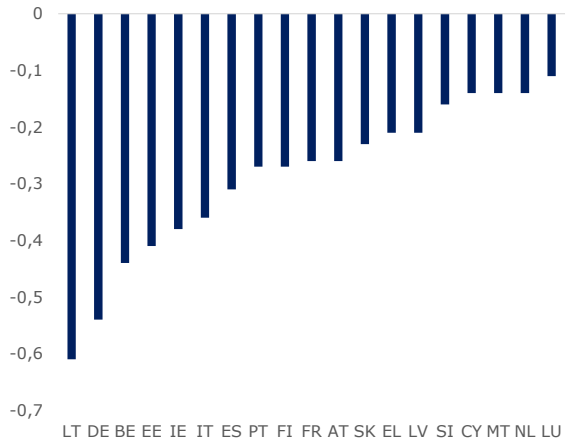
III.4.1. A first look at the data and literature

Figure III.1 shows the unconditional correlation between the aggregate price of goods imported from outside the euro area and the corresponding nominal effective exchange rate for each of the euro-area countries between the third quarter of 2003 and the third quarter of 2021. These correlations seem to suggest that there may be some significant differences in Member States' responsiveness to exchange rate changes.

These correlations are in line with results from available studies suggesting that at the aggregate level, the nominal exchange rate pass-through to import prices is well below unity across advanced economies, and that estimates sometimes vary a lot across countries and periods. For example, the Bank of England (2015) ([116]) estimates that the pass-through from exchange rate movements to UK import prices is about 60%. Berner (2010) ([117]) estimates for Germany a pass-through rate of about 42% in the short term of 3 months and 46% in the long term of 9 months. Fisher (2015) estimates the pass-though to non-oil imports at about 30% for the US. In their seminal paper, Campa and Goldberg (2005) ([118]) provide a broad range of estimates of short-term elasticities for euro-area countries from 0.16 in Ireland to 0.79 in the Netherlands, and of long-term elasticity from 0.06 in Ireland to 0.98 in France.

This subsection presents estimates of the sensitivity of the aggregate price of goods imported from outside the euro area to changes in various nominal (effective) exchange rates across the euro area. These estimates are obtained by estimating an error correction mechanism for each of the Member States separately. The sample covers the period from the first quarter of 2003 until the third quarter of 2021.

Graph III.1: **Correlation between import prices and exchange rates**
(quarter-on-quarter changes for 2003Q3-2021Q3)



(1) Aggregate price of goods imported from outside the euro area and the corresponding nominal effective exchange rate measured as the number of units of foreign currency per euro, so that a rise in the exchange rate indicates an appreciation of the euro and a decrease a depreciation.

Source: Author's estimates using Eurostat International trade in goods statistics data and data from the ECB Statistical Warehouse.

III.4.2. A reduced form regression analysis

The aggregate price of goods imported from outside the euro area is regressed on the euro exchange rate of a basket of non-euro EU countries' currencies ([119]), the US dollar and a basket of the currencies of selected group of other countries ([120]). Such a disaggregation of the nominal effective exchange rate allows for cross-currency differences in the exchange rate pass-through ([121]). Such differences may be due to differences in transaction costs, exchange rate risks, or exporters' price setting.

Other factors expected to affect the price of goods imported from outside the euro area are exporters' costs (measured by unit labour costs denominated in the currency of the exporter), the price of oil and non-fuel commodities (denominated in US dollars), and the domestic output gap as exporters (or

([116]) Bank of England (2015), *Inflation Report*, November 2015.
([117]) Berner, E. (2010), 'Exchange rate pass-through: new evidence from German micro data', *Économie internationale*, No 124, pp. 75-100.
([118]) Campa, J. and L. Goldberg (2005), 'Exchange Rate Pass-Through into Import Prices', *The Review of Economics and Statistics*, Vol. 87, No. 4, pp. 679-690.
([119]) Using import weights retrieved from the ECB Statistical Warehouse.
([120]) Australia (AU), Canada (CA), Switzerland (CH), Japan (JP), Norway (NO), New Zealand (NZ) and the United Kingdom.
([121]) Including various exchange rates in the regression analysis could create problems of multicollinearity that may increase the standard error of the point estimates. However, as discussed in Box III.1 for this exercise the problem of multicollinearity seems to be limited.

companies distributing imported goods ([122])) may set their prices taking into account overall macroeconomic developments in their export market.

Imports settled in several currencies may also have a different impact on aggregate import prices, arising not only from differences in their share of total imports, but also from the share of the currency used for invoicing.

In the subsequent regression analysis a significant difference between the long- and short-term equations is the type of restrictions imposed on the parameters associated with exchange rates and exporters' production costs. The parameters in the long-term equation are expected to be more homogeneous than the parameters in the short-term equations – as discussed below. See Box III.1 for more technical details on the estimation strategy.

III.4.3. The equilibrium relationship

To obtain the point estimates for the long-term exchange rate elasticities of the price of goods imported from outside the euro area, a long-term equilibrium equation (1) in Box III.1 has been estimated for each euro-area Member State separately. The point estimates for these elasticities (and their significance) as well as some diagnostic statistics are shown in Table B in Box III.1 and summarised in the upper pane of Graph III.2.

However, before discussing these point estimates, it should be borne in mind that a set of diagnostic statistical tests support the hypotheses that (i) the effect of the exchange rates on the prices of imported goods is economically meaningful over time; (ii) the import prices take equal account of changes in production costs and exchange rate movements; and that (iii) there are significant differences in the exchange rate elasticities of import prices across countries..

- *Cointegration*: the null hypothesis that the time series constituting the long-term equation are not cointegrated ([123]) is tested using Engle-Granger z-statistics. These tests suggest that this null hypothesis may be rejected without additional exogenous variables for most countries, or after adding a deterministic trend or squared trend for other countries. (See also Table B in Box III.1).

- *Homogeneity*: the null hypothesis that in the long term import prices take equal account of changes in production costs and exchange rate movements ([124]) is tested using a Wald F-statistics (in Table A in Box III.1). In most cases, this null hypothesis ([125])cannot be rejected ([126]). A notable exception is the restriction of long-term homogeneity between US dollars and US producer costs in Germany, Spain, Malta and Slovenia. For the countries for which this homogeneity restriction can be rejected, the long-term relation is re-estimated without the restriction (Table B in Box III.1).

- *Cross-country equality*: The confidence levels (based on likelihood ratio tests) at which the null hypothesis that (the sum of) the long-term exchange rate elasticities of import prices are the same (all possible combinations of two) across euro-area Member States are shown in the upper pane of Table E in Box III.1. These results suggest that the null hypothesis of the equality of long-term elasticities can be rejected for most country combinations at a fairly high confidence level.

III.4.4. The short-term dynamics

The short-term equation in first differences (quarter-on-previous-quarter) and with a (one quarter-lagged) error correction term ([127]), i.e. equation (2) in Box III.1, is estimated (i) without any restrictions on the parameters of the exchange rate or producer costs, but (ii) with the restriction that the price of oil and non-fuel commodities are immediately fully settled at the US dollar-euro exchange rate. This specification reflects the

([122]) See Colavecchio, R. and I. Rubene (2020), 'Non-linear exchange rate pass-through to euro area inflation: a local projection approach', *ECB Working Paper Series* 2362 for the impact of market power in the domestic transportation and storage sectors.

([123]) Cointegration is a statistical property whereby variables move (slowly) in similar but not identical ways, with the distance between them stationary. Cointegeation is a precondition for avoiding picking up any spurious correlation in regression analysis. See Engle, R. (2003), 'Time series analysis, cointegration, and applications', Nobel Lecture, December 8, 2003.

([124]) In equation (1) in Box III.1 the restrictions that $\alpha_{1i} = -\alpha_{2i}$ is imposed.

([125]) Technically speaking, the null hypothesis is that the parameter value of the exchange rate is equal to minus the parameter value of the production cost for each of the regions i=NEA, US and ROW.

([126]) Table 1 in Box III.1.

([127]) Using the error term of the long-term equation.

assumption that production costs and exchange rates show different short-term dynamics for goods, other than basic commodities. See Box III.1 for more details and point estimates.

Before discussing the point estimates shown in Table C of Box III.1 and summarised in the second pane of Graph III.2, note that the following hypotheses have been tested.

- *Uniformity:* The short-term equation has been tested for the null hypothesis that the parameters of the three effective exchange rates are the same within a Member State ([128]). This null hypothesis can be rejected at a fairly high confidence level for most of the euro area Member States ([129]). This suggests that the use of a single aggregate nominal effective exchange rate may be too restrictive when estimating the pass-through of exchange rate changes to import prices ([130]). A similar restriction ([131]) applies to the parameters of the production costs.

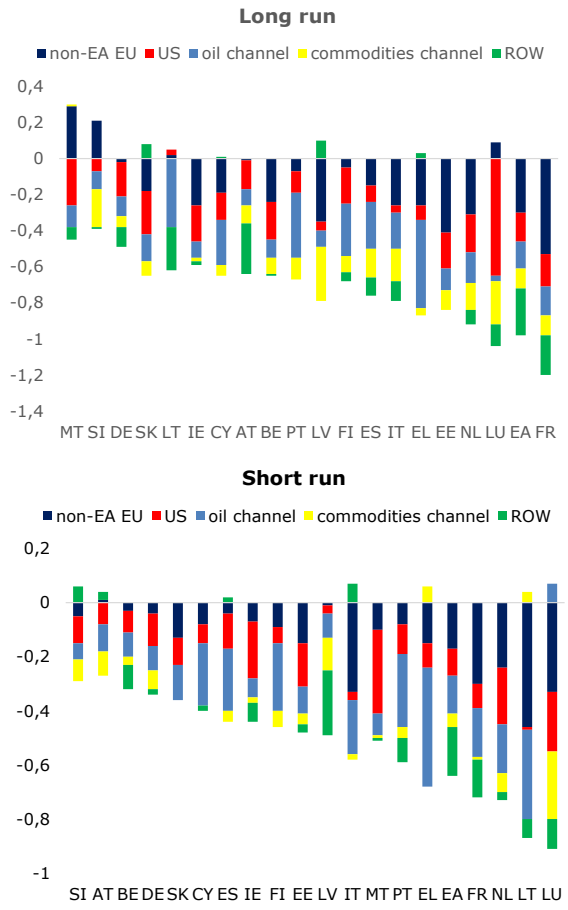
- *Cross-country equality:* The second pane of Table E in Box III.1 shows the confidence levels at which the null hypothesis that (the sum of) the short-term exchange rate elasticities of import prices are the same across Member States. These tests suggest that this null hypothesis can be rejected in a fairly high number of cases, but fewer cases than for the long-term elasticities (shown in the first pane).

III.5. The overall exchange rate pass-through

By stacking the five exchange rate channels ([132]) into one bar, the first and second pane of Graph III.2 show the magnitude of, respectively, the total long- and short-term exchange rate pass-through to the price of goods imported from outside the euro area.

The total length of each stacked bar provides an estimate of the total pass-through of a 1% change in all exchange rates at the same time ([133]). In perfect markets, one would expect that this value (in absolute terms) would be equal to one. All countries except France show an absolute value less than one for the long term.

Graph III.2: **Long- and short-term pass-through: decomposition along currencies**
(scales vary)



(1) A 1% change in all exchange rates at the same time.

Source: Author's estimates – Table B and C in Box III.1

Comparing the estimates for the long-term pass-through (first pane of Graph III.2) with those for the short-term pass-through (second pane of Graph III.2) indicates that as expected, the latter

([128]) I.e. in equation (2) in Box III.1 the restriction $\beta_{11} = \beta_{12} = \beta_{13}$ for the exchange rates is imposed while each log change in the exchange rate is multiplied by its weight in total imports.

([129]) See the p-values related to the likelihood ratio tests reported in Table C of Box III.1.

([130]) The point estimates for the aggregate nominal effective exchange rate are shown as a memo item in Table C in Box III.1.

([131]) I.e. in equation (2) in Box III.1 the restriction $\beta_{21} = \beta_{22} = \beta_{23}$ for the production costs is imposed while each log change in production costs is multiplied by its weight in total imports.

([132]) I.e. the non-euro area EU effective exchange rate, the US dollar related to US production costs, oil prices and prices of non-fuel commodities and the effective exchange rate with the rest of the world.

([133]) This 1% change is illustrative, to facilitate the interpretation of the point estimates.

are smaller (in absolute terms) ([134]) than the former for most Member States (notable exceptions are Malta and Slovenia) ([135]).

These differences show that it takes time before an exchange rate change is fully transmitted to import prices. This may reflect menu costs when setting import prices, as well as pricing and invoicing in euro's in medium and long-term contracts ([136]).

III.5.1. The components of the exchange rate pass-through

Looking at the specific components of the total pass-through, it should be noted that for the long- and short-term responsiveness to changes in the US dollar (red bar) ([137]), all the point estimates have the expected negative sign, are significant for most countries, and that the absolute value of the short-term elasticity is smaller than the long-term elasticity for most countries. All the point estimates for the impact of changes in the US dollar by way of the oil channel (blue bar) also have the expected sign and are almost all significant ([138]), while the short-term elasticities are smaller (in absolute terms) than the long-term ones. Comparing the point estimates for the dollar exchange rate impact on import prices by way of the oil channel (blue bars) with those by way of US production costs (red bars) suggests that the impact of US dollar changes is greater by way of the former than the latter channel in most Member States.

The short- and long-term responsiveness of import prices to change in the nominal effective exchange rate against a basket of non-euro EU currencies (black bar) have all the expected signs (except for Malta, Slovakia and Slovenia) and the short-term elasticity is smaller (in absolute terms) than the long-term elasticity in most cases.

([134]) As the exchange rates are measured as the number of units of foreign currency per euro, a rise in the exchange rate indicates an appreciation of the euro and a decrease a depreciation.

([135]) In the cases of Malta and Slovenia the elasticity of their nominal effective exchange rate against the basket with currencies of the non-euro EU countries has the "wrong" sign distorting its ranking. It would be beyond the scope of this section to identify the causes of this statistical result. Generally speaking, Campa and Goldberg (2005), op. cit. report that smaller European countries typically have noisier and less stable pass-through rates.

([136]) However, in some cases, in the long term a country may find more substitutes to meet its demand, with the result that the long-term elasticity may be lower than the short-term elasticity.

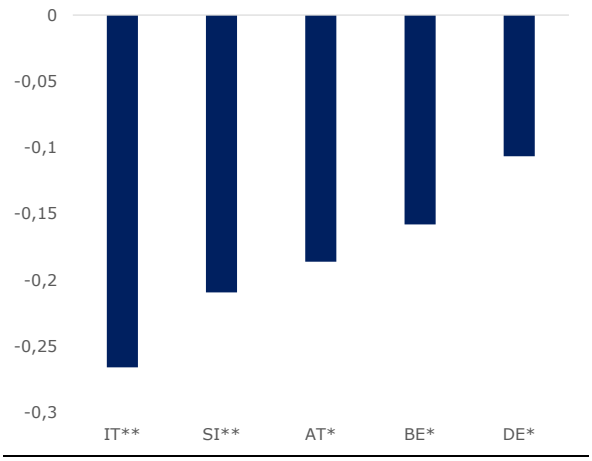
([137]) These estimates do not include the effects of the import of oil and non-fuel commodities.

([138]) A notable exception is the short-term elasticity for Luxembourg.

The elasticities for the nominal effective exchange rate covering the rest of the world (green bar) are (in absolute value) smaller than the ones reported for the US dollar and the effective exchange rate against the non-euro area countries. Albeit insignificant, the point estimates for some Member States show a positive value.

While the impact of production costs and of exchange rate changes are rather homogeneous in the long term for each of the currencies in question ([139]), the point estimates in Table C of Box III.1 suggest that the impact of production costs tends to be greater than the that of exchange rate changes in the short term.

Graph III.3: **Large changes in relation to the US dollar**



(1) A strong change is defined as a change in absolute terms larger than the standard deviation of changes over the sample period.

Source: Author's estimates.

III.5.2. Variable response intensity

The previous results suggest that in the short term all kinds of rigidities may hinder a full exchange rate pass-through. This may occur the costs of adjusting import prices are high. The short-term equation has therefore ben estimated making a distinction between small and large exchange rate changes ([140]). However, the results show that, in the case of a large exchange rate change, for only a

([139]) As tested in Subsection II.4.3.

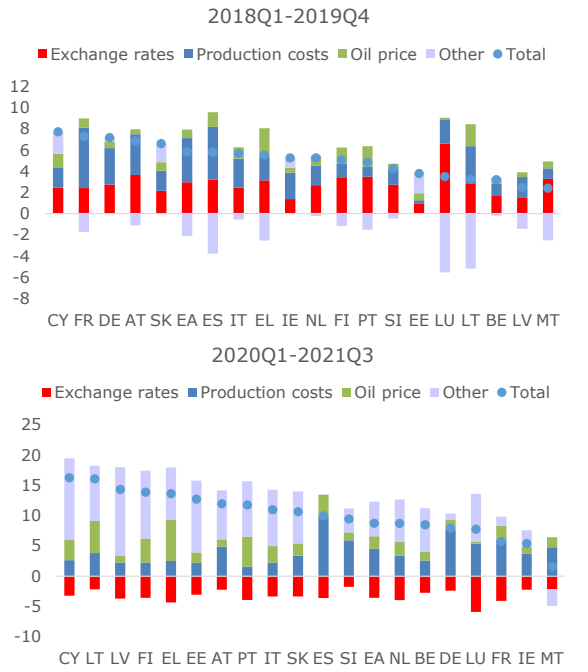
([140]) A large exchange rate change is defined as a change larger than one standard deviation of the changes in the exchange rate time series. This section only shows the results for strong changes in relation to the US dollar. No significant point estimates were obtained for the other currencies in question. A further analysis of whether or not there is an asymmetry between a positive and negative change did not yield significant results.

few countries a significant additional pass-through to short-term elasticity could be found, i.e. Italy, Slovenia, Austria, Belgium and Germany (see Graph III.3). The largest additional significant effect is to be found for Italy and the smallest for Germany, suggesting that for Italy, in the case of a large exchange rate shock, 25% more of the exchange rate change is passed through to import prices in the short term than in the case of a small shock.

III.5.3. The relative importance of exchange rate changes: illustrative breakdown

To get a better understanding of the relative importance of the impact of exchange rate changes on the prices of goods imported from outside the euro area, the upper pane of Graph III.4 shows a breakdown of the total change in import prices into its various components for the period from the first quarter of 2018 until the fourth quarter of 2019.

Graph III.4: **Breakdown of import prices**



(1) For each factor the observed quantity is multiplied by the corresponding point estimate in Table B of Box 1. 'Other' includes the output gap, global financial crisis and COVID-19 dummies, and the random component.

Source: Author's estimate.

Changes in exporters' production cost were the most significant factor determining the increase in import prices for most countries. This explains on average 50% of the change in import prices ([141]). The impact of exchange rate fluctuations (red bars) was fairly modest in Ireland and oil prices had a relatively strong impact in Greece and Lithuania.

The breakdown in the lower pane of Graph III.4 suggests that exchange rate fluctuations (red bars) had only a minor impact on import prices during the COVID-19 pandemic, albeit a tempering (negative) one compared with the strengthening positive) impact in the years before the pandemic.

III.6. Conclusions

The empirical analysis in this section suggests that the euro exchange rates have a significant impact on the price of imported good across the euro area, but this pass-through is not complete and the short-term pass-through is lower than the long-term one.

It also suggests that the overall exchange rate pass-through differs significantly across euro-area Member States. For instance the long-term pass-through in Germany is somewhat more than half the size of the pass-through in France, and the pass-through in the smaller Member States also caries a lot. At the same time, the short- and long-term exchange rate pass-throughs are well below unity in most Member States, and in some smaller Member States the short-term pass-through is higher than the long-term pass-through.

However, within-sample simulations show that exchange rate changes affected national import prices the same way across all euro- area countries, i.e. increasing import prices in the 2 years before the COVID-19 pandemic, but lowering them during the pandemic.

This section did not quantify how these differences may affect a country's inflation rate and external adjustment capacity. However, it should be kept in mind that euro exchange rate adjustments are a less effective way of absorbing common shocks as long as these differences persist. It would be beyond the scope of this section to identify the structural factors at national level that may explain these differences in elasticity.

([141]) Highest in Lithuania, lowest in Estonia.

Box III.1: The exchange rate elasticity of the import prices of goods imported from outside the euro area – a reduced form regression

Specification

The short economic literature review in Sub-section III.3 suggests that the price of identical goods in different markets may differ due to all kinds of market imperfections and macroeconomic conditions. As a result, the exchange rate elasticity of the import prices of goods imported from outside the euro area has been estimated using an error correction mechanism for each of the euro area countries separately.

Three areas from which goods are imported into the euro area countries are considered, i.e. the non-euro EU countries (non-EA EU), the United States (US) and the rest of the world (ROW). The long-term equation links the price of goods imported from outside the euro area (PM denominated in euro) to the exchange rates (ER) and production costs (PC denominated in foreign currency) of the trading partners in quarter t ([1]) as:

$$(1) \qquad ln(PM_t) = \alpha_0 + \sum_{i=1}^{3} \alpha_{1i} ln(ER_{i\,t}) + \sum_{i=1}^{3} \alpha_{2i} ln(PC_{i\,t}) + \alpha_3 ln\left(\frac{P\_OIL_t}{ER_{US\ t}}\right) + \sum_{l=1}^{m} \alpha_{4l} X_{lt} + u_t$$

where ER measures the number of foreign currency units per euro; P_OIL is the oil price ([2]); X covers all other relevant variables, u is a stochastic term, and $\alpha_{1i} < 0$ and $\alpha_{2i} > 0$.

The short-term equation reads as:

$$(2) \qquad \Delta ln(PM_t) = \beta_0 + \sum_{i=1}^{3} \beta_{1i} \Delta ln(ER_{i\,t}) + \sum_{i=1}^{3} \beta_{2i} \Delta ln(PC_{i\,t}) + \beta_3 \Delta ln\left(\frac{P\_OIL_t}{ER_{US\ t}}\right) + \sum_{l=1}^{n} \beta_{4l} \Delta X_{lt} + \beta_5 ECT_{t-1} + w_t$$

where w is a random component, ECT is the error correction term obtained from equation (1), and $\beta_{1i} < 0$ and $\beta_{2i} > 0$.

In the empirical analysis, the production cost is measured by the nominal unit labour cost (denominated in the currency of the exporter). For the homogeneous commodities traded on world markets, such as oil and non-fuel commodities, the exchange rate pass-through is assumed to hold immediately, i.e. specified as an explanatory variable as $ln\left(\frac{P_{oil}}{ER_{US}}\right)$ and $ln\left(\frac{P_{non\ -fuel\ \ commodity}}{ER_{US}}\right)$. X also includes the output gap of the importing country, as exporters' price mark-up depends to some extent on the local business cycle.

Data

The harmonised data on imports of goods from outside the euro area are retrieved from the Eurostat international trade in goods statistics (ITGS) database (series ei_eteu27_2020_m). 'Goods' refers to all movable property including electricity. The ITGS database follow the physical movements of the goods (except for some specific goods like vessels and aircraft). The European ITGS database constitutes an essential source of information for compiling statistics on the balance of payments and national accounts, but comparability across domains is affected by differences in concepts and definitions ([3]). The ITGS database reports the value and a quantity index of goods imported from outside the euro area ([4]). The import price is obtained by dividing the value by quantity variables and normalising it with reference year 2015 ([5]).

Data on the price of oil and non-fuel commodities are retrieved from the IMF primary commodity prices database. The bilateral exchange rates are obtained from the ECB Statistical Warehouse. The unit labour

([1]) A similar specification has been proposed by Campa and Goldberg (2005), *op. cit.*
([2]) It is assumed that the price of oil is set in US dollar.
([3]) For instance, for the ITGSdatabase international trade comprises the application of the principle of physical movements across national frontier, and for the balance of payments/national accounts statistics the change of economic ownership between residents and non-residents. See https://ec.europa.eu/eurostat/cache/metadata/en/ei_et_esms.htm for more details.
([4]) The monthly frequency is converted to a quarterly frequency by summing the values and averaging the quantity indices.
([5]) The euro area aggregates are obtained for the indicator in current prices by summing the corresponding variable across all euro area countries, and for the quantities by calculating the weighted average of the corresponding indicator for the euro area countries.

(Continued on the next page)

Box (continued)

cost data for the EU Member States are retrieved form the Eurostat national accounts, while those for the non-EU countries are retrieved from OECD Statistics.

Estimation results

The equations are estimated by applying ordinary least squares, i.e. the empirical analysis adopts a partial-equilibrium approach in that it assumes predetermined nominal exchange rate fluctuations, production costs and oil prices (measured in US dollars ([6]). Table A shows the F-Statistics p-values for the null-hypothesis that $\alpha_{1i} = -\alpha_{2i}$ ([7]) in the long-term equation (1). When the null-hypothesis can be rejected at a 0.05 or higher confidence level, Table B shows point estimates for the long-term equation (1) with the condition $\alpha_{1i} \neq -\alpha_{2i}$. ([8]) The absence of cointegration of the long-term relationship (1) is tested using the Engle-Granger cointegration z-statistic - shown in the last row of Table 2. The null hypothesis of no cointegration could be rejected for all Member States – in some case after adding a deterministic trend.

Table C shows point estimates for the short-term equation (2). The row with likelihood ratio p-values refers to the null-hypothesis that the point estimates for the exchange rate, i.e. $\beta_{11} = \beta_{12} = \beta_{13}$, and point estimate for the unit labour cost, i.e. $\beta_{21} = \beta_{22} = \beta_{23}$, are the same. The R-squared statistics are fairly high (except for Luxembourg and Ireland), while the Durbin-Watson tests tend to be inconclusive for some countries ([9]).

Table A –Parameter restrictions: F-statistics p-values

	NEA	US	ROW		NEA	US	ROW
EA	0,196	0,646	0,298	LV	0,752	0,169	0,370
BE	0,559	0,154	0,013 **	LT	0,015 **	0,663	0,006 ***
DE	0,773	0,011 **	0,676	LU	0,469	0,259	0,466
EE	0,410	0,459	0,032 **	MT	0,942	0,022 **	0,234
IE	0,743	0,240	0,249	NL	0,169	0,714	0,036 **
EL	0,064 *	0,187	0,169	AT	0,000 ***	0,775	0,019 **
ES	0,164	0,018 **	0,118	PT	0,656	0,964	0,341
FR	0,128	0,768	0,351	SI	0,288	0,000 ***	0,106
IT	0,920	0,081 *	0,453	SK	0,852	0,084 *	0,602
CY	0,422	0,139	0,943	FI	0,072 *	0,459	0,219

Note: The null-hypothesis is in equation (1) $\alpha_{1i} = -\alpha_{2i}$, for i= NEA, US and ROW; * for p<0,1, ** for p<0.05, *** for p<0,01

Table B: Factors affecting import prices – long-term (semi-)elasticities

Dependent variable: natural logarithm of aggregate import price in euro

	EA	BE	DE	EE	IE	EL	ES	FR	IT	CY
Non-EA EU NEER	-0,30	-0,24	-0,02	-0,41	-0,26	-0,26	-0,15	-0,53	-0,26	-0,19
US dollar	-0,16	-0,21	-0,19	-0,20	-0,20	-0,08	-0,09	-0,18	-0,04	-0,15
ROW NEER	-0,26	-0,01	-0,11	0,00	-0,02	0,03	-0,10	-0,22	-0,11	0,01
Non-EA EU production costs (in foreign currency)	***0,30***	***0,24***	***0,02***	***0,41***	***0,26***	***0,26***	***0,15***	***0,53***	***0,26***	***0,19***
US production costs (in US dollar)	***0,16***	***0,21***	0,81	***0,20***	***0,20***	***0,08***	0,96	***0,18***	***0,04***	***0,15***
ROW production costs (in foreign currency)	***0,26***	-0,21	***0,11***	-0,47	***0,02***	***-0,03***	***0,10***	***0,22***	***0,11***	***-0,01***
Price of oil / US dollar	0,15	0,10	0,11	0,12	0,09	0,49	0,26	0,16	0,20	0,25
Price of non-fuel / US dollar	0,11	0,09	0,06	0,11	0,02	0,04	0,16	0,11	0,18	0,06
GFC-dummy	0,03	0,03	0,03	0,04	0,00	0,03	0,02	0,01	0,04	-0,01
COVID-dummy	0,03	0,02	0,03	0,00	-0,04	0,05	-0,05	-0,03	0,00	0,11
Output gap	0,72	0,44	0,75	0,15	0,27	-0,14	-0,10	-0,05	0,34	0,08
Constant	2,63	3,59		4,54	3,19	1,89	-1,60	2,47	2,46	2,47
Trend		0,00		0,00	0,00	0,00	0,00		0,00	0,00
Trend squared					0,00					
Adjusted R-squared	0,99	0,97	0,99	0,97	0,95	0,97	0,98	0,99	0,98	0,95
Total number of observations	73	73	73	73	73	73	73	73	73	73
Total number of explanatory variables	9	11	9	11	11	10	11	9	10	10
Engle-Granger cointegration test: z-statistic	0	0,00	0,04	0,04	0,00	0,01	0,00	0,00	0,00	0,00
Memo item for p-val likelihood ratio test	0.00***	0.00***	0.00***	0.00***	0.00***	NA	0.00***	0.00***	0.00***	0.02**
One effective NEER	-0,25	-0,12	-0,26	-0,03	-0,28	-0,09	-0,10	-0,28	-0,17	-0,05
One effective production cost (in foreign currency)	0,76	0,94	0,97	0,92	0,61	0,40	0,61	1,17	1,04	0,62

Note: Estimates for equation (1). The bold italics point estimates indicate that the long-term homogeneity condition $\alpha_{1i} = -\alpha_{2i}$ holds. NEER is defined as the number of foreign

([6]) Following Dornbusch, R. (1987), 'Exchange rates and prices', *American Economic Review*, Vol. 77, No. 1, pp. 93–106.
([7]) In equilibrium, the import prices take equal account of changes in production costs and exchange rate movements. A negative sign as an increase in the exchange rate means an appreciation of the euro.
([8]) The point estimates for this restrictive version are reported as a memo item in Table B.
([9]) In the presence of autocorrelation, the variance estimates of OLS are biased downward, compromising inference about parameter homogeneity and cross-country equality. Nevertheless, the high point estimates for the coefficients of the error correction term suggest that the import price level adjusts quite quickly, tempering the risk that the short term dynamics are misspecified

(Continued on the next page)

Box (continued)

currency units per euro; a positive (negative) sign of the change in NEER indicates an appreciation (depreciation) of the euro. Non-EA EU covers the non-euro area Member States of the EU, ROW covers AU, CA, CH, JP, NO, NZ and UK. Sample 2003Q1-2021Q3; estimated with OLS. No p-values shown for the point estimates as standard t-statistics are not applicable in case of cointegration estimation. The Engle-Granger cointegration z-statistics shows the confidence level at which the null hypothesis of no cointegration can be rejected. As a memo-item the p-values of the likelihood ratio test shows the confidence level at which the null-hypothesis that the parameters of the three exchange rates, i.e. $\alpha_{11} = \alpha_{12} = \alpha_{13} = \alpha_1$, and corresponding labour unit cost, i.e. $\alpha_{21} = \alpha_{22} = \alpha_{23}, = \alpha_2$ are the same, with the last two rows showing estimates of α_1 and α_2.

Table B (continued): Factors affecting import prices – long-term (semi-)elasticities

Dependent variable: natural logarithm of aggregate import price in euro

	LV	LT	LU	MT	NL	AT	PT	SI	SK	FI
Non-EA EU NEER	-0,35	0,02	0,09	0,29	-0,31	-0,01	-0,07	0,21	-0,18	-0,05
US dollar	-0,05	0,03	-0,65	-0,26	-0,21	-0,16	-0,12	-0,07	-0,24	-0,20
ROW NEER	0,10	-0,24	-0,12	-0,07	-0,08	-0,28	0,00	-0,01	0,08	-0,05
Non-EA EU production costs (in foreign currency)	***0,35***	0,99	***-0,09***	***-0,29***	***0,31***	0,59	***0,07***	***-0,21***	***0,18***	***0,05***
US production costs (in US dollar)	***0,05***	***-0,03***	***0,65***	0,74	***0,21***	***0,16***	***0,12***	0,83	***0,24***	***0,20***
ROW production costs (in foreign currency)	***-0,10***	-0,51	***0,12***	***0,07***	-0,16	-0,44	***0,00***	***0,01***	***-0,08***	***0,05***
Price of oil / US dollar	0,09	0,38	0,03	0,12	0,17	0,09	0,36	0,10	0,15	0,29
Price of non-fuel / US dollar	0,30		0,24	-0,01	0,15	0,11	0,12	0,21	0,08	0,09
GFC-dummy	0,07	0,10	-0,02	0,01	0,02	0,03	0,03	0,04	0,06	0,04
COVID-dummy	-0,01	0,04	0,01	-0,01	0,03	0,03	0,06	-0,07	0,09	0,08
Output gap	0,43	0,48	2,23	0,14	0,32	0,85	0,09	0,31	0,87	0,84
Constant	2,41	1,67	0,51	0,77	3,31	3,49	1,84	-0,63	2,48	1,98
Trend	0,00		0,00	0,00	0,00				0,00	
Trend squared										
Adjusted R-squared	0,94	0,94	0,6	0,85	0,98	0,99	0,91	0,96	0,95	0,97
Total number of observations	73	59	61	74	73	73	60	73	70	73
Total number of explanatory variables	10	10	10	11	11	11	9	10	10	9
Engle-Granger cointegration test: z-statistic	0,00	0,09	0,07	0,01	0,00	0,00	0,03	0,02	0,01	0,00
Memo item for										
p-val likelihood ratio test	0.04**	0.01***	0.00***	0.00***	0.00***	0.00***	0.72	0.00***	0.00***	0.88
One effective NEER	0,04	-0,75	-0,13	-0,04	-0,23	-0,25	0,02	0,14	-0,12	-0,15
One effective production cost (in foreign currency)	0,88	0,78	0,75	0,12	0,44	0,88	0,49	0,43	0,29	0,67

Table C: Factors affecting import prices – short-term (semi-)elasticities

Dependent variable: natural logarithm in first differences of aggregate import price in euro

	EA	BE	DE	EE	IE	EL	ES	FR	IT	CY
Non-EA EU NEER	-0.17 **	-0.03	-0.04	-0.15	-0.07	-0.15	-0.04	-0.30 ***	-0.33 ***	-0.08
US dollar	-0.10 *	-0.08	-0.12 **	-0.16 *	-0.21 **	-0.09	-0.13 *	-0.09	-0.03	-0.07
ROW NEER	-0.18 **	-0.09	-0.02	-0.03	-0.07	0.00	0.02	-0.14 **	0.07	-0.02
Non-EA EU production costs (in foreign currency)	0.22 ***	0.08	0.05	0.06	0.25 *	0.21 **	0.23 **	0.33 ***	0.21 **	0.17
US production costs (in US dollar)	0.41 ***	0.37 **	0.62 ***	0.38	0.45 **	0.45 *	0.73 ***	0.28 *	0.38 *	0.47 **
ROW production costs (in foreign currency)	0.04	-0.10	-0.00	-0.13	0.04	-0.41 **	-0.01	0.09	0.04	-0.02
Price of oil / US dollar	0.14 ***	0.08 ***	0.09 ***	0.11 ***	0.07 ***	0.42 ***	0.23 ***	0.17 ***	0.18 ***	0.23 ***
Price of non-fuel / US dollar	0.04	0.02	0.06 **	0.02	0.00	-0.07	0.01	-0.01	0.01	-0.02
Depreciation v-a-v US	-0.05	-0.16 *	-0.11 *	-0.21	0.03	0.02	-0.08	-0.05	-0.27 **	-0.02
GFC-dummy	0.02 ***	0.03 ***	0.03 ***	0.02 *	0.00	0.01	0.02 **	0.01 *	0.03 ***	0.00
COVID-dummy	0.00	-0.01	0.01	0.01	-0.01	0.04 *	-0.00	0.01	-0.01	0.07 ***
Output gap	0.05	0.06	0.05	0.04	0.02	0.01	0.03	0.04	0.05	0.01
Error correction term	-0.49 ***	-0.57 ***	-0.72 ***	-0.65 ***	-0.42 ***	-0.54 ***	-0.59 ***	-0.41 ***	-0.63 ***	-0.40 ***
Adjusted R-squared	0.86	0.70	0.81	0.67	0.52	0.93	0.87	0.86	0.84	0.81
Durbin Watson	1.68	1.52	1.46	1.34	1.83	2.07	1.53	2.09	2.07	2.06
Total number of observations	71	72	72	72	72	72	72	72	72	72
Total number of explanatory variables	13	13	13	13	13	13	13	13	13	13
Memo item										
p-value likelihood ratio test	0.14	0.20	0.00***	0.15	0.14	0.00***	0.00***	0.00***	0.00***	0.08*
One effective NEER	-0.48 ***	-0.20 **	-0.19 *	-0.13	-0.26 **	0.05	-0.07	-0.35 ***	-0.11	-0.03
One effective production cost (in foreign currency)	0.58 ***	0.20	0.39 ***	0.04	0.43 ***	0.14	0.61 ***	0.68 ***	0.68 ***	0.31 **

Note: Estimation of equation (2). Point estimates with their significance level: * for p<0.10, ** for p<0.05 and *** for p<0.01.
The p-value of the likelihood ratio test shows the confidence level at which the null-hypothesis that the parameters of the three exchange rates, i.e. $\beta_{11} = \beta_{12} = \beta_{13}$, and corresponding labour unit cost, i.e. $\beta_{21} = \beta_{22} = \beta_{23}$, are the same.

(Continued on the next page)

Box (continued)

Table C (continued): Factors affecting import prices – short-term (semi-)elasticities

Dependent variable: natural logarithm in first differences of aggregate import price in euro

	LV	LT	LU	MT	NL	AT	PT	SI	SK	FI
Non-EA EU NEER	-0.01	-0.46 **	-0.33	-0.10	-0.24 ***	0.01	-0.08	-0.05	-0.13 *	-0.09
US dollar	-0.03	-0.01	-0.22	-0.31 ***	-0.21 ***	-0.08	-0.11	-0.10 *	-0.10	-0.06
ROW NEER	-0.24 ***	-0.07	-0.11	-0.01	-0.03	0.03	-0.09	0.06	0.00	0.00
Non-EA EU production costs (in foreign currency)	0.01	0.46 **	-0.05	-0.12	0.16	0.44 ***	0.28 **	-0.15 *	0.11	0.33 **
US production costs (in US dollar)	0.73 **	0.98 ***	1.52 *	1.15 ***	0.50 ***	0.40 **	0.01	0.84 ***	0.43 ***	0.57 ***
ROW production costs (in foreign currency)	-0.17	-0.17	-0.28	0.30 *	-0.04	-0.21	0.19	-0.58 ***	-0.10	-0.10
Price of oil / US dollar	0.09 ***	0.33 ***	-0.09	0.09 ***	0.17 ***	0.10 ***	0.28 ***	0.06 ***	0.13 ***	0.25 ***
Price of non-fuel / US dollar	0.07	-0.07	0.20	-0.04	0.04	0.07	0.02	0.05	-0.02	0.04
Depreciation v-a-v US	-0.14	-0.14	0.46	0.19	-0.03	-0.19 *	0.03	-0.21 **	-0.08	-0.04
GFC-dummy	0.04 ***	0.03 *	0.01	-0.00	0.01	0.01	0.03 **	0.02 **	0.03 ***	0.01
COVID-dummy	-0.02	-0.02	-0.05	-0.00	0.01	0.00	0.03 *	-0.01	0.03 **	-0.03
Output gap	0.15 ***	0.02	-0.24	-0.01	0.04	0.07	0.06	0.08 **	0.10 *	0.01
Error correction term	-0.44 ***	-0.37 **	-0.79 ***	-0.96 ***	-0.58 ***	-0.54 ***	-0.52 ***	-0.73 ***	-0.82 ***	-0.49 ***
Adjusted R-squared	0.62	0.85	0.39	0.73	0.86	0.61	0.89	0.80	0.81	0.86
Durbin Watson	1.59	1.45	1.64	1.79	2.03	1.49	1.51	1.49	1.69	1.67
Total number of observations	72	58	60	73	72	72	59	72	69	72
Total number of explanatory variables	13	13	13	13	13	13	13	13	13	13
Memo item										
p-value likelihood ratio test	0.02**	0.03**	0.23	0.00***	0.00***	0.07*	0.49	0.00***	0.02**	0.06*
One effective NEER	-0.36 ***	-0.64 ***	-0.24	-0.09 **	-0.26 ***	-0.01	-0.21 **	-0.19	-0.13 *	-0.09
One effective production cost (in foreign currency)	0.15	0.70 ***	0.83	0.64 ***	0.45 ***	0.71 ***	0.46 ***	-0.21 *	0.17 **	0.55 ***

Testing for the degree of multicollinearity ([10]) between the explanatory variables in tables C and D summarises the variance inflation factors (VIFs) ([11]) of the regressors in Table C, showing the minimum, maximum and median value of the VIF for each Member State. With all VIFs (except Malta) lower than 4, it can be inferred with some confidence that multicollinearity did not inflate the variance of the point estimates.

Table D - Variance inflation factors

	EA	BE	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT	LU	MT	NL	AT	PT	SI	SK	FI
Minimum	1,10	1,07	1,13	1,05	1,07	1,14	1,11	1,07	1,12	1,14	1,13	1,13	1,08	1,09	1,11	1,08	1,10	1,17	1,18	1,09
Median	1,69	1,63	1,69	1,62	1,70	1,63	1,69	1,62	1,66	1,43	1,64	1,96	1,74	1,67	1,69	1,57	1,67	1,64	1,62	1,65
Maximum	3,39	3,36	3,07	3,01	2,79	3,77	3,24	2,99	3,30	2,89	2,63	3,91	3,76	4,04	3,69	3,24	3,26	3,01	2,95	2,98

Note: VIF = 1 / (1-R^2_j) with R^2_j obtained by regressing the j^{th} explanatory variable on the remaining explanatory variables.

Table E shows the correlation for the estimates of the exchange rate elasticity ([12]) in tables B (long term) and C (short term) respectively, with the corresponding sample average of the share of total imports from outside the euro area. The strongest correlation is found for the US dollar ([13]), with a somewhat weaker correlation found for the basket of currencies from the rest of the world. A strong negative correlation may suggest that there are no great differences in the exchange rate pass-through for that specific currency across countries ([14]). A weak correlation with the wrong sign is found for the basket of currencies of non-euro EU Member States. This may be due to global value chain trade with euro invoicing in these countries ([15]).

Table E: Correlation between point estimate and import weight

	Non-EA EU	US	ROW
Long term	0,05	-0,40	-0,28
Short term	0,13	-0,41	-0,10

([10]) Multicollinearity increases the variance of point estimates; but does not make them biased.
([11]) For more details on this diagnostic statistic see https://online.stat.psu.edu/stat462/node/180/
([12]) The point estimates in Box III.1 and Graph III.2 measure the impact of a change in a particular exchange rate on import prices. Implicitly they cover both the magnitude of the pass-through and the import weight of the currency in question.
([13]) Remember that the exchange rate measures the number of foreign currency units per euro, so that a decrease (a depreciation of the euro) may cause a rise in import prices.
([14]) These cross-country differences have been tested more formally in Table E.
([15]) The correlation between the point estimates for and the import weight of the various currencies in a country are not shown as only three observations are available for each country, - compared to 19 observations for the cross-country correlations. Nevertheless, the likelihood ratio tests of the equality of the point estimates for the various currencies in a country are shown in Table C

(Continued on the next page)

Box (continued)

Testing for country differences in exchange rate elasticities

To test whether there are significant differences between the point estimates for the exchange rate elasticities β_{1i} across countries, a modified version of equation (2) is estimated by pooling the data for two countries and estimating the following equation for this pool ([16])

$$(3)\quad \Delta ln(PM_{kt}) = \beta_{k0} + \sum_{z=1}^{2}\sum_{i=1}^{3}\beta_{k1i}\ DUM_{zk}\ \Delta ln(ER_{ki\,t}) + \sum_{z=1}^{2}\sum_{i=1}^{3}\beta_{k2i}\ DUM_{zk}\ \Delta ln(PC_{ki\,t}) + \sum_{z=1}^{2}\beta_{k3i}\ DUM_{zk}\Delta ln\left(\frac{P\_OIL_{kt}}{ER_{kUS\ t}}\right) + \sum_{z=1}^{2}\sum_{k=1}^{n}\beta_{k4l}\ DUM_{zk}\ \Delta X_k + \sum_{z=1}^{2}\beta_{k5}\ DUM_{zk}\ ECT_{t-1} + w_{kt}$$

with the index k indicating the country. For the dummy it holds that $DUM_{zk} = 1$ if z=k and $DUM_{zk} = 0$ if $z \neq k$. To test the null hypothesis that the point estimates are the same for two countries (k=1,2), the second right-hand side term in equation (3) is replaced with $\sum_{i=1}^{3}\beta_{1i}\ \Delta ln(ER_{ki\,t})$, i.e. no differences in responsiveness from $\beta_{11i} = \beta_{21i}$. On retrieving the log likelihood of both estimated equations ([17]), Table F shows the p-values at which the null hypothesis (i.e. the same exchange rate elasticity between two Member States) can be rejected applying a likelihood ratio test. These results suggest that the null-hypothesis of the equality of long- and short-term elasticities can be rejected for most country combinations at a fairly high confidence level.

Table F: Same total exchange rate elasticity between two Member States (p-values)

	Long-term relationship																			
	EA	BE	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT	LU	MT	NL	AT	PT	SI	SK	FI
EA	-																			
BE	0.04**	-																		
DE	0.00***	0,13	-																	
EE	0.00***	0,58	0.00***	-																
IE	0.00***	0,33	0.00***	0,91	-															
EL	0.00***	0.01***	0.00***	0.04**	0.01***	-														
ES	0.01***	0.08*	0.00***	0.03**	0.00***	0,27	-													
FR	0,62	0.10*	0.01***	0.00***	0.01***	0.00***	0.01***	-												
IT	0.03**	0,11	0.00***	0.03**	0.01***	0.04**	0,59	0.05*	-											
CY	0.00***	0,11	0.00***	0,33	0.05**	0,43	0,3	0.00***	0,14	-										
LV	0.00***	0.01***	0.00***	0.08*	0.10*	0,89	0,2	0.00***	0.07*	0,46	-									
LT	0.00***	0.00***	0.00***	0.00***	0.00***	0,13	0,24	0.00***	0,19	0,13	0,42	-								
LU	0.00***	0.00***	0.02**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	-							
MT	0.00***	0.00***	0.04**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0,12	-						
NL	0.02**	0,64	0.00***	0,7	0,5	0.00***	0.02**	0,13	0,15	0.01**	0.00***	0.00***	0.00***	0.00***	-					
AT	0.01**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	-				
PT	0.00***	0.00***	0.00***	0.00***	0.00***	0,48	0,17	0.00***	0.01***	0.00***	0.03**	0,11	0.00***	0.00***	0.00***	0.00***	-			
SI	0.00***	0.00***	0.00***	0.00***	0.00***	0,14	0,16	0.00***	0.01***	0.00***	0.00***	0.01**	0.01**	0.02**	0.00***	0.00***	0,26	-		
SK	0.00***	0.00***	0.00***	0.00***	0.08*	0.00***	0.00***	0.00***	0.00***	0.00***	0.02**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	-	
FI	0.00***	0.01***	0.00***	0.01***	0.00***	0,15	0,24	0.00***	0.01**	0.06*	0.04**	0.01**	0.00***	0.00***	0.00***	0.00***	0,27	0,74	0.00***	-

	Short-term relationship																			
	EA	BE	DE	EE	IE	EL	ES	FR	IT	CY	LV	LT	LU	MT	NL	AT	PT	SI	SK	FI
EA	-																			
BE	0,29	-																		
DE	0.09*	0,69	-																	
EE	0.10*	0,3	0,46	-																
IE	0,13	0,36	0,88	0,65	-															
EL	0.00***	0.02**	0.08*	0.03**	0,13	-														
ES	0.09*	0,37	0,93	0,44	0,94	0,28	-													
FR	0,39	0.02**	0.00***	0.02**	0.02**	0.00***	0.01**	-												
IT	0.09*	0.03**	0.04**	0,19	0,21	0.01***	0,11	0,23	-											
CY	0.02**	0.08*	0,28	0.02**	0,24	0,67	0,64	0.00***	0.02**	-										
LV	0,11	0,2	0,64	0,52	0,87	0,16	0,67	0.02**	0,18	0,15	-									
LT	0,16	0.02**	0.01**	0.04**	0.04**	0.00***	0.03**	0,65	0,56	0.01**	0.02**	-								
LU	0,47	0,26	0,27	0.06*	0,25	0.10*	0,28	0,69	0,52	0,15	0,12	0,94	-							
MT	0,32	0,63	0,95	0,66	0,89	0.03**	0,84	0.05*	0,32	0,23	0,34	0.04**	0,1	-						
NL	0,34	0,21	0,14	0,62	0,29	0.00***	0,15	0,21	0,4	0.01**	0,23	0,18	0,42	0,61	-					
AT	0.08*	0,71	0,91	0,4	0,77	0,21	0,96	0.00***	0.01**	0,52	0,61	0.00***	0,16	0,67	0.06*	-				
PT	0.00***	0.00***	0.04**	0.04**	0,37	0.09*	0,15	0.00***	0.03**	0.07*	0,66	0.01***	0,24	0.05*	0.00***	0.06*	-			
SI	0.05**	0,29	0,84	0,64	0,96	0.10*	0,91	0.00***	0.06*	0,18	0,73	0.01**	0,23	0,86	0,17	0,9	0.07*	-		
SK	0.07*	0,12	0,42	0,28	0,75	0.08*	0,68	0.02**	0,37	0,35	0,38	0.06*	0,3	0,82	0,22	0,25	0,11	0,38	-	
FI	0.02**	0.08*	0,16	0.03**	0,21	0,18	0,4	0.01***	0,11	0,71	0,12	0.05*	0,35	0,3	0.02**	0,28	0.07*	0.09*	0,47	-

1) Lower part of symmetric matrix shown.

(2) Null hypothesis: β_11i = β_21i for i=NEA, US, ROW in equation (3) of Box III.1.

Likelihood ratio test. p-values: * for p<0.10, ** for p<0.05 and *** for p<0.01

([16]) A similar method holds for testing the cross-country equality of elasticities in equation (1).

([17]) I.e. the original equation (3) and the equation with the restriction $\sum_{i=1}^{3}\beta_{1i}\ \Delta ln(ER_{ki\,t})$.