EXCHANGE RATE PASS-THROUGH IN THE EURO AREA AND EU COUNTRIES

2020

BANCO DE ESPAÑA
Eurosistema

Documentos Ocasionales
N.º 2016

Eva Ortega and Chiara Osbat

EXCHANGE RATE PASS-THROUGH IN THE EURO AREA AND EU COUNTRIES

Eva Ortega

BANCO DE ESPAÑA

Chiara Osbat

EUROPEAN CENTRAL BANK

This paper has also been published as an ECB Occasional Paper with number 241, April 2020.

Documentos Ocasionales. N.º 2016

2020

The Occasional Paper Series seeks to disseminate work conducted at the Banco de España, in the performance of its functions, that may be of general interest.

The opinions and analyses in the Occasional Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the Internet on its website at: http://www.bde.es.

ISSN: 1696-2230 (on-line edition)

Abstract

Aggregate exchange rate pass-through (ERPT) to import and consumer prices in the EU is currently lower than it was in the 1990s and is non-linear. Low estimated aggregate ERPT to consumer prices does not at all mean that exchange rate movements do not have an impact on inflation, as aggregate rules of thumb mask substantial heterogeneities across countries, industries and time periods owing to structural, cyclical and policy factors. Looking also at new micro evidence, four key structural characteristics explain ERPT across industries or sectors: (i) import content of consumption, (ii) share of imports invoiced in own currency or in a third dominant currency, (iii) integration of a country and its trading partners in global value chains, and (iv) market power. In the existing literature there is also a robust evidence across models showing that each shock which causes the exchange rate to move has a different price response, meaning that the combination of shocks that lies behind the cycle at any point in time has an impact on ERPT.

Finally, monetary policy itself affects ERPT. Credible and aggressive monetary policy reduces the observed ex post ERPT, as agents expect monetary policy to counteract deviations of inflation from target, including those relating to exchange rate fluctuations. Moreover, under the effective lower bound, credible non-standard monetary policy actions result in greater ERPT to consumer prices. This paper recommends moving away from rule-of-thumb estimates and instead using structural models with sufficient feedback loops, taking into account the role of expectations and monetary policy reactions, to assess the impact of exchange rate changes when forecasting inflation.

Keywords: exchange rates, import prices, consumer prices, inflation, pass-through, euro area, monetary policy.

JEL classification: C50, E31, E52, F31, F41.

Resumen

La traslación del tipo de cambio (ERPT, por sus siglas en inglés) a los precios de importación y consumo en la Unión Europea es, en términos agregados, menor que en los años 90 y tiene un comportamiento no lineal. Estimaciones agregadas de una traslación pequeña a los precios al consumo no significan que los movimientos del tipo de cambio no tengan impacto sobre la inflación, pues estas estimaciones agregadas ocultan una gran heterogeneidad entre países, sectores productivos y periodos de tiempo que se deben a distintos factores estructurales, cíclicos y de políticas. Utilizando nueva evidencia microeconómica, se encuentran cuatro características estructurales clave que explican el ERPT en las diversas ramas de actividad: (i) el contenido importado del consumo, (ii) la proporción de importaciones facturadas en la propia moneda o en una tercera moneda dominante, (iii) el grado de integración del país y sus socios comerciales en las cadenas globales de valor, y (iv) el poder de mercado. Además, en línea con la literatura existente, se muestra evidencia robusta, utilizando distintos modelos, de que cada tipo de perturbación que mueve el tipo de cambio tiene una respuesta distinta en los precios: la combinación de perturbaciones que sustenta la posición cíclica de la economía tiene un impacto sobre el ERPT a precios.

Finalmente, la propia política monetaria también afecta al ERPT. Un comportamiento creíble y sistemático de la política monetaria reduce la traslación a precios del tipo de cambio a posteriori, pues los agentes esperan que la política monetaria contrarreste desviaciones de la inflación respecto de su objetivo, incluidas aquellas relacionadas con fluctuaciones del tipo de cambio. Además, bajo la cota efectiva de los tipos de interés, medidas no convencionales creíbles de política monetaria resultan en un mayor ERPT a los precios al consumo. Este documento recomienda no descansar en estimaciones agregadas sino utilizar modelos estructurales a la hora de evaluar el impacto del tipo de cambio sobre las predicciones de inflación: modelos que cuenten con suficientes interrelaciones entre los agentes y donde la formación de expectativas y la reacción de la política monetaria jueguen un papel importante.

Palabras clave: tipos de cambio, precios de importación, precios al consumo, inflación, traslación a precios, área del euro, política monetaria.

Códigos JEL: C50, E31, E52, F31, F41.

Index

Executive summary

The actions of central bankers aimed at stabilising domestic inflation also influence the relative price of their currency. This explains the attention paid to exchange rate pass-through (ERPT) in the preparation of monetary policy decisions.

The generic term "ERPT" refers to the complex relationship between exchange rates and prices in the short, medium and long run. First, this Occasional Paper contributes to clarifying the differences between various definitions of the pass-through concept and their respective appropriate metrics. Second, it reviews existing empirical estimates of ERPT to import and consumer prices, and compares them with new ones produced within a common framework. Third, it analyses the structural, cyclical and policy factors that may affect the exchange rate-prices nexus and make it heterogeneous across both countries and periods. A few possible sources and forms of non-linearity and the issue of shock-dependence are also discussed.

The paper corroborates recent estimates in the literature that the ERPT to consumer prices is around one-tenth of the ERPT to import prices. On the basis of empirical evidence from reduced-form models, a 1% depreciation in the euro raises total import prices in the euro area and its member countries on average by around 0.3% within a year, and the headline HICP by around 0.04%. Both estimates lie on the low side of the range of those found in the literature. For non-euro area EU Member States, the ERPT to consumer prices is of a similar magnitude, while that to import prices is somewhat higher, ranging between 0.4% and 0.8%. Structural models tend to deliver a higher and more gradual pass-through to consumer prices. Time-varying estimates for the euro area and for individual EU Member States suggest that the ERPT to total import prices and consumer prices has been stable since the 1990s and lower than estimates obtained in the literature for earlier decades. The ERPT to euro area import and consumer prices is also found to be non-linear – it is stronger for large exchange rate changes than small ones.

The link between the exchange rate and prices differs across countries, as it depends on their respective trade openness, the product and sectoral composition of the production sector, the relative integration of sectors and firms in international production chains, and the currency of invoicing for trade, among other things. These characteristics and the general macroeconomic environment may also change with time. Increased participation in global value chains (GVCs), larger market shares of exporters to euro area countries and euro area imports invoiced in euro (local currency pricing) reduce ERPT to import prices. Higher import content in consumption and low concentration and market power in the importing markets would explain the higher ERPT to consumer prices. Additionally, the less competitive the domestic distribution sector, the lower the pass-through to consumer prices.

The analysis using structural dynamic stochastic general equilibrium (DSGE) models shows that the ERPT to import prices is incomplete, but substantial, and that that to consumer prices, albeit about an order of magnitude lower, is not negligible. This result holds true even if some models, consistent with empirical evidence, assume incomplete pass-through to import prices at both the border and the retail level.

Shocks affect the measured co-movement between the exchange rate and inflation rates. The response of consumer prices relative to that of the exchange rate is somewhat larger in the case of shocks to monetary policy and to the exchange rate itself, for which there is also less cross-model heterogeneity, and lower for shocks to domestic aggregate supply. For demand shocks, the endogenous monetary policy reaction and the general equilibrium effects yield the estimated response of consumer prices relative to that of the exchange rate with a different sign when calculated with DSGE models rather than with structural Bayesian vector autoregression (BVAR) models (consumer prices rise after an expansionary demand shock in DSGE models despite the appreciation induced, while cheaper imports dominate the fall in consumer prices in BVAR models).

The fact that the relative dynamics of prices and the exchange rate depend on the shock they react to has been a major concern in policy circles over the past few years. Indeed, the treatment of ERPT in projection exercises is a very important practical issue for policy. Findings that the pass-through is shock-dependent has led some authors to caution against using rules of thumb and to try to close the circle by redefining rules of thumb in terms of relative contributions of shocks to movements in the exchange rate. This paper also cautions against this temptation, not only because of theoretical considerations, but also because of how difficult it is in practice to find robust results on which precise shocks drive macroeconomic variables at any point in time. At the same time, the use of large semi-structural models for the projections can insure against the limitations of relying on simple rules of thumb. Rich models are able to capture feedback effects as long as they are used in their entirety and not in part. The practice of additionally using DSGEs and vector autoregressions as satellite models or to cross-check the projections would also insure against mis-estimations of the effect of exchange rate changes.

Finally, the comparison of the co-movement between exchange rates and inflation under standard monetary policy and forward guidance illustrates that it is risky to rely on simple empirical regularities, owing to the duality of the exchange rate as a source of shocks and a monetary policy transmission channel. This again supports the case for using current structural models for scenario analysis and for enhancing them where possible, adding some of the structural features highlighted above. These include, but are not limited to, the non-linear response of prices to the size of exchange rate changes, the degree of participation in GVCs, firms' market power and the choice of invoicing currency for international trade.

1 Introduction and definitions[1]

Exchange rate pass-through (ERPT) is a central parameter in models used by central banks for preparing monetary policy decisions. It refers to the degree to which a country's import, producer or consumer prices change in response to a change in its exchange rate. Specifically, it is the percentage change in prices in response to a 1% change in the exchange rate. Throughout this paper, the exchange rate series are defined in such a way that an increase represents a depreciation.[2]

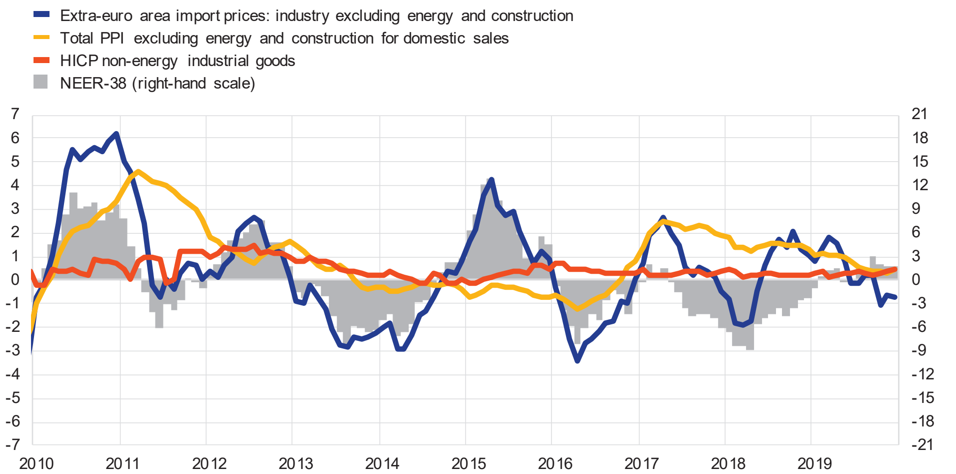
The extent and duration of the ERPT to import prices at the border and to final consumer prices is critically important for understanding the influence of the exchange rate on inflation. This is useful not only for forecasting inflation and setting monetary policy, but also for measuring the extent of expenditure switching that follows exchange rate changes, which, in turn, has an impact on real activity.

Typically, the sensitivity to the exchange rate declines along the price distribution chain: from import prices through producer prices to final consumer prices (see Chart 1). Accordingly, the ERPT to prices is defined as "incomplete" at a given horizon if prices respond less than one-to-one to exchange rate changes over that horizon.

Chart 1

Nominal effective exchange rate of the euro against 38 trading partners, import prices, the PPI and the HICP in the euro area

(year-on-year percentage changes)



Sources: Eurostat and ECB.
Notes: An increase in the exchange rate is depreciation. The latest observation is for December 2019.

ERPT can be quite different across countries that have different economic structures, e.g. in terms of openness or import structure. However, both academic discussions and policy models usually assume ERPT within a country to be linear and stable over

1 The editors thank M. Anastasatou, H. Camatte and I. Rubene for reviewing the full manuscript. We are very grateful to Luca Dedola for his comments and suggestions.

2 This is opposite to the way in which the official ECB exchange rate series are defined, but it is more intuitive for the analysis of the exchange rate impact on inflation.

time. The recent literature has challenged this linearity and stability given the fundamental economic structure of a country, based on two grounds. The first relates to a worldwide structural change: prices are sticky (especially downwards) and the effect of exchange rates on the pricing decisions of firms may have changed in a fundamental way since the globalisation shock of the early 2000s, with their increasing integration in global production networks.[3] The second relates to the fundamental drivers of exchange rate changes: in the past decade some studies have highlighted that the pass-through of exchange rate changes depends on the nature of the shock that caused the appreciation or depreciation in the first place.

This paper aims to establish fresh empirical facts about ERPT in the euro area and in EU Member States. Does it differ much across countries and, in any given country, across time? Is ERPT linear or non-linear and what form of non-linearity appears in the data, if any? Can we explain the heterogeneity across countries and time on the basis of structural characteristics and their evolution through time? Can we trace the time-varying impact of exchange rates back to the source of the macroeconomic shocks that moved the exchange rate and prices?

Moreover, this paper goes beyond this systematic empirical verification of claims and hypotheses put forward in the empirical literature. It digs deeper from the theoretical point of view into the mechanisms that link ERPT to the structural characteristics of the economy and into the nature of the shocks that at any time drive co-movement of exchange rates, prices and other macroeconomic variables. For that purpose, we use a series of structural macro models estimated for the euro area as a whole and for several individual euro area and non-euro area EU Member States.

An important contribution of this paper is its analysis of the shock-dependence of ERPT through the lens of two classes of model: (i) dynamic stochastic general equilibrium (DSGE) models, and (ii) structural vector autoregression (SVAR) models. For the sake of robustness, the results of many models of each class are compared and contrasted.

A corollary contribution is to establish more semantic discipline in the review of previous and fresh results, by clarifying the notion behind ERPT in each study. A careful look at the existing literature will reveal that such discipline is far from established. The next subsection clarifies the definitions used in the existing literature and sets out the ones consistently used throughout this paper. Section 2 reports new estimates of ERPT and compares them with existing ones, while Section 3 reviews structural factors that could explain the heterogeneity of ERPT across countries and time. Section 4 analyses in more detail the mechanisms of exchange rate transmission following various shocks using DSGE models, while Section 5 discusses the dependence of ERPT on shocks through the lens of SVAR models, elaborates on the robustness of results across models, compares the results with those from the DSGE models, and presents some cross-country results on shock-dependence. Section 6 draws implications of the results for monetary policy. Finally, Section 7 draws implications for the tools used in the monetary policy process and concludes.

3 The main argument is that higher integration in global supply chains brings the simple model of ERPT as a (constant) mark-up on domestic production costs far from reality, as inputs to production are also a bundle of domestic and foreign goods, which depends on multilateral exchange rates in a complex manner.

1.1 Definitions and alternative methods of quantifying ERPT

The largest branch of the literature focuses on a "structural" definition of ERPT arising from a pricing equation at the firm level or aggregated up to product, sector or country-level prices or inflation. This is what this paper will refer to as ERPT.

Papers in this branch of the literature often estimate a simple pricing equation, in which the considered price index (or its growth rate) is regressed on the exchange rate and some control variables. In its simplest structural form, in micro studies on individual goods prices, $P_{i,t}^F$ is the border price of a continuum of tradable goods $i \in (0,1)$ invoiced in the importer's currency. This border price is a function of the exporter's marginal cost and of the exchange rate: $P_{i,t}^F = f(mc_{i,t}^*, s_t)$. The corresponding aggregate import price level is given by

$$P_t^F = \left(\int_0^1 \left(P_{i,t}^F\right)^{1-\theta_F} di \right)^{\frac{1}{1-\theta_F}} \tag{1}$$

where θ_F is the elasticity of substitution across varieties of imported foreign tradable goods.

Correspondingly, and assuming that oil prices P_t^{oil}, expressed in domestic currency, and hence also affected by the exchange rate, represent the importance of commodity prices in production, the price of each domestically produced good j can be expressed as $P_{j,t}^H = h(mc_{j,t}, P_t^F, P_t^{oil})\ \forall j \in (0,1)$ and the corresponding aggregate producer price level is given by

$$P_t^H = \left(\int_0^1 \left(P_{j,t}^H\right)^{1-\theta_H} dj \right)^{\frac{1}{1-\theta_H}} \tag{2}$$

where θ_H is the elasticity of substitution across varieties of domestic tradable goods.

If we consider that consumption bundles are a combination of imported and domestically produced goods, the log-linearised consumption price index may be represented by a weighted average

$$\hat{p}_t^C = \phi_{oil}\hat{p}_t^{oil} + \phi_c^m \hat{p}_t^F + (1 - \phi_{oil} - \phi_c^m)\hat{p}_t^H \tag{3}$$

Note that ϕ_c^m can be directly associated with the structure of the economy. On the one hand, it tends to be larger for more open economies. On the other hand, the more the economy is engaged in international production-sharing, the lower the ϕ_c^m, as the price of imports intervenes indirectly in the consumption price index through the domestic production sector.[4] The channel through which imports enter the

[4] Interestingly, OECD data show that there is a strongly positive correlation between the import content of exports and trade openness, such that the direct impact of import prices on consumption prices is not necessarily larger for very open economies than for economies relying less on international trade (see de Walque et al. (forthcoming)).

consumption basket is essential to determining the profile of the exchange rate transmission to consumer prices.

A natural extension of equation (1), in the spirit of Burstein et al. (2003) and Corsetti et al. (2008) for example, is that the retail price of the internationally tradable good P_t^{Fr} is different from the border price P_t^F because of a wedge caused by local distribution costs:

$$\hat{p}_t^{Fr} = \hat{p}_t^F + \eta \hat{p}_t^N \qquad (4)$$

where $\eta > 0$ is a non-tradable bundle used to distribute the tradable good to the domestic consumers and firms, and P_t^N is its price.

In empirical studies using macroeconomic data, the impact of exchange rate changes on aggregate inflation is analysed using a distributed lag equation of this form:

$$\Delta p_t^z = \alpha + \sum_{k=0}^{K} \beta_k \Delta s_{t-k} + \sum_{k=0}^{K_r} \sum_{r=1}^{R} \gamma x_{rt-k} + \varepsilon_t \text{ with } z \in (F, Fr, C) \qquad (5)$$

where s_t is the exchange rate (nominal effective or bilateral), x_{rt} are *R* control variables and K is the maximum lag length. This applies to any import, producer, consumer or any other aggregate price. Lags of the left-hand-side inflation variable can also be added as explanatory variables, giving rise to autoregressive distributed lag specifications. The ERPT at any horizon h is measured by the (cumulative sum of the) coefficients of the exchange rate:

$$ERPT_h^z = \sum_{k=0}^{h} \beta_k \text{ where } z \in (F, Fr, C) \qquad (6)$$

The same equation with a full lag structure is identical to an inflation equation in a vector autoregression (VAR). Hence, when estimated using VARs, ERPT is defined as an impulse response.

When defined as a cumulative sum of coefficients or as an impulse response, the ERPT is the difference between the dynamic path of prices (or inflation) with and without the exchange rate change. This formulation allows a distinction to be made between short-run or impact pass-through and long-run pass-through, which empirically is typically set at two to three years. This measure of ERPT applies under the ceteris paribus condition, i.e. keeping other explanatory variables (for example, production costs) constant. Both in dynamic single equations and in VARs, ERPT at any given horizon is defined as the impulse response of inflation to the exchange rate “shock”. In single equations, this “shock” is not structurally identified but assumed to be exogenous by ensuring that there are no relevant omitted variables in the regression; in VARs it is identified using various schemes.

Following the structural modelling analysis by Corsetti and Dedola (2005) and the VAR approach by Shambaugh (2008), a recent branch of the empirical literature has investigated the shock-dependence of ERPT, i.e. the fact that the nature of the shocks causing the exchange rate to move affects the extent of their pass-through to prices. Intuitively, the nature of the shocks driving the exchange rate plays an important role in the propagation of the impact. Forbes et al. (2018), as well as Comunale and Kunovac (2017), recently used this type of approach in SVARs where not only the exchange rate shock, but also other shocks such as monetary policy, demand and supply were identified by sign and zero restrictions. This is a clear improvement in terms of more credible identification, compared with the earlier VARs often identified by recursive Cholesky structures (see, for example, Hahn (2003)). However, these models pose a new challenge in terms of interpretation, as already raised by Shambaugh (2008) who pioneered this strand of the empirical ERPT literature: while the pass-through to inflation following an exogenous exchange rate shock is clearly defined in terms of the impulse response, what is the pass-through after a monetary policy or a demand shock? Quantitatively, the methodology for computing the pass-through proposed originally by Shambaugh (2008) can be described as follows. Consider a shock *i* at time *t* that moves both the exchange rate and the inflation rate: the "pass-through" is computed as the ratio of the total (cumulative) effect of shock j on price p over the total (cumulative) effect of the same shock on the exchange rate s in the form of a price-to-exchange-rate ratio (PERR) such as:

$$PERR_{j,h}^{z} = \frac{\sum_{t=1}^{h} IRF_j(\Delta p_t^z)}{\sum_{t=1}^{h} IRF_j(\Delta s_t^z)} = \frac{IRF_j(p_t^z)}{IRF_j(s_t^z)} \text{where } z \in (F, Fr, C) \tag{7}$$

However, calling this ratio "ERPT" may lead to the misunderstanding that it is the same object defined in (6). In fact, whenever the shock j is not an exchange rate shock, the impact no longer reflects only the exchange rate changes, because equation (7) measures the co-movement of prices and exchange rates via the various channels of transmission of, for example, a demand or monetary policy shock. This transmission is analysed in depth in Section 4; for now, it suffices to clarify that **throughout this paper, we will refer to the definition in (6) as ERPT and to the definition in (7), i.e. the response of prices relative to that of the exchange rate after any shock, as the PERR.**

The idea of looking at the effect of exchange rate changes on prices as being conditional on the economic shocks that drive the macroeconomic conditions is analogous to the progress made by the literature on the impact of oil prices on inflation and real activity, in that both academics and policymakers found it necessary to ascertain whether oil price changes were driven by supply or demand shocks in order to understand and predict their impact on the economy.

Both ERPT and PERR measures are useful for assessing the relationship between exchange rates and prices and complement each other. This is suggested by the theoretical literature modelling pass-through and is detailed in Section 4 on structural macroeconomic models. It shows that both a country's structure (at the industry and the macro level) and the shocks underlying an exchange rate movement (see Forbes et al. (2017)) play an important role. A system approach, in SVAR or structural DSGE macro models, can disentangle exogenous shocks from changes in the exchange rate. As the latter is not really exogenous to monetary policy shocks for example, with the system approach it is possible to evaluate the monetary policy and other feedback effects on the impact of exchange rate changes on prices in a given economic situation.

In the literature, analysis using SVARs and DSGEs relies mainly on aggregate price indices data. Such indices have a distinct advantage in that they are closely related to the key concerns of monetary policymakers. However, there is a disadvantage to using aggregate data, in that they are likely to generate an "aggregation bias" in ERPT, associated with aggregating up to individual sub-sectors or good-level prices.[5] Possibly large and persistent heterogeneity in sector-specific price adjustments introduces an error when estimating ERPT on the basis of aggregate data. For example, it is known that services prices are stickier than goods prices and that raw goods prices are more flexible than processed goods prices (see Klenow and Malin (2010), Berger et al. (2017)). This could imply different dynamics in the impact of exchange rate changes on these sub-indices of consumer prices.

The aggregation bias should affect to a much lower extent, if at all, the results of **a third branch of the literature on ERPT, based on disaggregated analysis (at industry, firm or product level), which has the advantage of capturing the dynamics of the transmission of exchange rate changes to prices more accurately**. However, it has the disadvantage that models typically used for these studies are "restricted", as they are usually based on a static single equation approach that leaves out dynamic price adjustment and assumes exogeneity of the exchange rate (thus, neglecting monetary policy and other feedback effects).

All approaches (single equation, shock-based and structural estimates from fully fledged models) could and should be used, in a synergic and systematic way to explain empirical differences in ERPT, both across countries and over time.

At the same time, when looking at the results of each individual study, it should be borne in mind that they may be referring to very different definitions of ERPT, implying that one should exercise caution in deriving implications for one definition (and its applicability to a given policy question) on the basis of estimates based on other definitions.

The next section summarises the empirical contributions to the first two strands of the literature, with a particular focus on results for the euro area.

5 For a discussion on the problem of aggregation bias, see, for example, Lee et al. (1990), Imbs et al. (2005) and Imbs and Méjean (2015).

2 Empirical estimates of ERPT for the euro area and Member States

The empirical literature on ERPT based on the simple definitions given in equations (6) and (7) is very extensive. However, results for the euro area are rather scarce, owing in part to the length of the time series availability, i.e. only as of 1999. More findings are available for individual euro area countries for which longer time series are available. It is somewhat easier to estimate the ERPT to import prices than that to consumer prices because there is no need to model and capture the complicated domestic pricing chain mechanism, which can have a significant impact on the ERPT to consumer prices. However, possibly owing to data availability, studies on import prices often focus on trade in goods and exclude trade in services.

A number of caveats should always be kept in mind when comparing these estimates. First, the measures of import prices and consumer prices differ across various studies for various reasons. In terms of import prices, a choice needs to be made whether to consider trade in goods only or in goods and services. When studying euro area countries, an issue of particular importance is whether to use total or extra-euro area definitions for the data. The size of the estimated ERPT to import prices for the euro area and its member countries will differ whether or not intra-euro area imports are included. The exchange rate chosen for the analysis may also differ: some studies look at bilateral exchange rates, others at nominal effective exchange rates (NEER) calculated against various reference groups of trading partners. For the euro area as a whole, the most commonly used measure is the NEER of the euro calculated against

Table 1

Empirical estimates for the ERPT to import and consumer prices for the euro area

(percentage impact (after four quarters) following a 1% depreciation in the euro nominal effective exchange rate)

Study	Sample period	Methodology	ERPT to total import prices (extra plus intra)	ERPT to consumer prices
Hahn (2003)	Q2 1970-Q2 2002	Difference VAR (Cholesky)	0.70	0.09
Hahn (2003) – update	Q1 1997-Q4 2016	Difference VAR (Cholesky)		0.04
Landolfo (2007)	Q1 1970-Q4 2003	Dynamic simultaneous equation	0.58	0.09
Gaggl (2009)	M1 2000-M12 2007	VAR (Cholesky)	Up to 0.6	< 0.1
Comunale (2015)	Q1 1994-Q4 2014	Dynamic factor model (panel)		0.04 – 0.09*
Özyurt (2016)	Q1 1996-Q2 2015	Single equation time series	0.45**	-
Comunale and Kunovac (2017)	Q1 1992-Q2 2016	Bayesian VAR with sign restrictions	0.3	0-0.05
Ben Cheikh and Rault (2017)	Q1 1990-Q4 2013	Dynamic panel with system GMM	0.6-0.8	-
Colavecchio and Rubene (2020)	Q1 1997-Q1 2019	Local projections (linear)	0.33 (0.68**)	0.04
Author calculations	Q2 1997-Q4 2019	Time-varying estimate using Bayesian single equation	0.22 (Q1 1999-Q4 2019 average)	0.01 (Q1 2000-Q4 2019 average)

Source: Authors' compilation.
Notes: In the literature, the euro area may represent a smaller number of countries than in the current composition.
* Impact after one quarter; ** Extra-euro area import deflator.

Table 2

Empirical estimates for the ERPT to import and consumer prices for the largest euro area countries

(percentage impact in the short run (after four quarters) following a 1% depreciation)

Study	Sample period	Methodology	DE	FR	IT	ES	Other
Hüfner and Schröder (2003)	M1 1982-M12 2000	VECM (Cholesky)	CPI:0.06	CPI:0.08	CPI:0.08	CPI:0.08	NL CPI: 0.13
Choudhri et al. (2005)	Q1 1979-Q3 2001	VAR (sign restrictions)	CPI: 0.20	CPI: 0.10	CPI: 0.14		
Shambaugh (2008)	Q1 1973-Q4 1999	Difference VAR (sign restrictions, LR)	CPI: 0.37				
Goldberg and Campa (2010)	Q1 1976-Q4 2004	Single equation time series	CPI: 0.07 IP: 0.80	CPI: 0.48 IP: 0.98	CPI: 0.03 IP: 0.35	CPI: 0.36 IP: 0.70	NL: CPI 0.38; IP 0.84 BE: CPI 0.08; IP 0.68
Özyurt (2016)	Q1 1996-Q2 2015	Single equation time series	IP: 0.52**	IP: 0.68**	IP: 1.42**	IP: 0.81**	NL IP:0.55**
Comunale and Kunovac (2017)	Q1 1992-Q2 2016	Bayesian VAR with sign restrictions	IP: 0.3	IP: 0.2	IP: 0.4	IP: 0.3	-
Ben Cheikh and Rault (2017)	Q1 1990-Q4 2013	Dynamic panel with system GMM	IP: 0.38*	IP: 0.37*	IP: 0.59*	IP: 0.55*	NL IP: 0.40* BE IP: 0.43*
Colavecchio and Rubene (2020)	Q1 1997-Q1 2019	Local projections (linear)	HICP: 0.06 IP: 0.54 (0.64**)	HICP: 0.03 IP:0.34 (0.39**)	HICP: 0.05 IP: 0.63 (0.99**)	HICP: 0.09 IP: 0.54 (0.94**)	NL HICP: 0.05 BE HICP: 0.05
Author calculations	Q2 1997-Q4 2019	Time-varying estimate using Bayesian single equation	HICP: 0.05 (Q1 2000-Q4 2019 average)	HICP: 0.03 (Q1 2000-Q4 2019 average)	HICP: 0.04 (Q1 2000-Q4 2019 average)	HICP: 0.09 (Q1 2000-Q4 2019 average)	

Source: Authors' compilation.
Notes: Unless otherwise specified, "ERPT to import prices" (IP) refers to total imports (intra plus extra-euro area). In Comunale and Kunovac (2017), ERPT to HICP inflation is always very close to zero.
* Impact after one quarter; ** Extra-euro area import deflator.

38 or 19 trading partners, whereas for individual euro area countries sometimes the NEER, which also includes trade with other euro area countries, is used.[6] Furthermore, ERPT to import and consumer prices takes time to materialise. Therefore, the results should be compared at similar time horizons. Finally, as shown later, the profile and intensity of the transmission can change over time, potentially leading to different results depending on the time period used in the analysis.

An undisputed finding in the empirical literature is that ERPT declines along the pricing chain. It is highest and fastest for import prices at the border, but significantly smaller and relatively slower for final consumer prices. Table 1 reports available studies for the euro area, based on different sample periods: a 1% depreciation in the euro effective exchange rate raises total import prices (including intra-euro area trade) within one year by 0.3% to 0.8%. It declines along the pricing chain and has a less than 0.1% upward impact on headline HICP inflation.

The updated estimates in this paper find that ERPT to consumer prices is around one-tenth of that to import prices. Empirical evidence from reduced-form models suggests that a 1% depreciation in the euro raises total import prices in the euro area and its member countries, on average, by around 0.30% within a year, and headline

6 For information on the methodology, see Schmitz et al. (2012) and for information on revised trade weights, see "Revised trade weights for the effective exchange rates of the euro reflect the increasing importance of emerging market economies", *Economic Bulletin*, Issue 6, ECB, 2015.

HICP inflation by around 0.03% (ranging from -0.06% to 0.17%). Both estimates lie on the low side of the range of those found in the literature. For non-euro area EU Member States, the ERPT to consumer prices is of a similar magnitude, while that to import prices is somewhat higher (between 0.4% and 0.8%).

Available empirical evidence for the largest euro area countries confirms that the ERPT, as expected, is much larger for import prices than for consumer prices. It can differ substantially across countries (see Table 2). However, cross-study comparisons are complicated for the reasons outlined earlier, especially with regard to the choice of exchange rate measure and the sample coverage.

The estimations conducted for this paper found that ERPT to consumer prices (measured by the HICP) in the largest euro area countries is similar to that for the euro area as a whole (except for Spain, where it seems to be closer to 0.1%). The ERPT to import prices is more heterogeneous, in some cases exceeding that of the euro area as a whole.

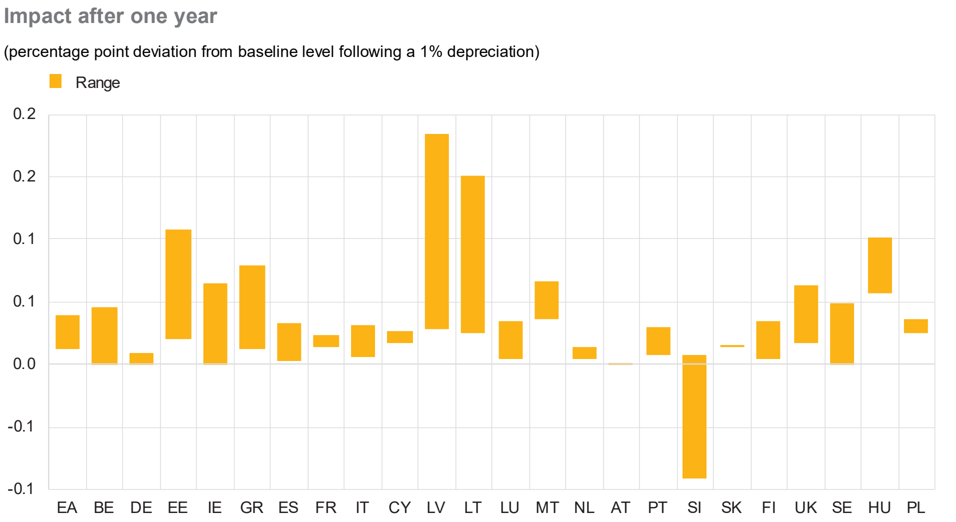
The next subsections report estimates of the ERPT obtained over a similar sample and using the same measures and specifications for all EU Member States, adopting a variety of approaches.

2.1 New simple reduced-form estimates of ERPT

Simple reduced-form estimates for euro area and non-euro area EU Member States produced for this paper suggest that the ERPT to consumer prices varies across countries (see Chart 2). Generally, the ERPT estimates are very small, increase over the time horizon, are often not significantly different from zero and are very sensitive to the equation specification. Bearing in mind this caveat on the sensitivity to the exact specification, a 1% depreciation in the euro NEER after four quarters leads to an upward impact on euro area headline HICP inflation of between 0.01% and 0.04%. Small and open economies tend to show somewhat larger ERPT,

Chart 2

ERPT to consumer prices for EU Member States



Source: Authors' calculations.
Notes: The results are obtained using data for the period from the first quarter of 1999 to the third quarter of 2017 for individual countries and to the fourth quarter of 2017 for the euro area as a whole. The ERPT was estimated using log-linear regression models, with log differences in the seasonally and working-day adjusted headline HICP as the dependent variable. The country-specific extra-euro area NEER was used for the euro area countries and the national NEER was used for the non-euro-area EU Member States.

while the results for the euro area and its largest economies (Germany, France, Italy and Spain) suggest a very small exchange rate impact on consumer prices. The reduced-form estimates for HICP inflation excluding food and energy are somewhat smaller than for headline inflation. The large sensitivity of the results to the chosen specification in each country, even within a common methodology, suggests that simple reduced-form equations for many euro area countries and some EU Member States should not be used in isolation to analyse ERPT to final consumer prices, but be complemented by more complete structural macroeconomic models that better capture various stages of the domestic pricing chain.

2.2 Time variation in ERPT

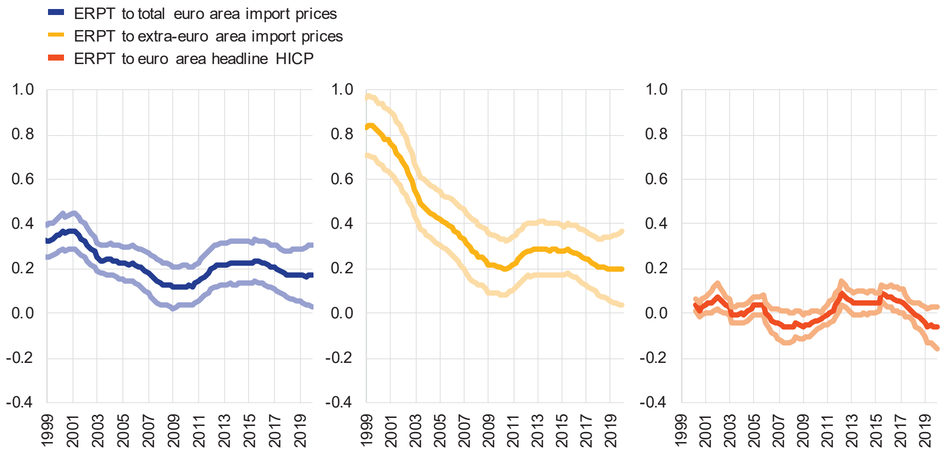
The literature has documented a fall in ERPT to import and consumer prices since the 1980s and 1990s (see, for example, Campa and Goldberg (2008)). Time-varying estimates computed for this paper show that, in the euro area, the ERPT to total import prices has been broadly stable over time (at around 20%, see the left panel of Chart 3). However, when decomposing import prices into the intra-euro area and extra-euro area components, the estimates for the euro area show **that ERPT to extra-euro area import prices declined from around 0.8% in 1999 to around 0.3% in 2008 and has remained broadly unchanged since** (see the middle panel of Chart 3).

The ERPT to euro area consumer prices estimated with this method has hovered around zero for most of the estimation sample, only occasionally showing significance (see the right-hand panel of Chart 3). The very low ERPT to consumer prices is consistent with what is found in the literature.

Chart 3

Time-varying ERPT to extra- and intra-euro area import prices and euro area consumer prices

(percentage impact on prices after four quarters following a 1% change in the effective exchange rate; defined as increase = depreciation)

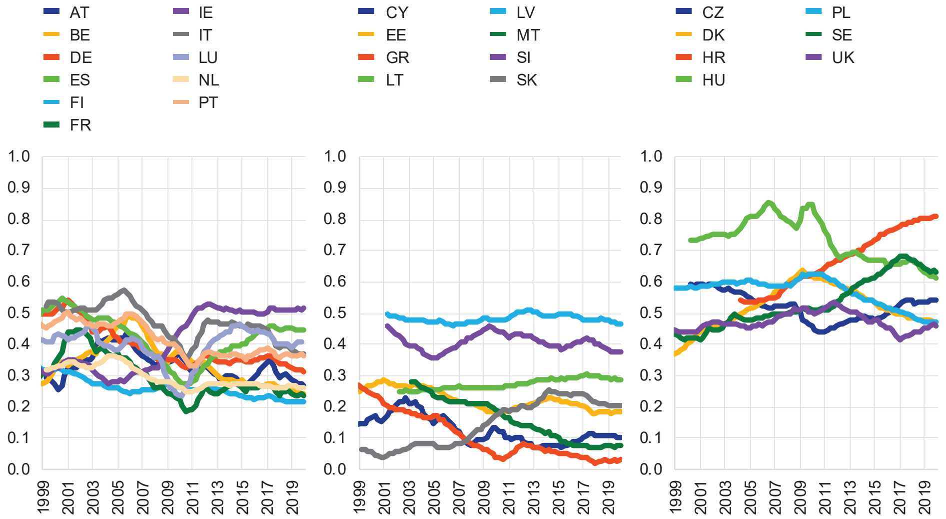


Source: Authors' calculations.
Notes: The time-varying ERPT to import and consumer prices is estimated using single equation regressions with drifting coefficients and stochastic volatility. Data are from the late 1990s to the fourth quarter of 2019. The solid line shows the median and the lighter lines show a credibility interval as given by the 16th and 84th percentiles of the posterior distribution.

Chart 4

Time-varying ERPT to total import prices in the euro area and non-euro area EU Member States

(percentage impact after four quarters (median) following a 1% change in the effective exchange rate (extra-euro area for euro area countries); defined as increase = depreciation)

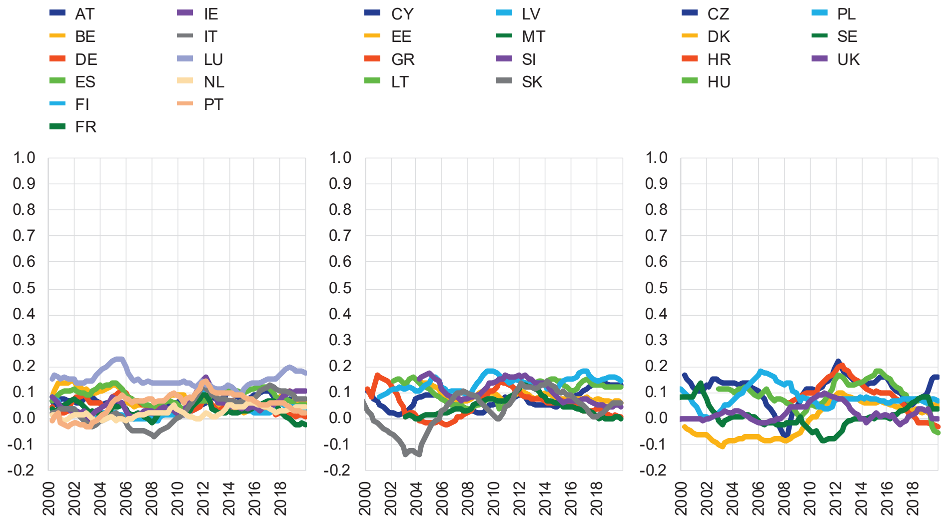


Source: Authors' calculations.
Notes: Estimates for Bulgaria and Romania are not available. The time-varying ERPT to import prices (measured by the imports of goods and services deflator) is estimated using single equation regressions with drifting coefficients and stochastic volatility. Data are from the late 1990s to the fourth quarter of 2019.

Chart 5

Time-varying ERPT to consumer prices in the euro area and non-euro area EU Member States

(percentage impact after four quarters (median) following a 1% change in the effective exchange rate (extra-euro area for euro area countries); defined as increase = depreciation)



Source: Authors' calculations.
Notes: Estimates for Bulgaria and Romania are not available. The time-varying ERPT to consumer prices (measured by the HICP) is estimated using single equation regressions with drifting coefficients and stochastic volatility. Data are from the late 1990s to the fourth quarter of 2019.

Time-varying estimates for the euro area countries and for non-euro area EU Member States show that the ERPT to total import prices and to consumer prices has been broadly stable since the end of the 1990s and lower than

estimates obtained in the literature for earlier decades (see Chart 4).[7] The level of ERPT to total import prices for goods and services (intra- plus extra-euro area) is very heterogeneous across countries: it is highest in Ireland, Latvia and Spain (between 40% and 50%), relatively high in Slovenia, Luxembourg, Portugal, Italy, Lithuania and Austria (around 30%-40%), but lower in Germany, Belgium, Finland, the Netherlands and France (around 20%-30%); estimates for other euro area countries are below 20%. The estimates for euro area countries are lower compared with those for the non-euro area Members States because import prices include intra-euro area imports, which are denominated in euro. The ERPT to total import prices is considerably higher in the non-euro area EU Member States: between 70% and 80% in Hungary, Croatia and Sweden, and 40%-50% in other countries (see the right panel of Chart 4).

The ERPT to the headline HICP is significantly smaller than that to import prices for almost all countries. The ERPT to consumer prices for most countries seems to have been generally low and stable (see Chart 5). Section 3 discusses the main determinants of the differences in ERPT across countries and time periods.

2.3 Non-linearity in ERPT

A strand of the literature has argued that ERPT may be non-linear. It may differ between depreciations and appreciations, large and small changes, the state of the economy – in terms of business cycle or the level of inflation. These aspects may affect the ERPT to import prices and consumer prices, albeit to different extents.

A number of factors may trigger a non-linear response of import or consumer prices to exchange rate changes. The price response to depreciations and appreciations may differ if firms face binding quantity constraints for production and/or distribution networks. It may also differ depending on the firm's market share strategy, partly determined by the competitive structure of the sector and market power of firms (see Delatte and López-Villavicencio (2012)). The cyclical state of the economy may also matter. In times of weak demand, firms may want to protect their market shares and the ERPT following depreciations may be lower; whereas following appreciations, firms may want to rebuild profits by increasing their mark-ups. Low inflation may also reduce ERPT (see Taylor (2000)).[8] Price rigidities (owing, for example, to the presence of menu costs) imply that ERPT could be larger following large exchange rate changes.

Empirical evidence on non-linear ERPT for the euro area is scarce, but country findings suggest that ERPT may depend on the direction of change. Some studies also point to higher ERPT after large exchange rate changes. For import prices, the ERPT tends to be higher after depreciations (and/or high depreciations) than after appreciations in Germany and France (see Berner (2010) and Bussière

---

7 Romania and Bulgaria are missing owing to limited data coverage. These reduced-form estimates find little persistence in the impact on prices of changes in the exchange rate, with substantially lower ERPT at longer horizons.

8 Empirical evidence that lower inflation has had a negative impact on ERPT is provided by Gagnon and Ihrig (2004), Ben Cheikh (2012a) and Jašová et al. (2016); Ben Cheikh et al. (2018) find that, for some euro area countries, ERPT is higher during expansions than recessions.

(2013)).[9] Campa et al. (2008) find that, after a deviation from long-run equilibrium, import prices adjust more quickly after a home currency appreciation than a depreciation, whereas there is no adjustment if the deviations are small. Evidence for consumer prices has been mixed across countries (see Delatte and López-Villavicencio (2012) and Ben Cheikh (2012b; 2012a)). Ben Cheikh (2012b) finds a higher ERPT to consumer prices after large exchange rate changes.[10] New evidence is provided by Colavecchio and Rubene (2020), who examine asymmetry in ERPT for the euro area and its member countries. Using the local projection method proposed by Jordà (2005), they obtain the dynamic responses of prices to exchange rate changes from a single equation which relates inflation to exchange rates, also controlling for competitors' export prices and a measure of slack (output gap or the unemployment rate).

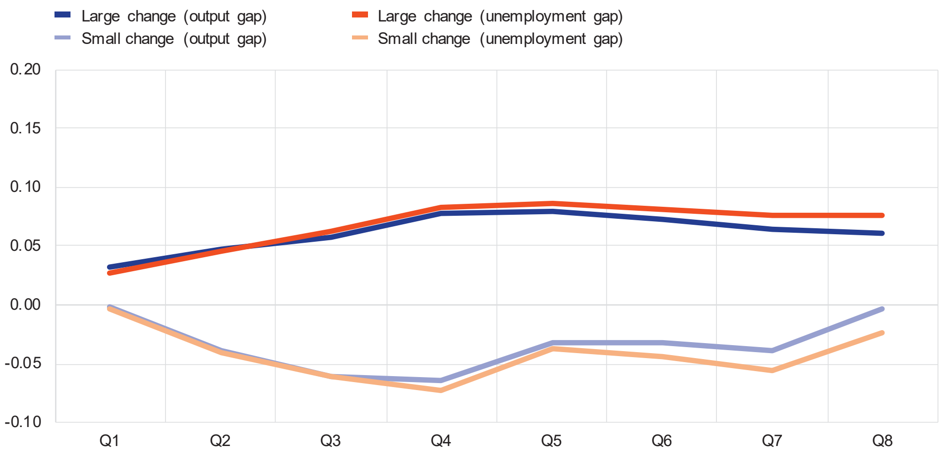
For the euro area, Colavecchio and Rubene (2020) find that, after one year, large changes in the exchange rate have an impact on import prices and headline HICP inflation, whereas small ones do not. The threshold for "large" exchange rate changes is defined as one standard deviation away from the mean (for the euro area, it is a 2.3% quarter-on-quarter change). After large changes, the ERPT to extra-euro area import prices reaches around 0.9 percentage points after one year, whereas after small changes, the impact is only statistically significant in the first quarter. The ERPT to consumer prices after large changes reaches 0.08 percentage points within one year, whereas small changes do not have an impact (see Chart 6 and Chart 7). The evidence for size non-linearity (i.e. only large changes matter) for the headline HICP

Chart 6

Euro area: ERPT to the headline HICP

Estimates using local projections

(percentage impact after a 1% change in the effective exchange rate; defined as increase = depreciation; large change defined as a 2.3% quarter-on-quarter change)



Source: Colavecchio and Rubene (2020).
Notes: The chart shows the impact estimated with two single equation specifications: with the output gap and the unemployment gap. The ERPT after large changes are significantly different from zero for eight quarters at a 5% significance level; after small changes, the ERPT is not significantly different from zero.

9 Demian and Di Mauro (2015), analysing only export volumes, find an asymmetry in ERPT: export volumes seem to react to appreciations, but not to depreciations.

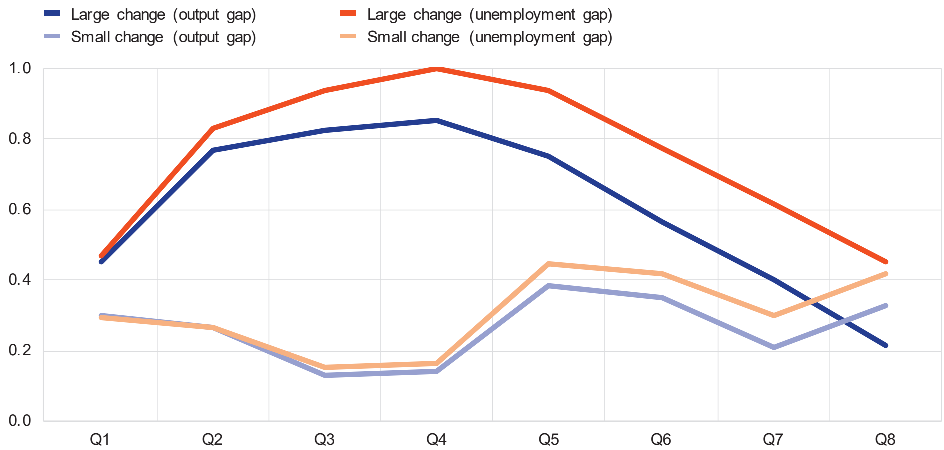
10 The countries with significantly higher ERPT for large exchange rate changes are Belgium, Germany, Spain, Finland, France, Greece, Italy, Luxembourg and the Netherlands.

Chart 1

Euro area: ERPT to extra-euro area import prices

Estimates using local projections

(percentage impact after a 1% change in the effective exchange rate; defined as increase = depreciation; large change defined as a 2.3% quarter-on-quarter change)



Source: Colavecchio and Rubene (2020).
Notes: The chart shows the impact estimated with two single equation specifications: with output gap and the unemployment gap. The ERPT after large changes is significantly different from zero for all horizons; after small changes, the ERPT is statistically different from zero only at the impact (i.e. first quarter) at a 5% confidence level.

and import prices is consistent with sticky prices. **No evidence is found for the euro area for sign non-linearity (i.e. different ERPT for depreciations and appreciations),** which is in line with what Lane and Stracca (2018) found for the real exchange rate in the euro area.

At the country level, Colavecchio and Rubene (2020) find mixed evidence of non-linear ERPT. Some larger euro area countries display significantly larger ERPT to import prices following euro appreciations than depreciations, but only at shorter horizons. The price response to large and small exchange rate movements is also rather heterogeneous and country-specific.

2.4 Sectoral level ERPT for the euro area import prices

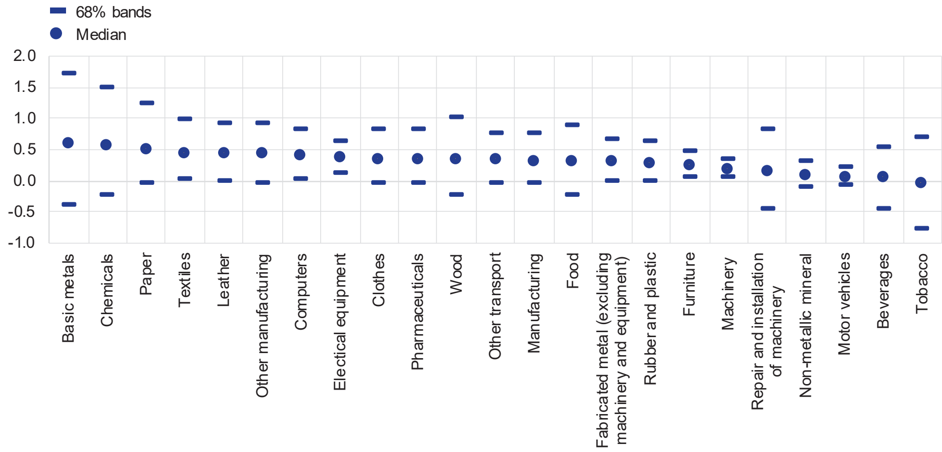
The ERPT across countries varies not only at a macro level, but also across various sectors. ERPT to import prices is found to be higher for energy products than for manufacturing products (see Campa and Goldberg (2008) and Ben Cheikh and Rault (2017)), as exporters appear to price-discriminate to a larger extent between markets for manufacturing goods than those for commodities (see Campa et al. (2005)). Updating earlier work, Osbat et al. (2019) estimate the ERPT to import prices in the euro area manufacturing sectors using VAR models with some exogenous variables. Consistent with other findings (see Imbs and Méjean (2015)[11]) and with the caveat of very large confidence bands, they find that the ERPT to import prices can vary quite substantially across industrial sectors (see Chart 8). Product characteristics are also found to play a role in the ERPT to producer prices. Among the subsectors of

[11] The paper finds that estimated elasticities at the sector level are heterogeneous and much higher than elasticities estimated at the aggregate level, which might fail to properly capture good-level heterogeneity and hence be downward-biased.

Chart 8

Euro area manufacturing sector-level ERPT to import prices of goods

(percentage point impact after a 1% depreciation in the euro nominal effective exchange rate)



Source: Osbat et al. (2019).
Note: Import prices refer to total euro area imports (intra plus extra).

the industrial sector (excluding construction), the ERPT is largest in electricity, gas and water supply, as well as in the energy sector, but the lowest for capital goods (see Hahn (2007)). In what follows, Section 3 reviews the main structural determinants and their role in explaining the differences in the ERPT across countries, sectors and time periods.

3 Heterogeneity in ERPT across countries, sectors and time periods: structural characteristics

This section investigates the main structural factors that could explain the heterogeneity in ERPT. These factors include the structure of the economy, the microeconomic structure and behaviour of firms, and the general macroeconomic environment. More specifically, this section looks at trade openness and import penetration (Section 3.1), integration into GVCs (Section 3.2), the degree of competition and market concentration (Section 3.3), and the currency of invoicing (Section 3.4).

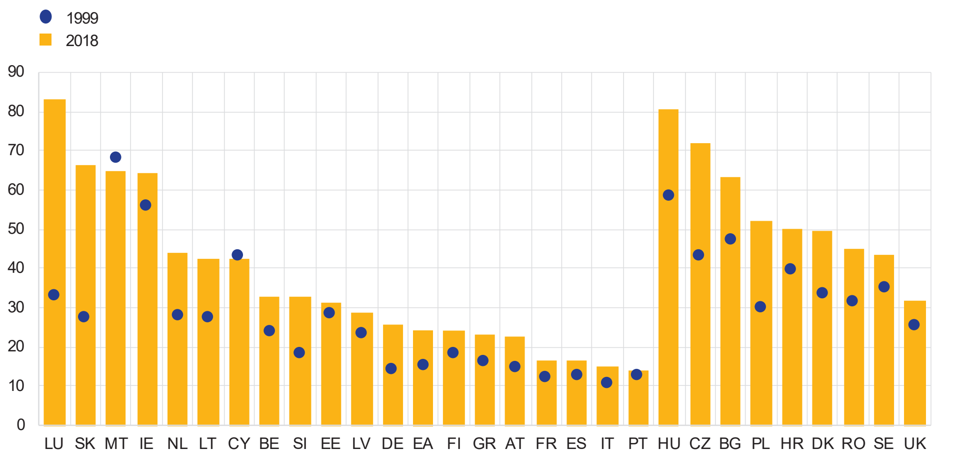
3.1 Trade openness

The degree of openness of the economy when measured as the import share in GDP is one of the first factors to consider when analysing ERPT. The larger a country's openness to imports, the higher, potentially, the impact of the exchange rate on import and consumer prices. Across the euro area, the openness to trade with non-euro area EU Member States differs substantially (see Chart 9). In smaller countries, it is significantly higher, whereas for larger countries and countries whose trade is concentrated with euro area partners (such as Greece and Portugal) the openness is smaller.[12] Compared with 1999, in most countries the importance of trade with countries outside the euro area has increased, most likely partly reflecting progress in trade liberalisation and an increase in participation in

Chart 9

Imports of goods and services share in GDP

(extra-euro area imports for euro area countries; total imports for non-euro area EU Member States; based on nominal values as a percentage)



Sources: Eurosystem projections database, Eurostat.
Note: Data for Malta refer to 2004 instead of 1999.

[12] Data for Ireland and Malta could be distorted upwards by the presence of multinationals.

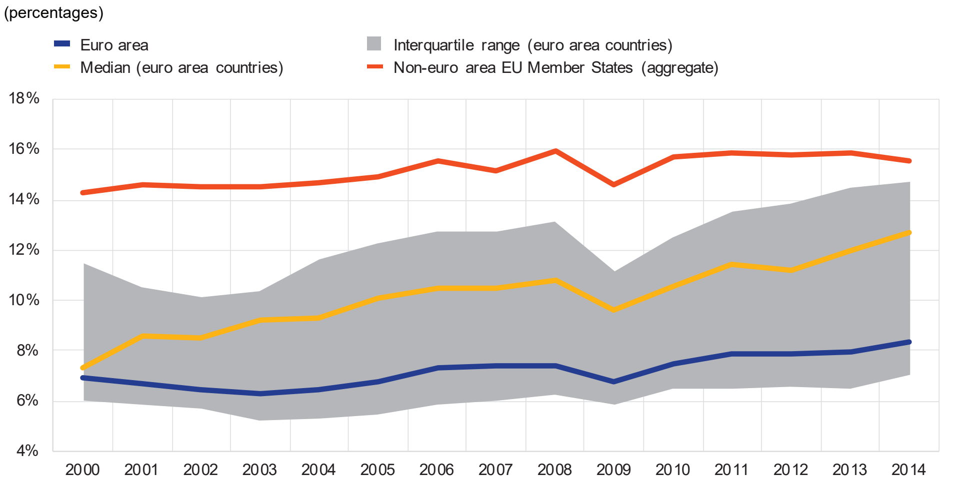
GVCs. Only in Malta and Cyprus has the share declined, reflecting faster-growing trade with other euro area countries.

Heterogeneity in ERPT to consumer prices both within and across countries is related to the differences in foreign product content in domestic consumption. The commonly used measure of openness (share of imports in GDP) is very broad and applies to the whole economy. For the purpose of understanding the difference in ERPT to consumer prices, it is better to focus on private consumption. An appropriate measure of the import content of private consumption can be obtained from input-output tables. A simple gauge of ERPT to consumer prices is given by the share of imported goods in the total consumption bundle: in general, the higher a country's import share in consumption, the higher the ERPT to its consumer prices.[13] As indicated in equation (3), this import content encompasses final consumer products and foreign inputs such as oil, other commodities and intermediate parts used in the production of domestic consumer products.

Direct import content of consumption for euro area countries, as measured by the share of private consumption, is relatively small, but it has increased over time and varies across countries. Developments in trade liberalisation, lower trade costs and the standardisation of production have boosted cross-border trade flows and fostered the organisation of production in cross-border production chains. Consequently, the share of imported (extra-euro area) consumer products in euro area consumption started to increase in the early 2000s. The import share in consumption has increased since 2000 in 13 out of 19 euro area countries and has stabilised at levels just above 8% for the euro area as a whole (see Chart 10).[14] However, the aggregate figure masks substantial cross-country heterogeneity, with small open economies in the euro area and non-euro area EU Member States posting higher import content of consumption (see Chart 11).

Chart 10

Direct import content in private consumption over time



Sources: World Input-Output Database (2016 release) and ECB calculations.
Note: Extra-euro area imports for the euro area countries; total imports for non-euro area EU Member States.

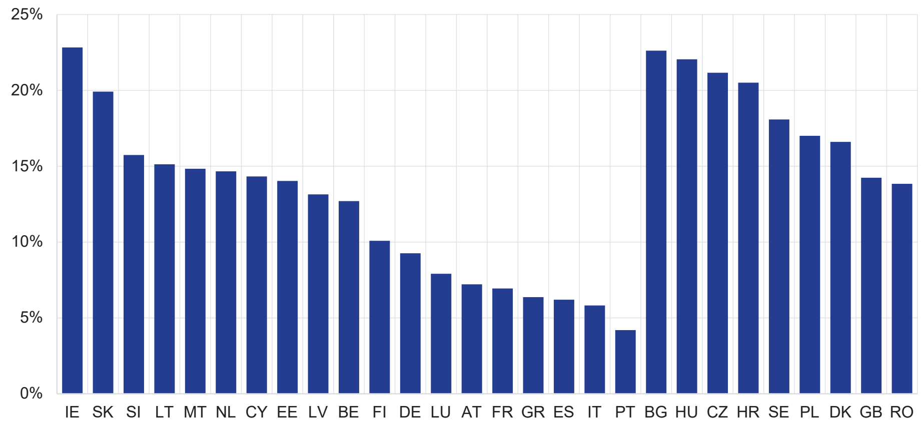
13 See Burstein et al. (2005) and Gopinath (2015).

14 The figures can be considered a lower bound, as they only take into account what is directly imported as final goods and do not include the value of imported inputs used in domestic production of final goods.

Chart 11

Direct import content in private consumption – EU Member States

(percentages; 2014)



Sources: World Input-Output Database (2016 release) and ECB calculations.
Note: Extra-euro area imports for the euro area countries; total imports for non-euro area EU Member States.

When also accounting for indirect import content of consumption, i.e. foreign value added in domestically produced consumer goods, the total import content of private consumption in the euro area was around 16% in 2014. Similarly to the direct content, the indirect import content has slightly increased over time, but differs substantially across euro area countries (see Box 1, which reports measures of total import content – direct and indirect – calculated at the industry level and for various consumption goods categories). Overall, the increase in total import content of private consumption would suggest that ERPT has risen in recent years.

Box 1

Import share in the HICP consumption basket

Prepared by Stefan Schaefer (Deutsche Bundesbank)

Estimates of exchange rate pass-through (ERPT) to consumer prices, especially the HICP excluding food and energy, are rather low, very heterogeneous and mostly fraught with a high degree of uncertainty. At the same time, the literature reports that the import content in final consumption of households is a relevant structural factor for the ERPT to consumer prices.

Against this backdrop, the import content in the consumption basket of the HICP sheds some light on three aspects of empirical ERPT estimates.[15] First, direct and indirect import content in consumption (DIICC) can be understood as an accounting-based gauge of how large ERPT could be.[16] Second, a disaggregate view of DIICC for euro area countries and across special aggregates of the HICP might

15 Such an exercise was conducted by Burstein et al. (2005) for selected South American, Asian and European countries, as well as the United States, by Gopinath (2015) for a number of OECD countries and by the International Monetary Fund (2016) for Latin America and emerging markets.

16 The underlying assumptions of such an ERPT measure are that all imports are invoiced in foreign currencies, ERPT to import prices is complete, mark-ups and distribution margins are constant and that endogenous responses and second-round effects do not occur. For further information, see Gopinath (2015).

shed some light on the observed heterogeneity in empirical ERPT estimates for inflation in the euro area.[17] Third, changes in the DIICC over time might be a source of time variation in ERPT estimates.

Chart A

Total (direct plus indirect) extra-euro area import content in consumption of euro area households

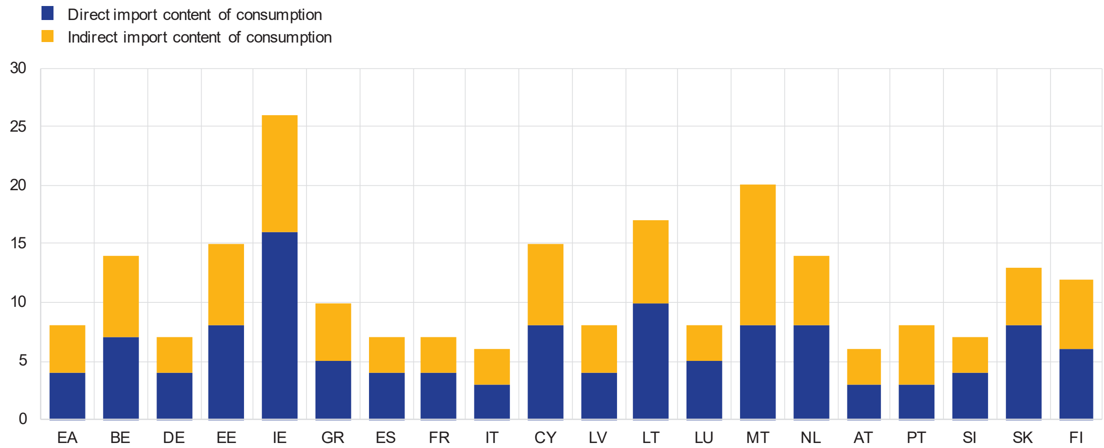
(as a percentage of total consumption)

Sources: World Input-Output Database, Eurostat, author calculations.
Notes: The euro area refers to the current composition of 19 member countries for all years.

Chart B

DIICC adjusted for invoicing currency for the HICP excluding energy and food

(as a percentage of total consumption)



Sources: World Input-Output Database, Eurostat, author calculations.
Notes: Direct import content of consumption is adjusted for the share of foreign currency invoicing.

According to calculations based on input-output tables from the World Input-Output Database (WIOD), the DIICC for the euro area was 16% in the HICP and 14% in the HICP excluding energy and food (HICPX) in 2014. There has been a small but steady increase in the DIICC since 2000. In terms

[17] The breakdown into special aggregates can only be conducted approximately with publicly available information. The computation is based on the correspondence list of Eurostat's Reference and Management of Nomenclatures (RAMON) and the Classification of Individual Consumption by Purpose (COICOP) weights. In addition, assumptions are made with regard to the redistribution across special aggregates of distribution services, research and development, as well as taxes less subsidies and international transport margins.

of the special aggregates of the HICP, the DIICC in energy appears most volatile, most likely owing to large oil price fluctuations, and that in non-energy industrial goods increases most strongly. DIICC for services is small and remained broadly unchanged over the period under review (see Chart A). For the euro area countries, the DIICC for the HICP ranges from 12% in Italy to 33% in Ireland and Malta. The estimate for the HICPX is only slightly lower and ranges from 10% in Spain to 33% in Ireland in 2014. Estimates for the special aggregates are also quite heterogeneous across the countries: the DIICC for energy ranges from 21% to 56%, for food from 13% to 43%, for services from 5% to 29% and for non-energy industrial goods from 22% to 47%.

These calculations can be used to roughly compute how various assumptions might affect this "accounting gauge" of the impact of exchange rates on HICP inflation. For example, relaxing the assumption of invoicing in foreign currency, one can use the fact that only roughly 60% of invoices in the euro area goods trade are denominated in foreign currency. Applying this "correction", DIICC for the euro area would fall for the HICP to 9% and for the HICPX to 8% (see Chart B).

3.2 Integration in GVCs

Another important determinant of the size of the ERPT is the integration in GVCs not only of a country, but also of its trading partners. A structural two-country model with trade in intermediate goods and staggered price-setting shows that the higher the participation of a country's trading partners in GVCs, the lower the pass-through to its import prices (see Georgiadis et al. (2019)). The predictions do not change if prices are flexible or sticky or when bilateral trade flows are priced in a third currency.

ERPT to import prices is lower, the more the inputs to domestic production are originated in the destination market, as highlighted by equation (3). When exporters source their inputs from the destination market, an exchange rate movement has a limited pass-through to import prices at the destination market owing to counteracting effects on the input costs side. To put it simply, an appreciation in the exporter's currency has two counteracting effects on the mark-up and on the cost: the price of exported goods expressed in the importer's currency increases, but at the same time the cost of foreign inputs in the exporter's currency decreases. This implies a lower ERPT than in the case of goods that are produced without foreign inputs. Amiti et al. (2014) combine the input-cost channel with the mark-up channel (see Section 3.3) and show that firms with high import shares and high market shares have low ERPT.[18] The fact that the most import-intensive firms are also big exporters mutually reinforces the two mechanisms.[19]

Empirical results confirm that the ERPT to import prices is lower, the higher the use of imported input from destination market in a sector's production. Using sectoral data, de Soyres et al. (2018) find that the ERPT decreases as the foreign

18 Hagemejer et al. (2020) find that the dampening effect of GVCs on ERPT may be non-linear, reflecting different firms' market power at various stages of the vertical specialisation process. As a result, their estimated ERPT for countries whose suppliers are strongly involved in GVCs amounts to 0.07 percentage points, which is four times smaller than for economies not participating in GVCs.

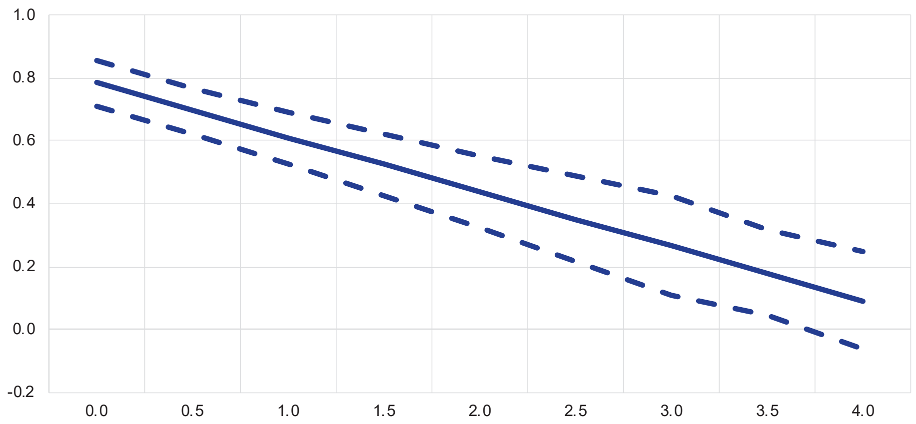
19 This study abstains from differentiating between the case of limited ERPT through sticky prices in destination markets (LCP) or limited ERPT in the context of flexible prices (see Section 3.4 and Section 4). Therefore, mark-up and import intensity are identified as general determinants of limited ERPT.

value added increases (see Chart 12). In particular, by taking into account the share of euro area foreign value added used by each country-sector exporting to each euro area country, it can be assessed to what extent the ERPT to import prices of each euro area country is reduced. Using this adjustment, the ERPT to Germany and France declines most, whereas for most other countries the impacts are small. For the euro area as a whole, the ERPT to extra-euro area import prices would be reduced from 0.8 percentage points to around 0.7 percentage points.[20] Another recent empirical study with a panel of advanced and emerging economies finds that growing backward GVC participation of the suppliers of imported intermediate input reduces the ERPT to producer prices: ERPT for suppliers strongly involved in the GVC production amounts to 0.07 percentage points, which is significantly smaller (four times) than for economies not participating in the GVC (see Hagemejer et al. (2020)). This study also finds that the dampening effect of GVCs on ERPT may be non-linear, reflecting different firms' market power at various stages of the vertical specialisation process.

Chart 12

ERPT to export prices

(x-axis: foreign value added as a percentage of bilateral total gross exports; y-axis refers to the percentage impact on export prices (goods and services) following a 1% depreciation in the bilateral exchange rate)



Sources: World Input-Output Database (2016 release) and de Soyres et al. (2018).
Notes: The estimates are obtained from a panel regression using annual country-sector bilateral trade data (distinguished by country of origin and country of destination). The panel comprises 40 countries, including the EU Member States.

The high euro area content in foreign production likely weakens the influence of foreign costs on euro area inflation. In some euro area countries (mostly the larger ones), their imports from abroad have a high content of their own value added, "round-tripped" from their exports back into their imports (see Chart 13). A recent study estimates that supply chain trade, both among domestic sectors and across countries, is an important determinant of consumer prices.[21] The higher the use of euro area inputs, the lower the pass-through of any exchange rate change to foreign input prices and, in turn, to euro area import prices. The estimated supply chain spillovers to consumer prices can be decomposed according to the country of origin, revealing that the relative weight of foreign input costs for the euro area as a whole is rather small (16%), after separating the effect of global oil prices (see Chart 14).

20 The coefficient for a destination-sector specific market share variable in the regression was not significant. This might be explained by the low variability across time of market shares at the sector level of aggregation.

21 See ECB Working Group on Global Value Chains (2019).

Results for the countries are heterogeneous, but reveal relatively strong production linkages within euro area countries which could dampen the exchange rate impact on domestic consumer prices (see the light blue part of Chart 14).

Chart 13

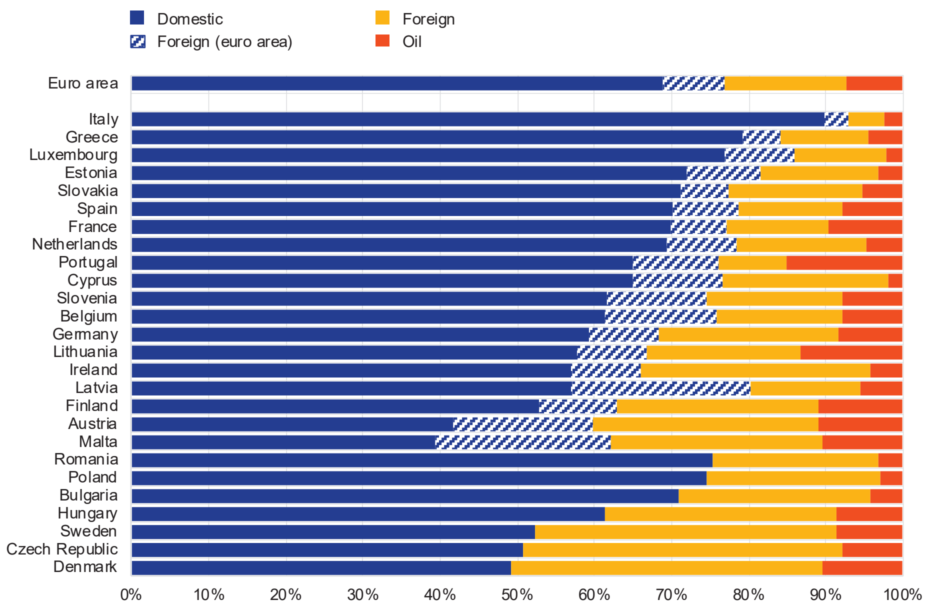
Euro area countries' input used to produce foreign exports to the euro area in 2008

Sources: World Input-Output Database (2013 release) and ECB staff calculations.
Note: Darker shades correspond to higher value added originated in the countries reported in rows in the exports to those countries reported in the columns.

Chart 2

Relative importance for domestic inflation of supply chain spillovers by origin

(percentage share of total supply chain effect)



Sources: World Input-Output Database (2013 release) and ECB staff calculations.
Notes: The data refer to 2008. The decomposition is based on the method presented in ECB Working Group on Global Value Chains (2019).

3.3 Market power and competition

The degree of competition across and within industries, as well as firms' pricing strategy, is a further factor determining differences in ERPT. The degree to which firms can adjust margins in response to an exchange rate change depends on their pricing power and market conditions. Bussière et al. (2016) find that market conditions in both the origin and destination countries play a role in determining the size of the ERPT.[22] Box 2 presents firm-level evidence on the role of dynamic pricing in ERPT to German package holiday prices.

ERPT decreases with increasing exporters' market shares, as firms with higher market power tend to adjust their mark-ups in response to exchange rate changes in order to keep market shares constant. In other words, when competition is low, ERPT is low. In monopolistic competition, both very small and very large exporters will experience little impact of changing their price on their market share and, thus, would pass through most of the exchange rate movements to selling prices. Based on firm-level data, Berman et al. (2012) and Amiti et al. (2014) find that the ERPT to import and consumer prices decreases as an exporter's performance increases, as measured by its market share according to Feenstra et al. (1996). More recently, Auer and Schoenle (2016) have suggested that the relationship between ERPT and market power is actually U-shaped, as both very small and very large exporters would pass on exchange rate movements entirely to selling prices. Devereux et al. (2017) confirm this U-shaped relationship and also find that ERPT falls as the importer's market share increases.[23]

In the euro area, there is a large degree of heterogeneity in market power at the sector level. Chart 15 shows a measure of market concentration (the Herfindahl-Hirschman index) and a measure of price-cost margins. The two indices are related to two different concepts of market power. The market concentration index describes the size distribution of the firms. According to this measure, metals, wood and food are the least concentrated sectors, while pharmaceuticals, cars and other forms of transport are at the opposite end. The median price-to-cost margin, in turn, gives a sense of the pricing power of firms in a sector.[24]

Distribution margins set by euro area local distributors are an additional factor that affects the pass-through throughout the supply chain, regardless of the strength of sensitivity of import prices to the exchange rates. If local distributors face strong competition and absorb exchange rate fluctuations in their own margins, there will be less pass-through to consumer prices than to prices at the border (see Burstein et al. (2003) and Goldberg and Campa (2010)).

Exporters with higher market power could be the most productive and supply high quality goods, which is an additional factor that lowers ERPT. From the

---

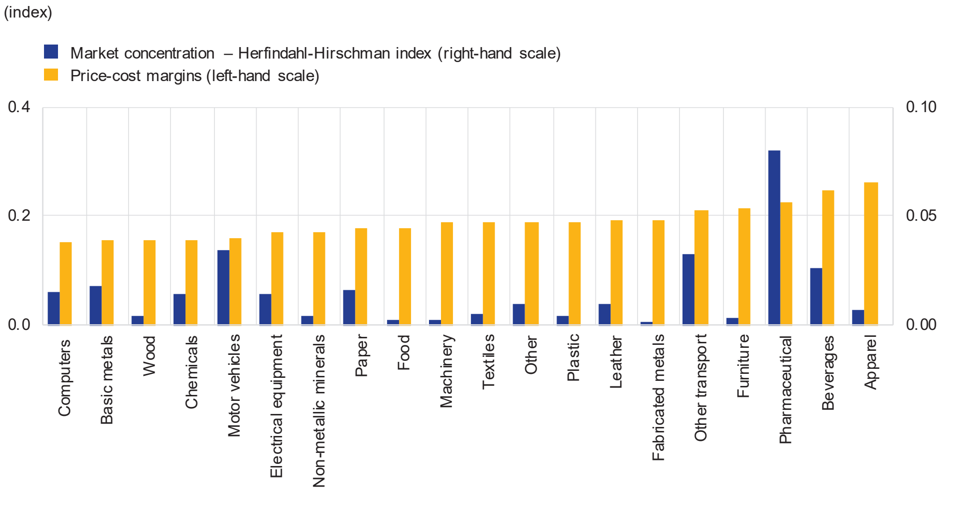
22 In product-country level bilateral export and import price equations, Bussière et al. (2016) show that controlling for time-varying country and product fixed effects changes the size of the export and import ERPT, highlighting the importance of profit margins, local prices and import costs.

23 In addition, large firms may be able to resort to exchange rate hedging via financial instruments (see Dekle and Ryoo (2007)) which would further decrease the sensitivity of their prices to exchange rate movements. However, financially constrained firms may have higher ERPT as they find it harder to hedge against the exchange rate changes (see Strasser (2013)).

24 An issue with the market concentration measure is that, in highly concentrated sectors, there is a large presence of big firms that are also two-way traders. As a result, the market concentration index might confound the effect of imported inputs and market power.

Chart 15

Euro area sectors' market concentration and pricing power



Sources: CompNet, Eurostat and authors' calculations.
Notes: Sector is defined at the 2-digit industry level (NACE rev.2). Sector-country figures are aggregated to the euro area sector level by weighing countries by their share, in any given sector, in total imports. The countries included are Belgium, France, Italy, Lithuania, Netherlands, Portugal, Slovenia and Finland.

supply perspective, high quality goods are associated with lower demand elasticity (also related to higher per-unit distribution costs) and hence higher scope for pricing-to-market and consequently lower ERPT (see Chen and Juvenal (2016)). Demand for a quality and heterogeneous valuation of quality by consumers also influences ERPT in such a way that demand elasticity decreases with quality and producers are more able to adjust their margins (see Auer et al. (2017)). Hence, the price of higher quality goods is less sensitive to exchange rate movements.

Box 2

Dynamic pricing and exchange rate pass-through

Prepared by Arne Nagengast, Dirk Bursian and Jan-Oliver Menz (Deutsche Bundesbank) on the basis of Nagengast, Bursian and Menz (2020)

Owing to the growing availability of firm-level and product-level data, recent studies have started to investigate the micro determinants of exchange rate pass-through (ERPT). While previous work has focused mainly on time-invariant product and firm characteristics, evidence on the role of dynamic pricing remains relatively limited. Dynamic pricing is a pricing strategy in which firms flexibly set prices for products or services taking into account current market conditions, such as capacity utilisation, customers' price sensitivity and the state of demand. For example, Broadway theatres offer large discounts on the day of the performance (see Leslie (2004)), Uber uses surge pricing, raising the price of a trip when demand exceeds supply within a fixed geographic area (see Cramer and Krueger (2016)), and airline tickets are usually cheaper when bought in advance (see Stavins (2001)). Such pricing policies have been employed for a long time in the transportation, hospitality, entertainment and energy industries. More recently, the emergence of e-commerce and the increasing use of digital price tags have enabled dynamic pricing to become more ubiquitous across industries, most notably in retail.

In this box, we explore how the heterogeneous response of consumer prices to exchange rate fluctuations can be explained by different forms of dynamic pricing. In particular, we study the effects of clearance sales, seasonality of demand and advance-purchase discounts. First, we provide a theoretical model that illustrates how foreign producers and domestic retailers adjust their prices to exchange rate fluctuations in these three settings. Second, we investigate empirically how prices and ERPT vary in these cases. We do so by analysing a unique German transaction-level dataset of package tours at a daily frequency between 2012 and 2018. The data were compiled by the Amadeus Leisure IT GmbH, an IT provider for the travel and tourism industry.

Building on Antoniades and Zaniboni (2016), we extend the model of international trade by Corsetti and Dedola (2005) to include heterogeneous retailers. On the consumer side, we model preferences using a quadratic utility function in line with Melitz and Ottaviano (2008). The price elasticity of demand is assumed to vary across consumers, and firms can use this for price discrimination insofar as consumers can be segmented sufficiently well according to observable characteristics, such as the time of purchase. Moreover, demand shows a strong seasonal pattern. When increasing capacity during periods of high demand (the high season), the producer incurs additional capacity costs resulting in time-varying marginal costs. Producers do not know the precise level of demand during the high season. Since increasing capacity at short notice is comparatively costly, information on the level of demand is valuable to producers. To acquire information regarding total demand, producers grant advance-purchase discounts during the high season. According to the model, ERPT increases for clearance sales in the presence of consumers with higher demand elasticity and also with capacity costs of producers. By contrast, ERPT is lower for advance purchases in the high season. Moreover, the model is also consistent with previous theoretical and empirical results on the relationship between producer, retailer and product characteristics with regard to ERPT.

To test the model predictions, we use a unique German transaction-level dataset on package tours at a daily frequency spanning around 8.5 million observations, including 58 tour operators (retailers) selling package tours to 9,823 hotels (producers) in 86 countries between 2012 and 2018. Furthermore, the dataset includes additional information on trip and traveller characteristics, which we complemented with detailed publicly available information on hotels using web scraping techniques as well as macroeconomic data.

The results suggest that ERPT to package tour prices at the micro level is incomplete and low, comparable to similar estimates for goods. In response to a 10% depreciation in the euro, package tour prices in euro increase by 1.5% after one year. To test the three main predictions of our theoretical model, we estimate standard pass-through regressions (Gopinath et al. (2010)) using a transaction-level model. Overall, we find robust empirical evidence for our model predictions regarding the impact of dynamic pricing on ERPT.

First, ERPT for last-minute bookings defined as package tours booked 14 days or fewer before departure is higher than for the average tour. In addition, traveller characteristics and consumption choices are consistent with the notion that the demand elasticity of consumers increases as the departure date approaches. Therefore, there is evidence that firms successfully use price discrimination by indirectly segmenting consumers with high and low valuations in the same country by their time of purchase. Second, ERPT increases with the capacity costs of hotels in the destination country using one country-specific and two hotel-specific measures of capacity costs. Third, ERPT decreases for advance-purchase discounts granted for high-season tours. Moreover, this effect is more pronounced for those hotels for which capacity costs are higher, i.e. those that stand to benefit the most from resolving demand uncertainty ahead of time by increasing capacity at an early stage at a lower cost. In summary, the empirical evidence is consistent with the view that hotels use advance-purchase discounts to plan their capacity for the high season.

3.4 Currency of invoicing

The choice of currency of invoicing determines the extent of the response of prices to an exchange rate movement. An exporter can choose to price its products in (i) its own currency (producer currency pricing – PCP), (ii) in the destination's currency (local currency pricing – LCP), or (iii) in a third "dominant" or "vehicle" currency. The invoicing decision serves as an active channel through which producers adjust their prices in relation to their own market power and to local competition conditions.[25] Intuitively, prices fixed in the local currency are almost irresponsive to the bilateral exchange rate between the local currency and the currency of the producer, whereas prices in the producer or dominant currency would have a higher ERPT. Furthermore, price stickiness plays a role, as the more frequently prices are adjusted over time, the smaller the difference in ERPT between the two extreme cases.[26] These findings are supported by two empirical country-specific studies prepared for this paper. The first study reports firm-level empirical evidence on the pass-through of different currencies to Italian firms' export prices (see Box 3). The second reports an analysis of invoicing currency pass-through and ERPT to import prices in Danish firms (see Box 4).

Around half of extra-EU imports are invoiced in euro (with some heterogeneity across countries), suggesting that for ERPT to euro area prices is limited. The share of imports priced in euro has been fairly stable over time and is slightly higher for services, compared with goods imports for the euro area aggregate (52% versus 48%, see Chart 16). In the light of the theoretical and empirical findings mentioned above, this would point to limited ERPT to euro area import prices. The main other currency of invoicing is the US dollar, which has a share in extra-EU imports of goods by country ranging from over 30% for Austria to 62% for Ireland (see Chart 17). The particularly high share of US dollar invoicing in Ireland, the Netherlands and Malta is most probably related to the activity of multinational enterprises operating in those countries. Therefore, US dollar movements against third currencies may also influence the import price dynamics of the euro area. Moreover, imports of petroleum goods are denominated mainly in US dollar. With regard to transactions with non-euro area EU Member States, owing to the relatively large size of the euro area compared with other non-euro area EU Member States and to the Single Market framework of the EU, it is reasonable to assume that trade within the EU is predominantly invoiced in euro. It is also interesting that imports in non-euro area EU Member States are invoiced mostly in dominant currencies (US dollar and euro) and a large share is in euro in many countries.[27] Differences within the services sectors are also relevant.

---

25 See Bacchetta and van Wincoop (2005) and Goldberg and Tille (2016) among others. If a firm invoices its products in its own currency, they mechanically become relatively more expensive in the local destination currency if it depreciates. This is referred to as PCP and corresponds to a full pass-through of exchange rate changes to import prices. In markets and industries with high competition, this would lead to losses in market share. In the case of low competition, however, firms can more easily adjust their prices to the local destination currency and yet maintain their market share. The alternative is LCP, and consequently zero pass-through to the destination's import prices, with the exchange rate impact being absorbed by the mark-up. Furthermore, the higher the absolute size of the transactions, as well as the higher the relative size of the transactions at the industry level, the more exporting firms will use LCP.

26 When prices are completely rigid, the ERPT to import prices is 100% when goods are priced in the producer's currency, whereas it is 0% in the case of LCP. Gopinath et al. (2010) find with US data that the ERPT to US import prices is 95% and 25% respectively for goods priced in foreign currency and in US dollar (local currency). Casas et al. (2017) show theoretically and empirically that dominant ERPT is high, regardless of the country of origin and destination, and Boz et al. (2017) find empirical evidence for the importance of the US dollar fluctuations in determining changes in prices and in trade.

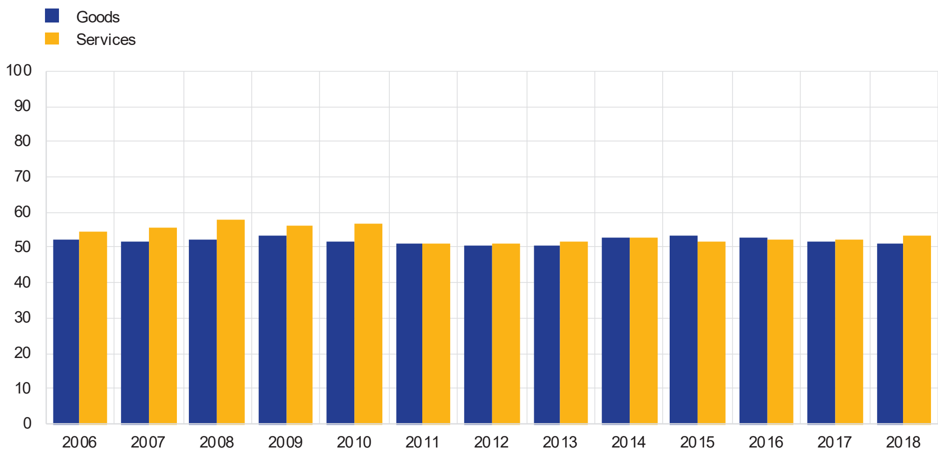
27 Chen et al. (2019) investigate the effect of invoicing in vehicle currencies (third currencies) on the ERPT to import prices in the United Kingdom. They find that using the bilateral exchange rate rather than the vehicle currency exchange rate substantially underestimates ERPT to goods priced in vehicle currencies.

According to balance of payment data, extra-euro area services trade is settled mainly in euro for the euro area countries that have a large tourism sector, while the share is smaller for countries specialising in financial services trade.

Chart 16

Euro as the invoice currency for extra-euro area imports

(percentage share)

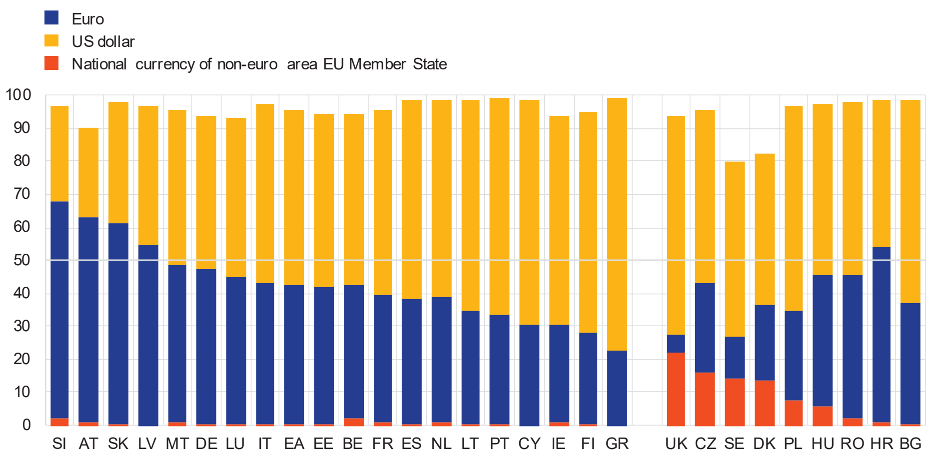


Source: “The international role of the euro”, ECB, June 2019.

Chart 3

Euro as the invoice currency for extra-EU imports of goods

(percentage share)



Source: Eurostat.
Note: Data refer to 2018, except for Estonia and the euro area when they refer to 2016.

Box 3
Invoicing currency, exchange rate pass-through to export prices and business activity: evidence from an analysis of Italian firms

Prepared by Alessandro Borin and Elena Mattevi (Banca d’Italia)

This box investigates the role of the currency of invoicing in determining the exchange rate pass-through (ERPT) to Italian firms’ export prices and the relationship between firms’ invoice choices and pricing strategies.[28] To the extent that the determinants of these decisions can be thought of as general for any country, this analysis can also give indications on the determinants of invoicing of euro area imports from the point of view of exporting firms from the rest of the world.

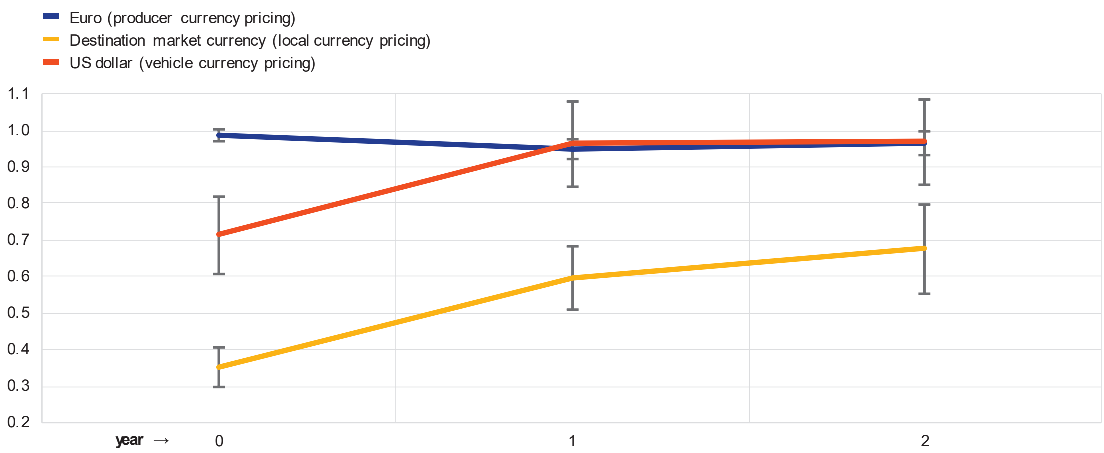
First, Italian firms set their prices mainly in euro. This is also true when they export outside the EU, although a significant proportion of transactions to non-EU Member States is invoiced in other currencies,[29] usually in US dollar: in 2015 25.7% of exports to non-EU Member States were invoiced in US dollar (70.7% in euro). Of those directed to the United States, over 55% were invoiced in euro.

Second, ERPT regressions by firm, product and market of destination show that the currency of invoicing significantly influences the relationship between import/export prices and exchange rate variations. Import prices of destination country vary far more when Italian exporting firms set their prices in euro than when they set them in the currency of the destination country (see the chart). When goods are priced in US dollar in a third market (i.e. other than the United States), price changes are driven by the US dollar exchange rate, rather than by the bilateral rates between the euro and the partner's currency. This suggests that list prices are fairly rigid in the currency they are denominated in, at least up to the three-year horizon considered. Exchange rate changes lead to an almost one-to-one change in import prices only when firms invoice in euro, which leads to a marked response in exported volumes. The effect on shipped quantities is less pronounced when goods are priced in the importer's currency.

Chart

ERPT on destination countries' prices by invoicing currency

(cumulative effects)



Source: Authors' estimates.
Notes: The cumulative effects are estimated by using the following regression model: $\Delta \ln UV_{idpkt} = \alpha + \sum_{z=0}^{2} \beta_z \Delta \ln NER_{d(t-z)} + \sum_{z=0}^{2} \gamma_s \Delta \ln NER_{d(t-z)} \times \delta_{Dollar} + \sum_{z=0}^{2} \theta_z \Delta \ln NER_{d(t-s)} \times \delta_{LCP} + \sum_{z=0}^{2} \varphi_z \Delta X_{d(t-z)} + \rho_z \Delta X_{d(t-z)} + \delta_d + \delta_i \times \delta_t + \delta_s \times \delta_t + \delta_{dollar} + \delta_{LCP} + \varepsilon_{idpkt}$, where $\Delta \ln UV_{idpkt}$ is the log variation of export prices, proxied by unit values computed by firm (i), destination country (d), HS6 product (p), invoicing currency (k) and year (t); $\Delta \ln NER_{d(t)}$ is the log change of the bilateral exchange rate; $X_{d(t)}$ are destination market controls (GDP and the PPI); δ_h are dummies for destination market, firm-year, sector-year, invoicing currency. The exports towards the United States invoiced in US dollar are classified in the LCP group. Standard errors are clustered at the destination country level.

28 See Borin (2018) for further details.

29 Although referring to potentially different concepts, the terms "invoicing currency", "list-price currency" and "pricing currency" are used synonymously, given that some empirical analyses have shown that they are interchangeable in almost all transactions. For more details, see Friberg and Wilander (2008).

Box 4

Invoicing currency and exchange rate pass-through to import prices in Danish firms

Prepared by Mark Strøm Kristoffersen (Danmarks Nationalbank)

Using the micro data behind the import price index for goods in Denmark, we estimate the role of the invoicing currency in the exchange rate pass-through (ERPT) to import prices in Danish firms.

We use monthly data for the period from 2004 to mid-2017 (432,577 observations). For all import prices, we observe the currency of denomination, which we assume is a good proxy for the currency of invoicing (Friberg & Wilander, 2008).

At the firm-good level, we estimate the equation

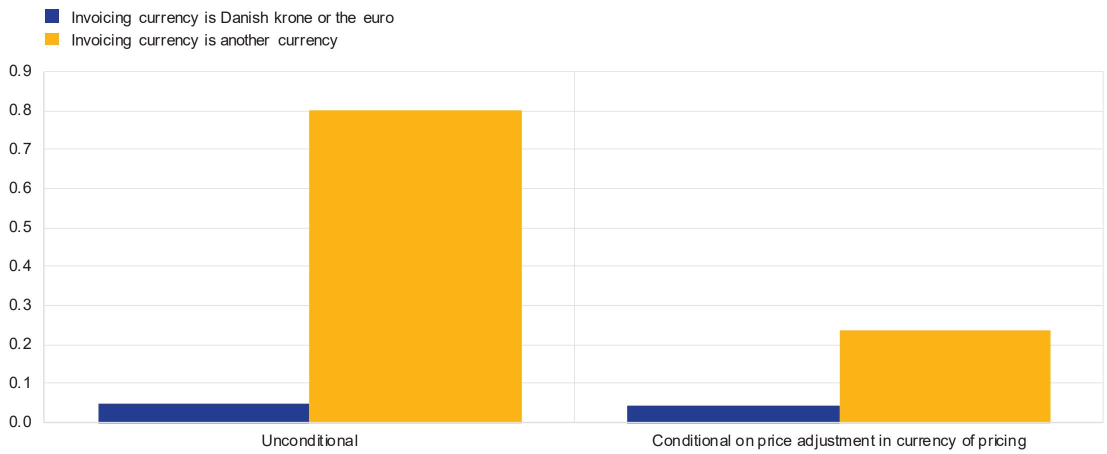
$$\Delta p_{ijt} = [\beta_{DKK_{euro}} I_{ijt} + \beta_{not\ DKK_{euro}} (1 - I_{ijt})] \Delta s_t + \mu_j + Z'_{ijt}\gamma$$

where Δp_{ijt} is the change in the log import price in Danish krone of good i in firm j. I_{ijt} is an indicator that takes the value 1 if the price is denominated in Danish krone or in euro, and 0 if the price is denominated in another currency. Δs_t is the log change in the NEER. Hence, β_{DKK_euro} is the pass-through (on impact) to prices denominated in Danish krone or euro, and $\beta_{not\ DKK\_euro}$ is the pass-through to prices denominated in other currencies. μ_j are firm fixed effects and Z_{ijt} is a vector of controls, including the log change in weighted foreign consumer prices, using the weights from the effective exchange rate, and the indicator of whether the import price is denominated in a currency other than the Danish krone or euro. Invoicing in either of those currencies makes no practical difference given the almost zero variation in the Danish krone to euro exchange rate.

Chart

ERPT to import prices in Danish firms and the role of invoicing currency after one month

(percentage point change in import price in Danish Krone following a 1% depreciation in the nominal effective exchange rate)



Source: Authors' calculations.
Note: All reported estimates are significantly different from zero at the 5% significance level.

We estimate the model with two specifications of the left-hand side variable: one with unconditional changes in the import price measured in Danish krone and one with import price changes in Danish krone conditional on a non-zero adjustment in the import price measured in the invoicing currency (see Gopinath et al. (2010)).

The results suggest that the ERPT is higher on impact for goods where the price is denominated in other currencies than Danish krone or euro (see the chart). The average pass-through to import prices across all goods is approximately 0.1 percentage point, which is in line with previous estimates using aggregate Danish data (see Kristoffersen and Spange (2016)). The pass-through on impact for prices denominated in other currencies is also found to be significantly higher than the pass-through for prices denominated in Danish krone or euro when conditioning on a non-zero adjustment in the import price measured in the invoicing currency. The pass-through on impact is smaller for prices denominated in currencies other than the Danish krone or euro when conditioning on a non-zero price adjustment in the import price measured in the invoicing currency.[30]

[30] For a subset of firms, the micro price data can be enriched with firm characteristics. The results presented in this box are robust to other specifications, e.g. replacing the firm fixed effects with the log firm size (measured by number of employees) and industry fixed effects.

4 ERPT in structural macroeconomic models

The results obtained in the previous sections point to a non-negligible ERPT to import and consumer prices. Additionally, the empirical studies discussed in Section 3 provide evidence of an increasing import content of final consumption goods. The import content of production has also increased over time. This increase in openness could imply an increase in ERPT, but other trends may counterbalance this potential effect: notably, it was shown that GVC integration tends to dampen ERPT to import prices, as does the fact that around one-half of euro area imports are invoiced in euro.

In this section, we consider various DSGE models that account for most of the facts described above. Structural DSGE models allow the impact of exchange rate changes on prices to be studied using the structural determinants of the pricing equations investigated empirically in the previous section, as well as the endogenous response of the economy in a general equilibrium context. This section evaluates the relationship between exchange rate and price dynamics with the help of seven DSGE open-economy models of the euro area and four DSGE models of other economies.[31] All models are New Keynesian, i.e. based on nominal (price and/or wage) rigidities. Monetary policy, modelled by a Taylor rule on the short-term policy rate, plays a non-trivial stabilisation role.[32]

The analysis using DSGE models complements that of the previous sections, but also takes the analysis of ERPT a step further. This is because the general equilibrium properties of the models and their richness capture the transmission mechanisms of ERPT in more depth. More specifically, their forward-looking nature allows us to account for the effects of expectations following current and expected changes in exchange rates and other key macroeconomic variables, such as output, inflation and the monetary policy stance. This channel is missing in the empirical models considered in the previous sections and it leads to differences in terms of the degree of ERPT in some cases. Furthermore, the DSGE analysis allows us to isolate the different effects stemming from LCP, price stickiness and home bias in consumption, all of which have a significant effect on the degree of pass-through. Finally, the analysis also enables counterfactual exercises to be conducted, accounting for fully credible announcements about the future monetary policy stance, namely forward guidance. For these reasons, the DSGE model analysis of this section sheds further light on the transmission channels of ERPT.

---

31 For the purposes of this analysis, Suomen Pankki – Finlands Bank, the Banca d'Italia, the Deutsche Bundesbank, De Nederlandsche Bank, the ECB, the Nationale Bank van België/Banque Nationale de Belgique and Banca Naţională a României provided their models of the euro area. The Central Bank of Ireland, Česká národní banka, Národná banka Slovenska and Sveriges Riksbank provided models of their country's economy.

32 DSGE-based analysis has several advantages in this context. The micro-founded pricing equations illustrate firms' forward-looking decisions about price adjustment in response to exchange rate changes. Moreover, models are applied to the quarterly data through calibration or estimation of key parameters. Therefore, they are able to provide not only a fully theory-consistent transmission mechanism, but also quantitative results. The simulation of multiple models, based on different specifications and values of parameters, allows us to evaluate the robustness of the results across models.

The two measures of the relationship between prices and exchange rates – ERPT and PERR described in Section 1 of this paper – can be derived from structural models and are intricately intertwined with each other. The first is the coefficient that multiplies the exchange rate in the import pricing equation ("shock-invariant" ERPT to import prices). It is a convolution of structural parameters of the model: trade openness, long-run mark-up, nominal price stickiness, curvature of the demand curve, degree of international production-sharing and distribution costs.[33] Similarly, the weight of foreign goods in the consumption basket enables a shock-invariant ERPT to total consumer prices to be computed. The second measure is the response of prices relative to that of the exchange rate (PERR), a measure computed for shocks to domestic monetary policy, exchange rate, domestic aggregate demand and domestic aggregate supply.

The main results are as follows. First, the ERPT to import and consumer prices is not negligible, even in models which, consistent with the empirical evidence, have lower incomplete ERPT to import prices at the consumer level than at the border. Second, the obtained PERRs for import prices are generally large for all types of shock, except for aggregate supply shocks (especially at the retail level). Third, the PERRs for consumer prices are also not negligible,[34] even though they evolve more gradually. Fourth, these results are rather robust across models.

The general equilibrium structure of the models implies rich dynamics and mechanisms through which ERPT evolves. However, the way in which the nominal exchange rate and the aggregate price level are determined is crucial. First, the assumption of international trade in assets gives rise to the uncovered interest rate parity (UIP) condition.[35] This means that the expected exchange rate changes depend on the interest rate differential between two regions, and as such on the relative monetary policy stance. The latter affects ERPT substantially given the commitment of monetary policy to price stability. The UIP condition can capture the fact that a contractionary monetary policy leads to appreciations and vice versa. The analysis of the shock-dependent PERR below elaborates further on how the monetary policy stance can mitigate or strengthen the sensitivity of prices to exchange rate movements. Second, the aggregate price level contains direct and indirect effects of exchange rate fluctuations. The direct effects stem from the import share content of final consumption goods, while the indirect effects stem from the import content in the production of domestically produced goods. Given the higher degree of price stickiness domestically, and for a given import-to-GDP ratio, a low import share of final consumption goods yields a lower ERPT.

The section is organised as follows. First, it describes the sources of incomplete ERPT and reports the main results, i.e. the estimated shock-invariant ERPT. Second, it discusses the shock-dependent PERR and summarises the transmission mechanisms of shocks to quantities and prices.

---

[33] The "per period" version of this measure is the only one reported here and represents the share of a permanent change in the exchange rate that passes to prices each quarter until the pass-through is complete. Note that the full "long-run" pass-through is derived directly from the "per quarter" one by ignoring the nominal price stickiness.

[34] With the exception of aggregate supply shocks, for which they remain more contained and of reversed sign. Consumer prices in these models are generally measured by private consumption deflators.

[35] This condition does not hold true perfectly in the models considered given the existence of risk premia in the holdings of foreign assets.

4.1 Shock-invariant ERPT: sources of incompleteness and estimates

In general, in structural macroeconomic models the incomplete ERPT to import prices is due to international price discrimination. If the markets for tradable goods are (exogenously) segmented, firms can set a different price for each destination market (i.e. there are deviations from the law of one price). In some models, ERPT is incomplete and gradual because of LCP holding at the border, i.e. the nominal prices of imports at the border are set and sticky in the currency of the destination market. In these models, ERPT to import prices is gradual at both the border and consumer level. In other models, PCP holds at the border and prices are set and sticky in the currency of the producer, while LCP holds at the consumer level. In this case, ERPT is instantaneously complete at the border and gradual at the consumer level. Finally, in some other models, the country-specific distribution sector intensive in local non-tradable goods is a second source of international price discrimination, in addition to LCP at the border. When setting the local prices of the tradable good, firms take into account the local distribution services. The latter introduce the distinction between wholesale (border) and retail (consumer) prices. LCP at the consumer level or repricing at the consumer level owing to the existence of a distribution sector is in line with the data documented in Section 3. The DSGE models presented in this section incorporate this crucial feature observed in the data and hence are able to capture the lower ERPT to final consumer prices.

In the models, firms producing the tradable good set a price for each destination market, taking into account nominal price adjustment costs, local distribution sector and local demand conditions, which depend upon the elasticity of substitution between domestic and imported goods in the different production sectors together with the respective weight of imports.

At this point, it is important to note that LCP does not necessarily imply that ERPT is zero. When firms engage in LCP, their profits are sensitive to exchange rate movements. This is because they invoice in foreign currency (taking into account foreign demand only) but compute their revenues in their domestic currency. As a result, the optimal price that they set does not depend only on the present discounted value of their marginal costs, but also on the expected path of the nominal exchange rate. **Thus, not only current changes in the exchange rate matter, but also expectations about any future changes.** At this stage, the degree of price stickiness matters – the higher the price stickiness, the lower the frequency of price adjustments owing to exchange rate fluctuations alone. **Price stickiness is an important factor affecting ERPT,** which is not taken into account in the empirical models discussed the previous sections.

Another important factor is market power. As documented in Section 3, **a higher market share can be expected to reduce ERPT**. The monopolistic competition assumption in the DSGE models used for this analysis implies that producers set their prices as a mark-up above their marginal costs. The aim is not to mimic the behaviour of mark-ups observed in the data, but to highlight that the DSGE models considered account for this source of a drop in ERPT.

Finally, **home bias also dampens ERPT**. As reported in Section 3.1, although the import content of consumption has increased over the years, it is still low. A low share of imported goods in the consumption basket dampens the direct effects of exchange rate fluctuations on final consumer prices. All the DSGE models considered account for this high degree of home bias in consumption.

In the (log-linear version of the) pricing equation of imported goods, $ERPT^F$ is the coefficient that multiplies the exchange rate. It is a convolution of structural parameters and steady-state values of some variables. Two parameters contribute to determining the size of the $ERPT^F$: import price stickiness and the parameter of the steady-state distribution margin (which measures the weight of distribution services in the retail price of imported goods). The higher the values of these two parameters, the lower the $ERPT^F$. This concept of $ERPT^F$ captures the contribution of the nominal exchange rate to import prices in the considered period (the quarter in our models), taking as given the values of all other variables and the expected values of all variables, including the expected future values of the exchange rate and the shocks (ceteris paribus assumption).[36]

According to the range of DSGE models for the euro area, $ERPT^F$ is about twice as large at the border than at the consumer (retail) level (see Table 3). Ceteris paribus, 40% (20%) of exchange rate fluctuations are passed through to border (retail) prices of euro area imports. The average $ERPT^C$ to total consumer prices is 4%. Similar cross-model average ERPTs are obtained when considering models of some economies other than the euro area (see Table 3).

Table 3

Estimated ERPTs per quarter

Impact after a 1% depreciation in the exchange rate

(percentage points)

	To import prices (border)	To import prices (retail)	To total consumer prices
Models used to obtain estimates for the euro area			
Burlon et al. (2018)	0.22	0.11	0.03
Suomen Pankki – Finlands Bank model based on Lindé et al. (2009)	0.56	0.56	0.09
De Nederlandsche Bank model based on Bolt et al. (2019) and Gomes et al. (2012)	0.04	0.04	0.01
Hoffmann et al. (2020)	0.23	0.12	0.03
Coenen et al. (2018)	1.00	0.29	0.04
De Walque et al. (2017)	0.23	0.19	0.03
Banca Naţională a României	0.36	0.16	0.07
Models used to obtain estimates for selected countries			
Clancy et al. (2016) for Ireland	0.04	0.04	0.01
Andrle et al. (2009) for the Czech Republic	1.00	0.12	0.04
Senaj and Vyskrabka (2011) for Slovakia	0.53	0.53	0.135
Adolfson et al. (2013) for Sweden	1.00	0.01	0.002

Source: Authors' calculations.
Notes: The table reports the "per period" impacts and shows the share of a permanent change in the exchange rate that passes to prices each quarter until the pass-through is complete. The full "long-run" pass-through is derived directly from the "per period" one by ignoring the nominal price stickiness. "Import prices" refers to extra-euro area imports in all models, with the exception of the Suomen Pankki – Finlands Bank model which also includes intra-euro area imports.

[36] Corsetti et al. (2008) emphasise that a large proportion of the empirical literature measures ERPT as the percentage change in import prices denominated in the local currency resulting from a 1% change in the bilateral exchange rate between the exporting and the importing country, all other things being equal. This is the ERPT in the shock-invariant approach.

4.2 Time-varying and shock-dependent response of prices relative to that of the exchange rate

In DSGE models, the PERR is determined by the general equilibrium solution, which in turn depends on the shock-invariant ERPT. Table 4 reports estimates (cross-model median, first and third quartiles) for euro area $PERR_h^z$ for $h = 1,4,8,12$ and $z\epsilon\{F, Fr, C\}$ conditional on each of the considered shocks to domestic monetary policy, the exchange rate (often referred to as UIP), domestic aggregate demand and domestic aggregate supply (*F* refers to import prices at the border, *Fr* to import prices at the retail level and *C* to total consumer prices).

Table 4

$PERR_h$ to euro area prices

Impact after a 1% change in the exchange rate (an increase is a depreciation)

(percentage points)

a) Import prices (at the border): $\boldsymbol{PERR_h^F}$

		Quarter I	Quarter IV	Quarter VIII	Quarter XII
Exchange rate	median	0.4	0.8	0.8	0.8
	q1-q3	0.20.5	0.70.9	0.81.0	0.71.0
Monetary policy	median	0.4	0.8	1.0	1.0
	q1-q3	0.30.4	0.81.0	0.91.0	1.01.4
Aggregate demand	median	0.3	0.6	0.6	0.6
	q1-q3	0.10.5	0.50.7	0.40.7	-0.80.8
Aggregate supply	median	0.3	0.6	0.6	0.7
	q1-q3	0.20.4	0.60.8	0.30.9	0.41.9

b) Import prices (retail): $\boldsymbol{PERR_h^{Fr}}$

		Quarter I	Quarter IV	Quarter VIII	Quarter XII
Exchange rate	median	0.2	0.4	0.6	0.7
	q1-q3	0.10.3	0.30.6	0.60.7	0.61.3
Monetary policy	median	0.3	0.6	0.8	0.9
	q1-q3	0.20.3	0.50.7	0.80.8	0.81.0
Aggregate demand	median	0.1	0.6	0.7	0.7
	q1-q3	-0.10.2	0.31.0	0.00.8	-3.20.8
Aggregate supply	median	0.1	0.1	0.1	0.6
	q1-q3	0.00.2	0.00.5	-0.30.4	0.00.8

c) Consumer prices: $\boldsymbol{PERR_h^C}$

		Quarter I	Quarter IV	Quarter VIII	Quarter XII
Exchange rate	median	0.0	0.1	0.3	0.5
	q1-q3	0.00.1	0.10.2	0.20.4	0.30.5
Monetary policy	median	0.1	0.3	0.6	0.8
	q1-q3	0.00.1	0.20.4	0.60.7	0.80.9
Aggregate demand	median	-0.1	0.2	0.4	0.6
	q1-q3	-0.50.0	-0.11.7	-0.51.0	-4.00.9
Aggregate supply	median	-0.2	-0.3	-0.2	-0.1
	q1-q3	-0.60.0	-0.6-0.1	-0.80.0	-0.44.7

Source: Authors' calculations.
Notes: "Import prices" refers to prices of extra-euro area imports. Consumer prices are measured by the private consumption deflator. The table summarises the results obtained from the euro area DSGE models listed in Table 3. The only exception is the Suomen Pankki – Finlands Bank model which did not provide the results for the aggregate supply; in addition, this model uses both extra and intra-euro area imports, and is therefore also not included in the results for import prices. "q1-q3" refers to the first and third quartiles of the models' distribution.

The main results are as follows. First, the (across-model median) $PERR_h^F$ is positive and not negligible at all horizons and across all shocks (see Table 4a). Second, $PERR_h^F$ is larger following a shock to, in decreasing order, monetary policy, exchange rate, aggregate supply or aggregate demand. Third, $PERR_h^F$ increases over time, given that import prices adjust gradually, while the nominal exchange rate reacts ("jumps") immediately in response to the considered shock. At the end of the first year, $PERR_4^F$ is rather large (0.8 percentage point) in the case of the UIP and monetary policy shocks, while it is slightly lower (0.6 percentage point) in the case of demand and supply shocks. These two shocks imply a smaller positive response of import prices, because euro area households rebalance demand towards domestic goods, inducing exporters to the euro area to limit the increase in the prices of their goods. Table 4b and Table 4c show corresponding estimates for import prices at the retail level ($PERR_h^{Fr}$) and for consumer prices ($PERR_h^C$).

The main results show that, like ERPT, PERRs decrease along the pricing chain. The ratio of import prices at the border to exchange rate changes ($PERR_h^F$) is higher than at the retail level ($PERR_h^{Fr}$), which, in turn, is higher than for the consumer prices. $PERR_h^C$ is lower than $PERR_h^{Fr}$ because prices of domestic goods are stickier than those of imported goods, and their weight in the consumption basket is large. Third, $PERR_h^C$ is generally positive and large in the case of the monetary policy, demand (i.e. preference) and exchange rate (i.e. UIP) shocks. It is negative in the case of the preference shock on impact (the exchange rate appreciates while prices increase) and in the case of supply (i.e. technology shock) at all horizons (the exchange rate depreciates while prices decrease).

Finally, cross-model uncertainty is low in the case of the monetary policy and UIP shocks. It is large in the case of the preference and supply shocks. For these shocks, $PERR_h^C$ is negative if the nominal exchange rate does not depreciate by a sufficient amount after the initial appreciation to offset the movement in domestic producer prices.

Results of the DSGE models for individual countries (Czech Republic, Ireland, Slovakia and Sweden) are in line with those for the euro area. The PERR for import prices is larger at the border than at the retail level (two of the models assume full ERPT to import prices at the border). The PERR for total consumer prices is sizeable for shocks to domestic monetary policy and the exchange rate.

4.3 Explaining the response of prices relative to that of the exchange rate: the shock transmission mechanisms

In order to better explain the mechanisms underlying the response of prices relative to that of the exchange rate ($PERR_h$) we report the responses of the main macroeconomic variables to the considered shocks in the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)), which is rather rich in terms of features (LCP, distribution sector, intermediate goods in the production function).[37] The mechanisms and their sensitivity to alternative parametric assumptions are explained in detail for an exchange rate shock and broadly outlined for the other shocks.

[37] The same model is simulated in the sensitivity analysis, to assess the impact of forward guidance (see Section 6), and for the historical decomposition of the exchange rate and prices (see Section 5).

4.3.1 Shock to the exchange rate (depreciation)

The impulse responses corresponding to the benchmark case are reported in dark blue in Chart 18 (panels a to f); the lines in other colours show the results of the sensitivity analysis, where the model was simulated shutting down in turn the channels corresponding to some of the structural features highlighted in Section 3. In the case of a depreciation in the euro nominal exchange rate, there are two main initial responses: (i) import prices at the border increase following the nominal exchange rate depreciation,[38] and (ii) agents substitute US dollar-denominated for euro-denominated assets owing to the UIP condition.

Aggregate import prices adjust only gradually to the changes in the exchange rate because of price stickiness: individual firms adjust short-run mark-ups. Import prices at the retail (i.e. consumer) level adapt to a lower extent than at the border. The prices of the domestic distribution services – which introduce a wedge between the import prices at the border and the retail level – evolve at an even slower pace.

Import prices push total consumer prices upwards, in spite of them having a relatively small weight in the consumer price index. Prices of domestic goods (not reported), associated with a much larger weight in the index, also increase owing to the increase in the price of intermediate foreign inputs and to the shift in domestic and foreign demand towards domestic goods. The central bank raises the policy rate in response to the inflationary pressures and the small positive effect on the euro area GDP,[39] mitigating somewhat the depreciation in the euro. In fact, through the UIP condition, the higher domestic interest rate relative to the foreign interest rate counteracts the initial depreciation in the currency.

The last row of Chart 18 (panels e and f) reports the PERRs for import prices and consumer prices. In the short run, the pass-through to import prices at the border is incomplete. The $PERR_h^F$ decreases gradually over time, as the fall in import prices is larger than that dictated by the exchange rate, because of lower domestic demand for imports. With regard to consumer prices, $PERR_h^C$ is lower than $PERR_h^F$ because the price of domestic goods is much stickier and adjusts more sluggishly to the UIP shock. It increases as prices of domestic goods gradually rise.

Chart 18 (panels a to f) also displays a **sensitivity analysis of the role of some structural determinants studied in previous sections which are included in structural DSGE macro models**. The following cases are considered: (i) full competition in imports at the border, i.e. no nominal stickiness at the import price level (yellow), (ii) no distribution costs (red), and the omission of the international trade and GVC participation dimensions: (iii) no foreign intermediate inputs in domestic production (green), and (iv) no import content of exports (light blue).[40]

The sensitivity analysis shows which parameters are more important in driving the results: (i) **shutting down import price nominal rigidity – the import price**

---

38 The simulation is for a +1% UIP shock, which follows an AR (1) process with persistence set at 0.9.

39 The higher monetary policy rate induces households and firms to reduce consumption and investment. At the same time, and for the same reasons that import prices increase, the export prices expressed in the currency of the destination market (not reported) decrease. The implied expenditure-switching effect favours exports and reduces imports, improving the net trade (not reported). The net effect on the euro area real economic activity is slightly positive (not reported).

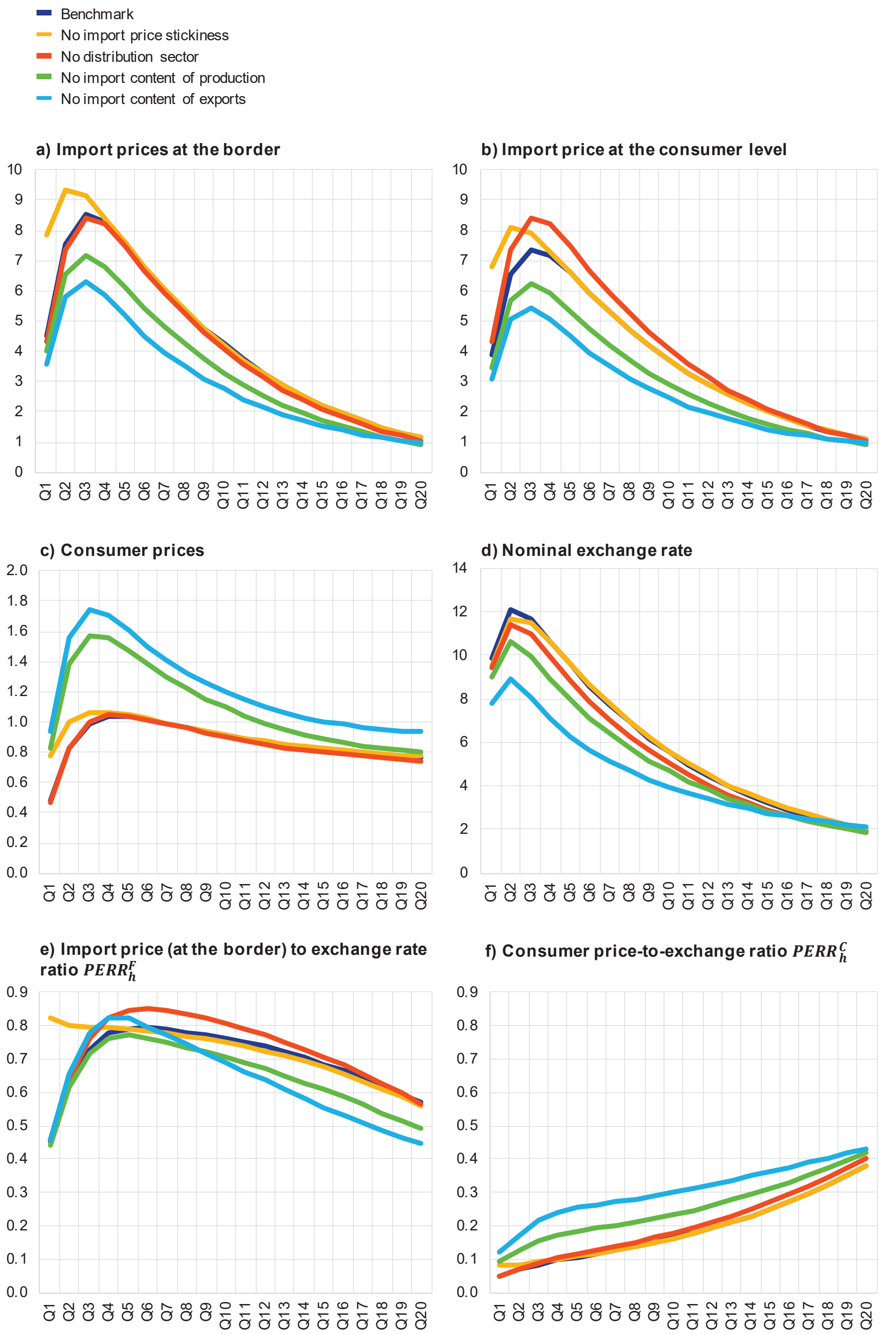
40 For a more detailed explanation of the different mechanisms at work when passing from one assumption to the other, see de Walque et al. (2019).

response at the border is nearly twice as large on impact but returns to the benchmark case after one year, in line with the low estimated nominal stickiness. This is transmitted directly to consumer prices with the same order of magnitude.

Chart 18

Exchange rate (i.e. UIP) shock: macroeconomics effects, PERRs and sensitivity analysis

(percentage points, the simulation is for a +1% UIP shock, which follows an AR (1) process with persistence set at 0.9)



Source: Authors' calculations using the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)).
Note: "Consumer prices" refers to the private consumption deflator. "Import prices" refers to prices of extra-euro area imports.

Notably, when the nominal stickiness is disregarded, the ratio of import prices to the exchange rate is quasi-constant over time;[41] (ii) the benchmark distribution margin is relatively small (14%) and setting it at zero has no marked influence on the results;[42] (iii) removing foreign intermediate inputs from the list of production factors doubles the share of consumption goods affected by the expenditure-switching effect. Overall economic activity is enhanced compared with the benchmark, and the monetary authority reacts accordingly, reducing the persistence of the nominal exchange rate via the UIP condition. The induced lower increase in import prices is not sufficient to counterbalance the fact that there now is a larger share of imported goods in the (new) consumption basket. **In the end, the consumer price response is much larger when the share of foreign intermediate inputs in domestic production is set at zero; and (iv) if, together with the absence of foreign intermediate inputs, the import content of exports is also set at zero, all the results described in (iii) are exacerbated.** The PERR is then around two and a half times larger than in the benchmark for the first year.

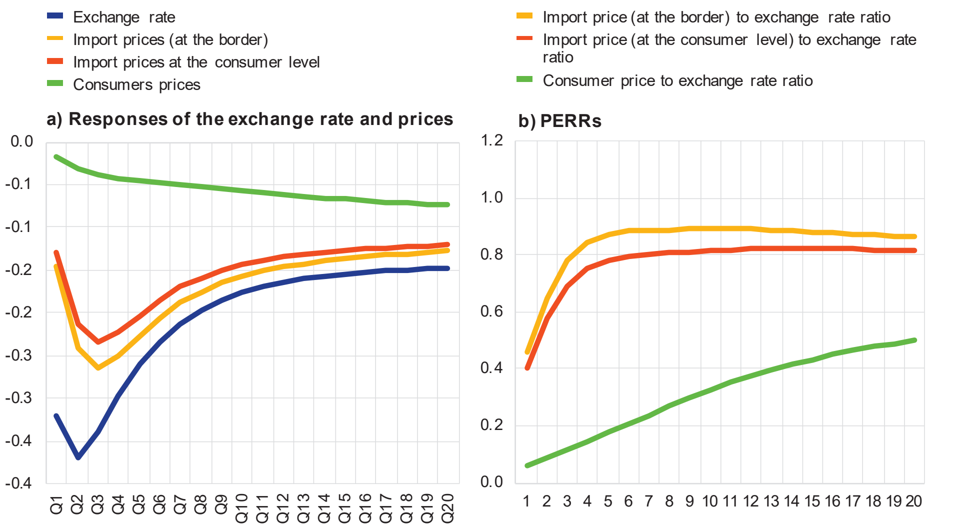
4.3.2 Domestic monetary policy shock

We consider the quarterly responses of the main euro area macroeconomic variables to a 25 basis point (annualised) shock to the Taylor rule in the initial quarter. After the initial increase, the policy rate gradually returns to its baseline level.[43]

Chart 19

Monetary policy shock: macroeconomic effects and PERRs

(percentage points, the monetary policy shock is defined as a 25 basis point (annualised) shock to the Taylor rule in the first quarter)



Source: Authors' calculations using the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)).
Note: "Consumer prices" refers to the private consumption deflator. "Import prices" refers to prices of extra-euro area imports.

---

41 The implied limited drop in domestic demand is more than offset by the improvement in net trade resulting from the expenditure-switching effects.

42 The monetary authority reacts with a somewhat larger increase in the policy rate, inducing less persistent dynamics for the nominal exchange rate. It is predominantly this change in the denominator that induces the increase in the different PERRs. In the absence of this channel, the expenditure-switching effect induced by the devaluation is stronger in both economies compared with the benchmark, such that there is a greater improvement in net trade and GDP.

43 The initial increase is slightly lower than 25 basis points because the initial policy rate response is also dictated by the systematic component of the Taylor rule, which partially offsets the shock.

The higher (real) interest rate induces an appreciation in the euro through the UIP condition and a decrease in euro area aggregate demand for consumption and investment. Foreign firms exporting to the euro area react by reducing the prices of their goods invoiced in euro. Owing to the nominal rigidities, the reduction is gradual and not as large as the appreciation in the euro, and firms adjust their mark-ups temporarily (see panel a of Chart 19).

The consumer price index decreases consistently with the decrease in import prices and euro area aggregate demand. However, it does so sluggishly because of the higher stickiness and higher share of domestically produced goods. The PERR for import prices at the border and the retail level, as well as the PERR for total consumer prices, shows that the PERRs decline along the distribution chain (panel b of Chart 19). At the same time, all the above-mentioned PERRs tend to increase over time, because the nominal exchange rate initially has a larger response than that of prices.

4.3.3 Domestic aggregate demand and aggregate supply shocks

Following an expansionary euro area aggregate demand shock[44], the initial excess demand is absorbed by an increase in GDP and a gradual increase in prices, prompting the central bank to raise the interest rate. As a consequence, the euro appreciates.[45] Firms face a persistent increase in demand for their products and increase their mark-up. Therefore, import prices follow the appreciation but fall by less than they would have done without the improvement in domestic conditions. Total consumer prices initially decrease in line with the drop in import prices but after a while, the consumer price impulse response turns positive, following the increase in prices of domestic goods and the bottoming-out of prices of imported goods. The net effect of the two opposite forces (exchange rate appreciation and higher aggregate demand) is that the $PERR_h^F$ is positive and hump-shaped, while the $PERR_h^C$ is negative (the corresponding price index increases despite the exchange rate appreciation).

After a positive total factor productivity shock[46], the excess supply is absorbed through the fall in domestic costs and prices. Given the large home bias, total consumer prices decrease. The central bank reduces the policy rate, stimulating domestic aggregate demand and triggering nominal exchange rate depreciation. Import prices increase, consistent with the depreciation and increase in aggregate demand. Total consumer prices still gradually decrease, as they are dampened by the fall in prices of domestic goods. The PERR for import prices is positive both at the border and at the retail level, while that for consumer prices is negative.

To conclude, compared with the effect of a UIP shock, the relative response of consumer prices to exchange rate changes is largest following a monetary policy shock. In this case, the deflationary effect of the shock on producer prices is

---

[44] This is a 1% positive consumption preference shock, which follows an AR (1) process with persistence set at 0.9.

[45] The switching effect is negative on exports and positive on imports. Import prices increase owing not to the favourable movement in relative prices, but also to the higher euro area aggregate demand. Import prices decrease in line with the exchange rate appreciation.

[46] This is a 1% increase in total factor productivity that dies out by 10% every period.

complemented by the imported deflation in the CPI. By contrast, the direct effect of demand and productivity shocks on domestic producer prices more than offsets imported inflation. However, Section 6 below shows how forward guidance somewhat mitigates this effect.

Overall, as suggested by the sensitivity analysis, the structural determinants of ERPT are key to understanding the transmission mechanisms of exchange rate fluctuations to import and consumer prices and economic activity following any relevant macroeconomic shock. Box 5 illustrates how ERPT may differ depending on a firm's pricing regime, i.e. whether it uses LCP, PCP or dominant currency pricing.

Box 5
The importance of the dominant currency paradigm

Prepared by Martino Ricci (ECB)

Theoretical macroeconomic models allow us to study the shock-dependence of exchange rate pass-through (ERPT) in a general equilibrium set-up in which important determinants such as expectations, price rigidities and the pricing scheme considered are explicitly spelled out and interact with each other. Given the increasing relevance of international linkages, it is important to analyse the response of foreign-originated shocks in the context of a rich model with a detailed coverage of foreign economies. Indeed, the transmission of foreign shocks might well be different from that of domestic shocks. This is particularly true when considering shocks originating from regions such as the euro area and the United States, which play a prominent role in the international trade system.

Focusing on monetary policy shocks, this box analyses how different pricing regimes, namely producer currency pricing (PCP) and dominant currency pricing (DCP), affect the impact of various possible shocks on exchange rates, import prices and consumer prices (measured by the CPI) using ECB-Global[47]. In doing so, it first focuses on the transmission of changes from the exchange rate to prices in response to shocks to the domestic policy rate and then compares them with the response to the US monetary policy shock. Although it does not explicitly refer to the role of the euro in global trade, the theoretical implications can be extended to the euro area.

A recent strand of the literature has emphasised the importance of a few currencies for global trade prices and volumes (see Boz et al. (2017) and Gopinath (2015)). In particular, the US dollar plays a dominant role in the international price system, as a large share of global trade, even excluding the United States, is invoiced in dollars. The implications of the US dollar being the main currency of invoicing might be large for the response of prices relative to that of the exchange rate (PERR), particularly when shocks originate in the United States and spill over to other countries.

Charts A and B show the PERR for import prices and CPI in the case of domestic and US monetary policy shocks. Focusing on US monetary policy shocks, several elements of the analysis are worth mentioning. First, the PERR is larger under DCP than PCP. This is easily explained by the fact that the share of trade invoiced in US dollar is larger for each country and, therefore, changes in the US dollar exchange rate have a larger impact. Second, the PERR is different than in the case of a

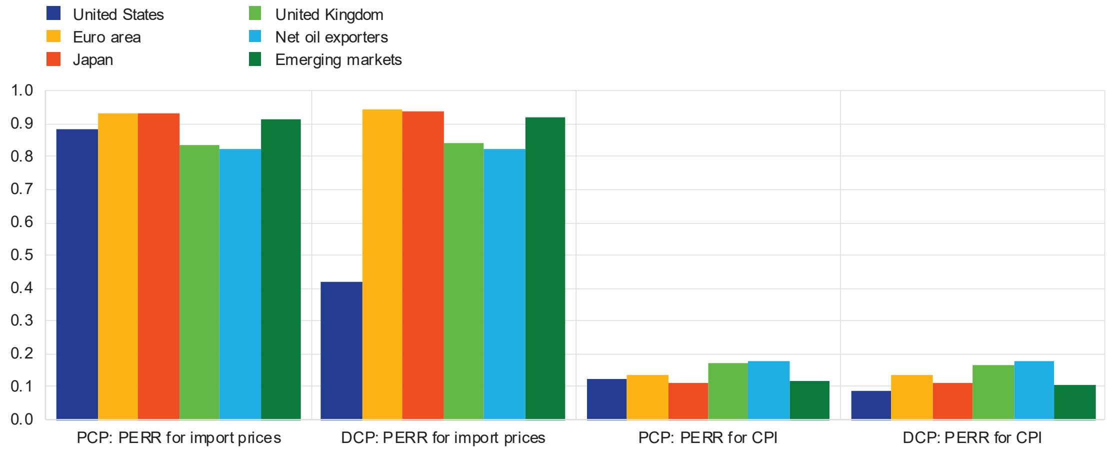
[47] ECB-Global is a rich semi-structural, multi-country model featuring diverse real and financial cross-border spillover channels for the global economy (for details see Dieppe et al. (2018)). This model has been recently modified to incorporate the dominant currency paradigm. In the current specification of the model, DCP takes into account only the role of the US dollar as a global currency of invoicing.

domestic shock, underlining the dependence of the PERR on the type of shock hitting the economy, as extensively documented in the literature (see Section 5). Finally, the response of net oil exporters stands out, being larger than in other countries under both PCP and DCP. The reason is that oil prices are not sticky: an appreciation in the US dollar is more than offset by a decline in oil prices and vice versa. This slows down price adjustment for oil importers.

Chart A

PERR following a domestic monetary policy shock

(percentage points impact after a 1% depreciation in the nominal effective exchange rate)

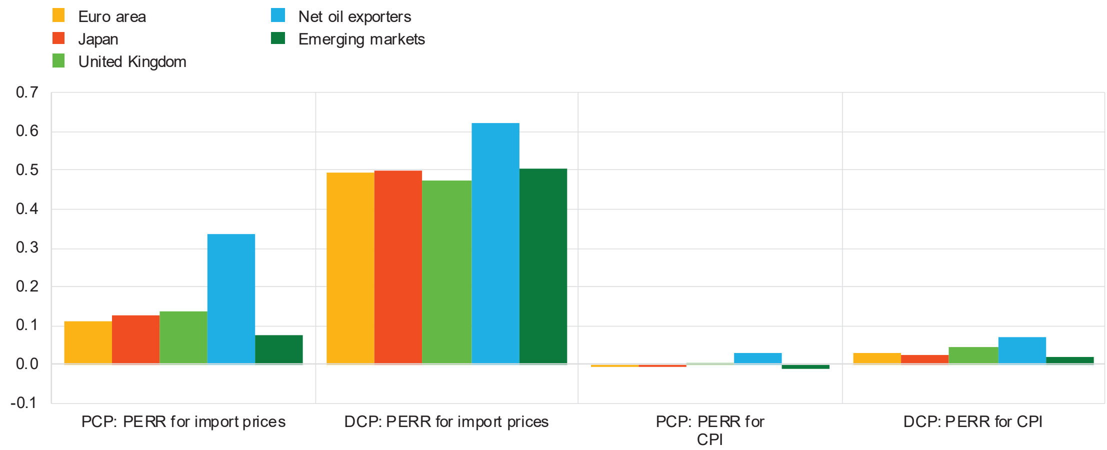


Source: ECB staff calculations.
Note: DCP, as introduced in ECB-Global does not take into account the role of the euro as the second largest currency of invoicing in global trade.

Chart B

PERR in the case of a US monetary policy shock

(percentage points impact after a 1% depreciation in exchange rate vis-à-vis the US dollar)



Source: ECB staff calculations.
Note: DCP, as introduced in ECB-Global, does not take into account the role of the euro as the second largest currency of invoicing in global trade.

5 Shock dependence of ERPT[48]

The previous section has illustrated why not every exchange rate movement is the same when it comes to evaluating its effect on prices. This point was taken up by policymakers just over a decade after the seminal academic contribution by Corsetti and Dedola (2005), when Kristin Forbes in 2016, then a member of the Monetary Policy Committee of the Bank of England, noted how "using rules of thumb for exchange rate pass-through could be misleading".[49] Overall, reduced-form estimates of ERPT to import prices using macro data can change across specifications and samples, as evidenced by the wide range of estimates discussed above. Estimates of pricing equations are better obtained from micro data when instruments for identification are available. It is even harder to rely on rules of thumb for the impact of exchange rates on consumer prices, not only because micro datasets on consumer prices are less available and usually less rich than those on trade prices, but also because of the complex mechanisms highlighted in the previous section: the constellation of shocks that move the exchange rate and the HICP at any point in time impinges on their co-movement.

There was a suggestion to "recombine" the shock-dependent impacts (PERRs) using as weights the importance of each shock in the historical decomposition of the exchange rate. However, this approach would not be straightforward either in theory or in practice, because it is very difficult to find a robust characterisation across models of the configuration of shocks that drive the exchange rate and prices at any point in time. This section illustrates this issue after reviewing the results from a set of alternative structural BVAR models and comparing them with those obtained using the structural models described in Section 4.

5.1 Shock-dependent impact of exchange rates in the euro area as determined using SVAR and DSGE models

The model comparison is performed using the PERR definition of exchange rate pass-through, i.e. the ratio of the impulse response function of prices to that of the exchange rate following each shock. The data cover a period from the 1990s to the most recent quarter available.[50] The Bayesian SVARs considered rely on sign and zero restrictions for identifying the shocks. This imposes parsimony on the models, but it is not possible to build an encompassing model featuring all the shocks we would be interested in (not least for computational reasons). As a consequence, the models differ in terms of the variables considered and the set of shocks that they are able to identify. Only some, i.e. Comunale and Kunovac (2017) and Forbes et al. (2018)[51]

---

48 We are very grateful to Luca Dedola for his comments and suggestions. For more details, see Comunale (2020).

49 See Vox.EU column by Forbes, K., Hjortso, I. and Nenova, T., 12 February 2016.

50 The latest observation is for the first quarter of 2019 for all models except for the model of Leiva et al. (2020) and Conti et al. (2017), for which estimation ends in the second quarter of 2019.

51 Forbes et al. (2018) is used here only as a robustness check and their identification is applied to the euro area case. As a result, it is important to note that the results for the euro area reported here are not taken directly from the Forbes et al. (2018) paper.

include import prices, but the first uses relative monetary policy of the euro area with respect to the United States[52], while the latter includes only the euro area monetary policy. Lastly, Leiva et al. (2020) use a measure of relative monetary policy, but do not include import prices in the model.[53] Conti et al. (2017) has only the euro area monetary policy as endogenous, while the US monetary policy is taken as an exogenous variable.[54] The SVARs also differ in terms of the exchange rate considered. The exchange rate is either the bilateral EUR/USD rate (Leiva et al. (2020) and Conti et al. (2017)) or broad nominal effective exchange rate (Forbes et al. (2018) and Comunale and Kunovac (2017)). These choices make the SVARs manageable and allow a combination of several identifications and data series to be studied. In what follows, PERRs following four common shocks are analysed and compared across the SVAR and DSGE models: an exogenous exchange rate shock, domestic demand and domestic supply shocks and a monetary policy shock.

For domestic demand shocks, in the less structurally constrained approach of SVARs, the sign of the PERR is always negative for consumer prices (see Table 5). In the fully structural DSGE models,[55] the endogenous monetary policy reaction and the general equilibrium effects trigger a rise in consumer prices after an expansionary demand shock despite the appreciation induced, while in the SVAR models the cheaper imports dominate the fall in consumer prices. With regard to import prices in the SVARs, we can see a negative sign only in the model by Comunale and Kunovac (2017). Lastly, domestic supply shock-driven ratios for consumer prices are negative in both the SVARs and DSGEs, declining after two years in the DSGEs.[56]

Overall, the dynamics of the impacts on consumer prices are larger and more persistent in DSGEs than in the SVARs considered. As the horizon increases, the PERR in DSGEs increases because of the endogenous response of monetary policy and other variables (causing, for example, the PERR to the demand shock to quickly turn positive in the DSGE). The PERR is generally much lower in SVARs than in DSGEs at horizons larger than four quarters from the shock. This may also be caused by the quick dynamics imposed in the sign restrictions of the SVARs, as most restrictions are imposed at impact. By contrast, the price rigidities embedded in the DSGEs slow down some responses: for instance, a reaction to monetary policy shocks needs more than one quarter to be transmitted.

For import prices, the DSGEs can be taken as a guide for the SVARs, as the sequencing in DSGEs is clear, for both the signs and the timing of the identification restrictions. Results for import prices can be obtained only from two of the available SVAR models (Comunale and Kunovac (2017) and Forbes et al. (2018)). These models have a rather different way of including monetary policy and global shocks, and yield different PERRs for import prices. They are therefore not robust. For

---

52 There could be issues with using relative monetary policy shocks; for evidence of asymmetries between the Federal Reserve System and the ECB, Jarociński and Karadi (2020).

53 This SVAR model has been also augmented with exogenous oil prices (SVAR-X approach).

54 These results come from an updated version of Conti et al. (2017) and the set-up includes the composite indicator of systemic stress (CISS) for the euro area.

55 It is important to recall that the results across DSGE models are quite heterogeneous for this shock, as pointed out in Section 4.

56 Only in the SVAR model by Conti et al. (2017) does the PERR from a domestic supply shock turn positive after four quarters.

Table 1

Empirical estimates for shock-dependent PERRs in the euro area

Impact after Q1 to Q12 of a 1% depreciation in the exchange rate (nominal effective exchange rate or EUR/USD)

(percentage points)

Type of shock	Horizon	Relative response of consumer prices to exchange rate change		Relative response of extra-euro area import prices to exchange rate change
		Median DSGE	Median SVAR	Median DSGE
Exogenous exchange rate	Q1	0.00	0.07	0.40
	Q4	0.10	0.07	0.80
	Q8	0.30	0.07	0.80
	Q12	0.50	0.07	0.80
Domestic demand	Q1	-0.10	-0.08	0.30
	Q4	0.20	-0.11	0.60
	Q8	0.40	-0.12	0.60
	Q12	0.60	-0.12	0.60
Monetary policy	Q1	0.10	0.07	0.40
	Q4	0.30	0.09	0.80
	Q8	0.60	0.10	1.00
	Q12	0.80	0.12	1.00
Domestic supply	Q1	-0.20	-0.05	0.30
	Q4	-0.30	-0.05	0.60
	Q8	-0.20	-0.04	0.60
	Q12	-0.10	-0.04	0.70

Source: Authors' calculations.
Notes: "Consumer prices" refers to HICP inflation in the SVAR models and to the private consumption deflator in the DSGE models. The median of the DSGEs is obtained from the euro area models provided in Table 3. The Suomen Pankki – Finlands Bank model, which includes both extra and intra-euro area imports, was not used to compute results for import prices; it is also did not provide the supply shock results. The median of the SVARs for consumer prices is obtained from results based on Comunale and Kunovac (2017), Leiva et al. (2020), an update of Conti et al. (2017) and the identification as in Forbes et al. (2018).

this reason, and for reference purposes only, the median for DSGE models is reported in Table 5.[57]

The identification schemes across the available SVARs differ, but are generally comparable and quite closely match (up to some unrestricted responses) those in the structural model of reference (see de Walque et al. (2017)). The one restriction that does not match between the SVARs and DSGEs is the impact of the domestic supply shock on inflation: in the SVARs, a restriction is imposed at impact to set-identify the supply shock from the demand shock, while in the DSGEs the effect at impact is not different from zero. The opposite signs for demand versus supply shocks to prices and quantities only appear and become substantial after three to four quarters.[58]

The PERR is larger for import prices than consumer prices in both the SVARs and DSGEs. In line with the results documented in the literature on ERPT and in this paper, the PERR declines substantially along the pricing chain.

57 The SVAR PERR results for import prices based on Comunale and Kunovac (2017) and identification as in Forbes et al. (2018) are provided in Comunale (2020).

58 This profile is probably not robust and very sensitive to small variations in the parameters set. With some parameter configurations, the decrease in domestic producer prices will dominate slightly in the HICP aggregation, while for others it will be the increase in import prices.

SVARs and DSGEs are more or less comparable in terms of short-run PERRs for UIP and monetary policy shocks. The highest PERR in the SVARs is estimated for monetary policy shocks (either domestic or relative), which is in line with the literature. This is especially true in Comunale and Kunovac (2017), who identify a relative euro area-US monetary policy shock. The results of the DSGEs show that the PERR for the exogenous exchange rate shock is particularly strong for import prices, while it tends to be smaller than the other shock-dependent PERRs for consumer prices.

Accounting also for time variation (as in Leiva et al. (2020)), exogenous shocks to the exchange rate seem to have passed to HICP inflation with more intensity since 2010. This is especially true for most of the old euro area countries. One possible explanation, worth exploring in future research, is that sharp movements in energy prices affect the pass-through of concomitant changes in the US dollar exchange rate. As for the euro area as a whole, the effect has remained rather constant, with the only exception of the global crisis period, when it was insignificant.

5.2 Historical shock decomposition of exchange rates: robustness and uncertainty

The previous section established that, in terms of shock-dependent PERRs, the results are qualitatively relatively robust across DSGEs and SVARs. The next question is: what is the constellation of shocks at any given time? The historical shock decomposition forms the “narrative” that a given model provides regarding the economic forces driving the economy. It turns out that it is much more difficult to establish the robustness of such narratives than it is for the shape of impulse responses and their ratios. This subsection shows the different historical decompositions resulting from the SVARs and the DSGEs. The SVARs offer historical shock decompositions of the exchange rate evolution depending on the different definitions of variables, identification schemes and specifications (see Comunale (2020)). The DSGEs can provide guidance by giving more discipline on the responses, explicitly modelling the transmission mechanisms and understanding the motivations behind such responses as discussed in Section 4.3. Comparing quarter-on-quarter decompositions across many models is not very appropriate because they are rather sensitive to the exact model specifications. This is possibly due to the use of different variables and/or identifications across models in order to account for monetary policy and global shocks.[59] However, an alternative way of seeing whether the results are at least qualitatively robust and isolating the shocks of interest is to report the cumulative historical decomposition for a specific episode of interest. For this exercise, the choice of episode should be guided by a qualitative assessment in terms of what shock caused the exchange rate to move.

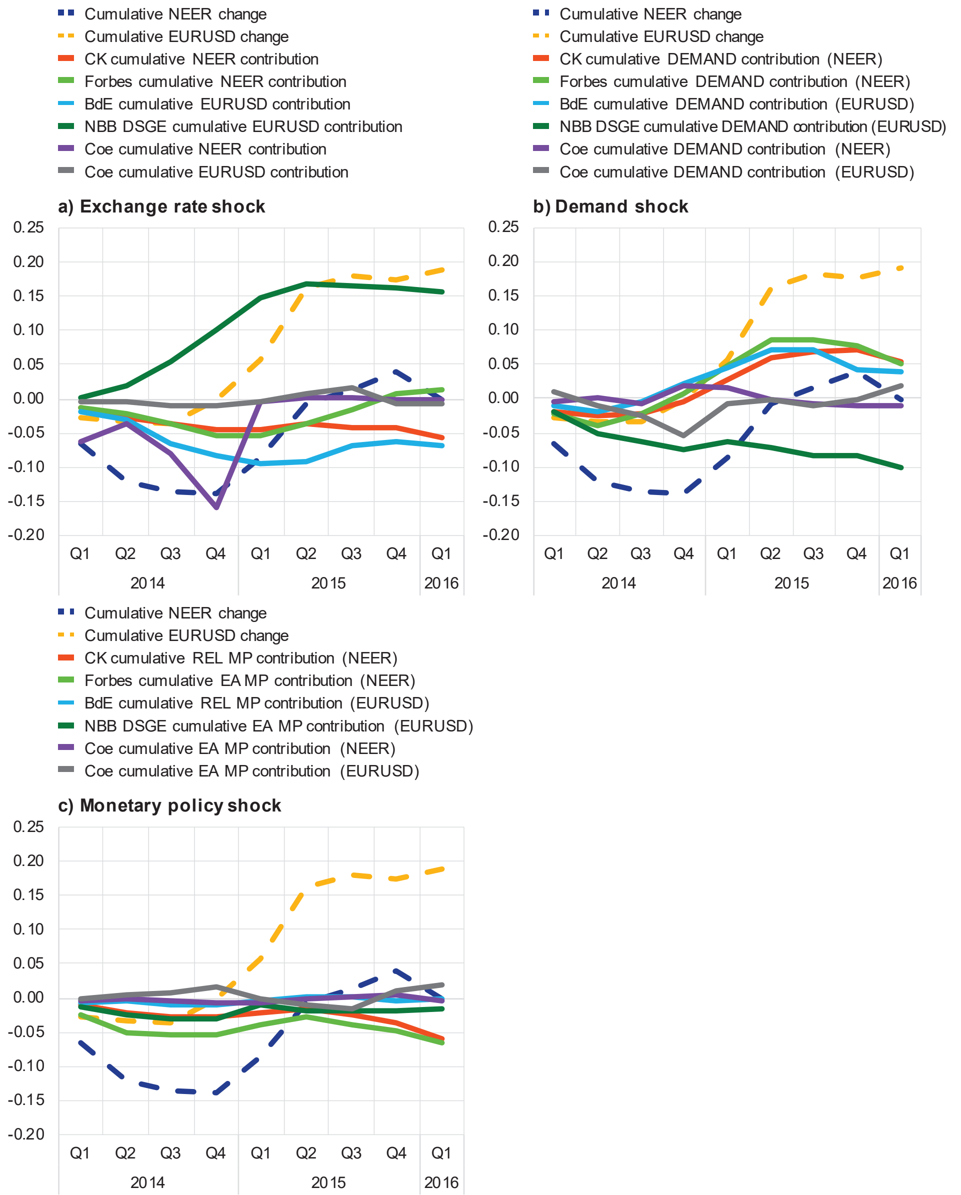
T**he period just before and following the announcement of asset purchase programme (APP) on 2 October 2014 enables an analysis of whether the models**

[59] For example, Comunale and Kunovac (2017) and Forbes et al. (2018) include in their models foreign export prices in order to model global shock, whereas Leiva et al. (2020) use exogenous oil prices. Conti et al. (2017) include exogenous US monetary policy, whereas in Comunale and Kunovac (2017) and Leiva et al. (2020), US monetary policy is embedded in the model via the relative monetary policy variable.

Chart 4

Robustness of historical shock decompositions: announcement of APP episode – SVARs and DSGEs

(percentage points, cumulated historical decomposition from Q1 2014 to Q2 2016)



Source: Authors' calculations.
Notes: "CK" refers to Comunale and Kunovac (2017). "Forbes" refers to the identification in Forbes et al. (2018). "BdE" refers to Leiva et al. (2020) and "Coe" is the updated version of Conti et al. (2017). "FX" refers to exchange rate shock, "REAL MP" refers to the relative monetary policy and "EA MP" refers to the euro area monetary policy. The results for the DSGE model show responses obtained from the Nationale Bank van België/Banque Nationale de Belgique (NBB) model of the euro area economy (see de Walque et al. (2017)).

agree qualitatively on the cumulative contribution of shocks to cumulative changes in exchange rates. The exchange rates started to appreciate after the third quarter of 2014 (EUR/USD) or the fourth quarter of 2014 (euro nominal effective exchange rate). In the DSGEs, the exchange rate shocks can anticipate depreciation one quarter ahead, and this is partially dampened by the appreciation as a result of demand shocks. In the SVARs, a contribution of foreign exchange rate shocks is most pronounced in the case of the NEER. All SVAR models find that the overall demand shocks explain a substantial part of the change in the exchange rate, while the monetary policy shocks play a minor role (see Chart 20). In the model by Comunale and Kunovac (2017), global shocks also seem to play a role (see Comunale (2020) for more detailed results).

5.3 Shock-dependent PERRs in euro area countries

The modelling challenges of analysing the shock-dependence of the impact of exchange rate changes become even greater when looking at individual countries. For DSGEs this is because they imply a big modelling effort in general and for SVARs the reason is that exchange rate and monetary policy shocks in the euro area cannot be identified using data from only one country.

Even bigger modelling challenges arise if we want to look at the shock-dependent impact of exchange rates on sub-components of the HICP or trade prices. It is useful to assess how HICP inflation and its sub-components (HICPX, non-energy industrial goods, services and real GDP), as well as import prices, react to the euro area shocks that can be identified via SVARs, i.e. exchange rate or monetary policy shocks. Moreover, the potential heterogeneous reactions across countries can also be informative.[60]

Having retrieved the common exchange rate and historical shocks from various SVARs and from the DSGEs, we perform a local projection exercise as in Jordà (2005) country by country.[61] In these regressions, the shocks appear without any lags, there are no lags for the dependent variable and there are no control variables. The HICP and some of its sub-components for all 19 euro area countries and for the euro area as a whole are regressed on a constant and a shock. The start of the sample coincides with the start of each shock or price series – depending on which is shorter – and the end date is always the first quarter of 2019. More specifically, we have different inflation measures (year on year) as dependent variable $\mathrm{Y_t}$ and the outcomes from common exchange rate and monetary policy shocks $\epsilon_{\mathrm{t,k}}$.The common monetary policy shocks can be of different types depending on which SVAR we consider. We can have only a euro area monetary policy shock (following Forbes et al. (2018) or the updated version of Conti et al. (2017)) or a relative monetary policy shock as in Comunale and Kunovac (2017) or Leiva et al. (2020). The shocks are quarter-on-quarter variations.

$$\mathrm{Y_t} = \alpha + \phi_{\mathrm{k}}\epsilon_{\mathrm{t,k}} + \varepsilon_{\mathrm{t}}$$

In the formula above, k refers to the shock (exchange rate or monetary policy). The different ϕ_{k} coefficients will therefore be specific for each euro area country and the euro area as a whole.

60 Recently a similar idea/approach has been used for potential output and demand/supply shocks in Coibion et al. (2018) and also applied for ERPTs in the euro area in a time-varying framework in Leiva et al. (2020).

61 The exercise has also been done running simple regressions (not with local projections) with monetary policy and exchange rate shocks added together, because they are orthogonal with lags from 0 to 4. The results are comparable to those resulting from local projections, especially in terms of the differences between the new and old member countries and between the HICP and the HICPX. The results are available in Comunale (2020).

The impact of exchange rate shocks on HICP inflation is slightly larger in some new euro area countries, such as the Baltic States, but the range of estimates across models is wide. The results for euro area monetary policy shocks are similar. Using the relative monetary policy shocks instead, there is some heterogeneity across SVARs, not only in the new member countries, but also in some of the older ones. HICP inflation in Italy, France and Germany react basically in the same way as the euro area as a whole to relative monetary policy shocks.

Compared with HICP inflation, the coefficients for an exogenous exchange rate shock and for a relative monetary policy shock for HICP inflation excluding energy and food are generally lower. More specifically, they are very close to zero for most of the older euro area countries in the case of exchange rate shocks. Looking at the components, it seems that the pass-through of exchange rate shocks to the HICPX is small because of both sub-components, i.e. the prices of services and of non-energy industrial goods.[62]

Using the time-varying parameter dynamic factor model (as in Leiva et al. (2020)) to assess cross-country heterogeneity, the estimates indicate a generalised and persistent increase in the effect of exogenous exchange rate shocks on inflation around 2010 across euro area countries. This is especially the case in Spain, but also in Italy, France and Germany. For the euro area as a whole, by contrast, the effect has remained relatively stable, which implies an increase over time in the synchronisation of HICP dynamics for most of the euro area countries. With regard to the HICP components, the increase in the effect of exchange rate shocks on inflation since 2010 has been significant for energy prices. However, it has been rather weak and more uncertain for food prices. Again, the increase responses around 2010 could be partly related to the role of energy prices; more research into this is warranted, however.

As for the HICPX, the effect is both negligible and very uncertain across countries. However, the co-movement of HICPX inflation across euro area countries is not very strong, and in the Baltic States the co-movement in this measure of underlying inflation has even decreased over time.

62 The non-energy industrial goods price index is the reason for the zero pass-through to the HICPX in most cases, but not in Malta and Slovakia. In this analysis, however, the measure of underlying inflation is the HICPX, but there are other measures which may yield different results (see, for example, ECB (2018)). However, a thorough analysis of these other measures requires further research.

6 Implications for monetary policy

The exchange rate in open economies plays a dual role in monetary policy. On the one hand, nominal exchange rate shocks are a source of inflation fluctuations and monetary policy should react to them to achieve the goal of price stability in the medium term. Hence, the degree to which exchange rate shocks are passed through to inflation are important for policy-setting in open economies. On the other hand, the exchange rate is also a channel through which monetary policy stabilises inflation.

First, this section looks at the exchange rate as a channel of conventional and unconventional monetary policy transmission, for both the ECB and the Czech Republic, an EU Member State with an independent monetary policy. Second, it discusses new results on the impact of forward guidance, and third, it provides a review of recent work on the role of exchange rates in transmitting the effects of quantitative easing.

6.1 The exchange rate as a channel of monetary policy transmission

In a prototype New Keynesian open-economy structural model, there are two main channels through which monetary policy affects inflation. First, there is the standard inter-temporal channel that operates through the Euler equation.[63] Second, in open economies, an increase in the policy rate also leads to a temporary exchange rate appreciation, which is an additional anti-inflationary factor.[64]

The strength and the speed of the transmission of monetary policy through the exchange rate channel depend on a number of features of the economy. Obviously, it depends on the proportion of imported goods in the final consumption bundle, as well as on the transmissions and wedges discussed in Section 4. Less obviously, but equally importantly, it also depends on the policy itself.

To highlight this point, consider the framework from Section 4, which is underpinned by an equation for imported prices $p_{F,t}$ as a function of the exchange rate s_t, marginal costs mc_t^* and expected terms:

$$p_{F,t} = \frac{1}{z_1}(s_t + mc_t^*) + \frac{z_2}{z_1}p_{N,t} + \frac{z_3}{z_1}\left(\beta E_t p_{F,t+1} + p_{F,t-1}\right)$$

63 This channel works as follows: an increase in policy rates leads agents to postpone consumption, which cools aggregate demand, and through nominal rigidities the fall in aggregate demand leads to a decline in inflation.

64 This is due to the uncovered interest rate parity (UIP). In its simplest form, which equates the expected exchange rate change with the interest rate differential, the UIP equation dictates that an unexpected policy hike prompts a jump appreciation that would be followed by a gradual depreciation. In more elaborate policy models, the UIP equation is often modified by a smoothing term and/or by an endogenous risk premium term. These terms ensure that the impulse response of the exchange rate to a policy hike has a profile that is closer to the “conventional wisdom”, i.e. the hike first prompts a gradual appreciation that is then also followed by a gradual depreciation.

This equation can be iterated forward, showing that the imported prices depend on the expected profile of all future exchange rate levels:

$$p_{F,t} = \frac{1}{z_1} E_t\left[(s_t + mc_t^*) + \beta z_3 (s_{t+1} + mc_{t+1}^*) + \beta^2 z_3^2 \quad (s_{t+2} + mc_{t+2}^*) + \cdots\right] + other\ terms$$

If agents know that monetary policy reacts aggressively to external inflationary shocks (such as foreign price shocks or UIP shocks), they expect interest rate changes that will move the exchange rate so that import prices return to their steady-state values. Hence, such shocks will have a relatively low impact on import price inflation if the policy is expected to react aggressively.[65] Therefore, the aggressiveness of the policy is an important determinant of the ERPT. If the policy reacts credibly and systematically to inflationary and disinflationary exchange rate movements, the observed (reduced-form) relationship between exogenous exchange rate movements and domestic inflation may be relatively weak, implying a low ERPT. Indeed, this theoretical mechanism that relates credibility of monetary policy and low ERPT has been confirmed by a number of empirical studies (e.g. Carrière-Swallow et al. (2016)); recently McLeay and Tenreyro (2019) made the same point about the Phillips curve.

This framework can also explain one of the reasons behind the shock-dependency of ERPT described in Sections 4 and 5. Exchange rate shocks that are more permanent in nature (or that are perceived as such by economic agents) would have a larger impact on import prices and hence on overall inflation. This is due to the presence of expected future exchange rate levels in the equation for $p_{F,t}$ above.

This framework also explains why ERPT differs for various monetary policy scenarios. Consider monetary policy in a situation of an effective lower bound (ELB) on interest rates facing an anti-inflationary shock, such as an appreciation in the domestic currency. If policy rates cannot fall, the endogenous exchange rate stabilisation channel is lost. The appreciation shock would imply a higher and more persistent fall in import prices, and hence in overall inflation, than in the case of unconstrained policy. Obviously, this is an overly simplified view, as the central bank can influence the term structure of interest rates with instruments other than the policy rate. Indeed, the recent literature confirms that non-conventional monetary policy easing leads to a nominal depreciation, albeit potentially with more complex patterns, as the effects of shocks depend on the way they affect agents' expectations (see Inoue and Rossi (2019)).

Finally, this framework bears an additional important policy message. Since ERPT depends on the nature of the monetary policy, it is not appropriate to conclude that if ERPT is small then exchange rate movements are not important for inflation and for monetary policy. On the contrary, when monetary policy internalises the effects of exchange rate movements, the ERPT estimated ex post by reduced-form equations may seem small.

65 The exchange rate channel is also important for domestic inflation shocks. The hike after a domestic inflation shock would imply an exchange rate appreciation and hence a fall in import prices, which would counterbalance the domestic inflation pressures. Under a systematic inflation targeting policy, this may lead to the inverse statistical relationship between non-tradable goods price inflation and the exchange rate.

6.2 The exchange rate channel under forward guidance

During its APP and with the main policy rate at the effective lower bound, the ECB used forward guidance quite extensively to provide economic agents with information on its future policy stance. The forward guidance of the ECB contained information on its intentions with regard to the future path of interest rates after the end of the APP, as well as guidance on the APP itself. As far as guidance on interest rates is concerned, the ECB credibly committed to keeping interest rates low in order to ultimately boost economic activity through the expectations of the private sector. As long as the economic prospects for the economy in the euro area remained weak, the ECB included remarks in its official communication to the press that pointed either directly (i.e. Odyssean forward guidance) with an explicit time frame or indirectly (i.e. easing bias) to interest rates being kept at a low level.

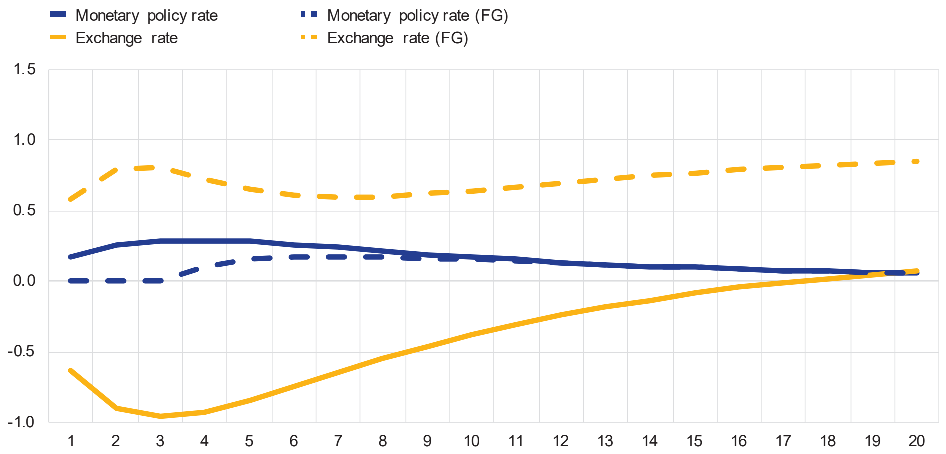
The experiments in the DSGE models described in Section 4 also considered forward guidance, restricting the focus to pure Odyssean forward guidance on the future path of the policy rate. In all experiments, forward guidance is considered to be a credible announcement by the ECB to keep the policy rate constant at its baseline level during the initial three quarters (we consider a rather small number of quarters to avoid the forward guidance puzzle).

The announcement by the ECB, in this case, states explicitly the time frame within which the policy rate will remain at the baseline (i.e. steady-state) level, as well as the magnitude of the increases following the exit from the zero lower bound. The latter element is consistent with the assumption, inherent in all the DSGE models considered, that agents have a perfect knowledge of the interest rate rule of the central bank.

Chart 21

Expansionary aggregate demand shock and three-quarter forward guidance (FG) in the euro area: interest rate and the exchange rate

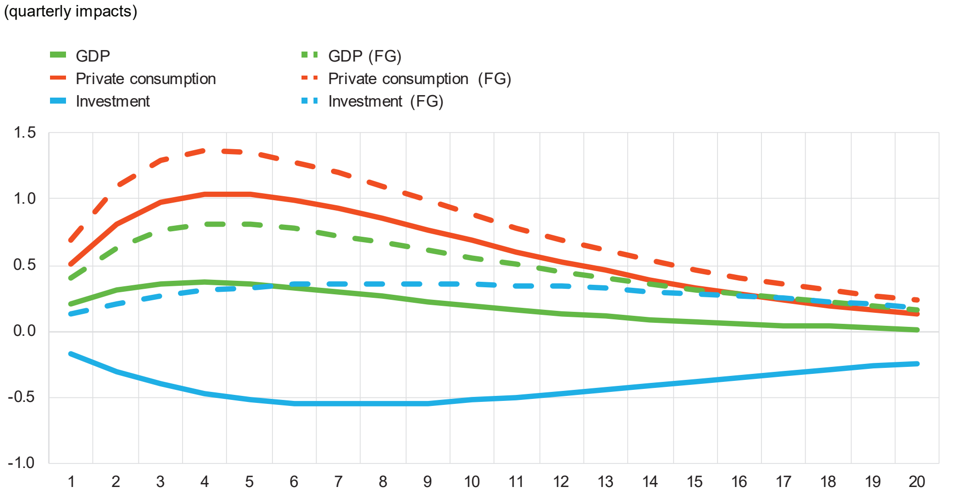
(quarterly impacts)



Source: Authors' calculations using the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)).
Notes: An aggregate demand shock is simulated as a 1% unexpected increase in consumption preference and the shock follows an order one autoregressive process with persistence set at 0.9. The impulse response functions show as percentage point deviations from the steady-state values for the exchange rate, and from the absolute values for the monetary policy rate. The monetary policy rate reaction is annualised.

Chart 22

Expansionary aggregate demand shock and three-quarter forward guidance (FG) in the euro area: real variables



Source: Authors' calculations using the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)).
Notes: An aggregate demand shock is simulated as a 1% unexpected increase in consumption preference and the shock follows an order one autoregressive process with persistence set at 0.9. The impulse response functions show as percentage point deviations from the steady-state value of each variable.

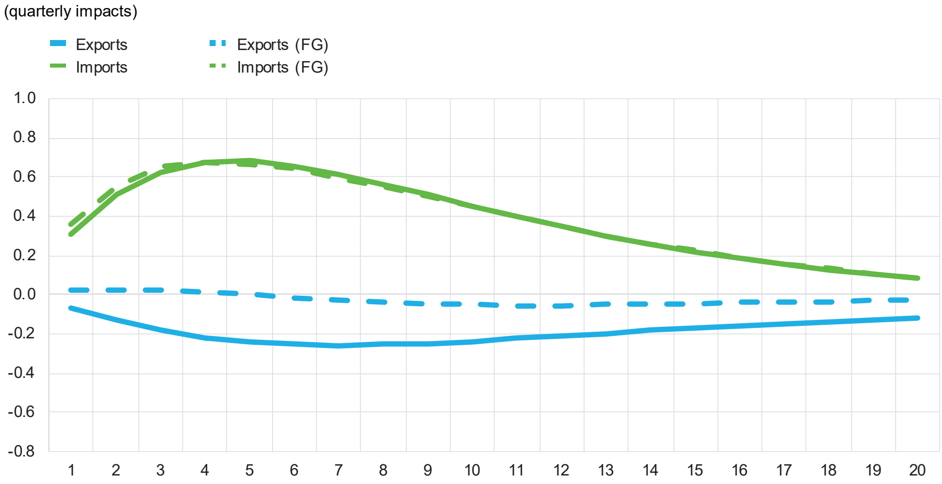
We consider a consumption preference shock only, given that its inflationary nature allows for a policy rate rise upon exit from forward guidance. Charts 21-24 report the responses of the main macroeconomic variables. The shock stimulates aggregate demand. Both consumption and consumer prices increase (prices increase to a lower extent, because of short-run nominal rigidities). Total consumer prices increase owing to a high home bias of domestic goods in the consumption basket.

As also explained in Section 4, under a standard monetary policy rule (i.e. the Taylor rule always holds), the domestic central bank raises the monetary policy rate thus increasing the real interest rate. This stabilises domestic demand and inflation. Given the greater preference for consumption and higher interest rates, investment persistently decreases. The domestic monetary policy rate is persistently higher than the foreign policy rate, inducing domestic agents to increase demand for domestic relative to foreign assets. As domestic assets are denominated in domestic currency and foreign assets in foreign currency, the domestic nominal exchange rate appreciates immediately. This appreciation triggers a decrease in the (domestic currency) prices of imported goods. Owing to LCP and distribution services, import prices do not decrease as much as the exchange rate appreciates (mark-ups adjust). Furthermore, given the increase in local aggregate demand, the pass-through to import prices is incomplete. The overall impact of the exchange rate change on consumer prices is negative, because the nominal exchange rate appreciates while consumer prices increase.

By contrast, under a three-quarter forward guidance, the domestic monetary policy rate is initially kept constant, and given the higher initial overall consumer price inflation, the real interest rate decreases. Now, the real interest rate drops during these first three quarters, which allows private consumption and investment to increase further after the shock (investment increases under forward guidance,

Chart 23

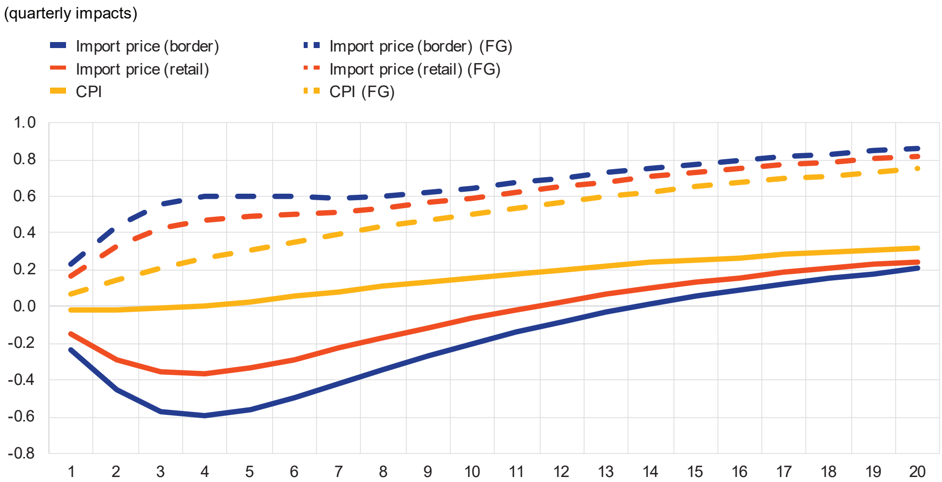
Expansionary aggregate demand shock and three-quarter forward guidance (FG) in the euro area: external trade



Source: Authors' calculations using the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)).
Notes: An aggregate demand shock is simulated as a 1% unexpected increase in consumption preference and the shock follows an order one autoregressive process with persistence set at 0.9. The impulse response functions show as percentage point deviations from the steady-state value of each variable.

Chart 24

Expansionary aggregate demand shock and three-quarter forward guidance (FG) in the euro area: import and consumer prices



Source: Authors' calculations using the Nationale Bank van België/Banque Nationale de Belgique model of the euro area economy (see de Walque et al. (2017)).
Notes: An aggregate demand shock is simulated as a 1% unexpected increase in consumption preference and the shock follows an order one autoregressive process with persistence set at 0.9. The impulse response functions show as percentage point deviations from the steady-state value of each variable.

instead of decreasing as under standard monetary policy); thus, economic activity and inflation increase further (amplification effect).

Higher euro area aggregate demand stimulates euro area imports (see Chart 23), inducing an expansionary spillover to the foreign economy. The foreign central bank increases its monetary policy rate immediately. The induced nominal exchange rate depreciation, in this case, is triggered by the higher foreign interest rates (euro area households increase their demand for foreign currency-denominated assets), given that monetary policy in the euro area is assumed to keep rates at the effective lower bound. Ceteris paribus, the depreciation induces an increase in imported prices. Moreover, under LCP and local distribution services, the larger (than under standard monetary policy) increase in aggregate demand favours, together with the exchange rate depreciation, the larger increase in the prices of imports and domestic goods and, thus, in total consumer prices (see Chart 24).

When computing the PERR under forward guidance, the seven models representing the euro area in Section 4 converged towards larger average and median PERRs than under standard monetary policy. In particular, PERRs increase quickly in the quarters during forward guidance and then stabilise close to unity in the medium run. Under standard monetary policy, however, the PERR for consumer prices turns negative in the medium run.

The results under forward guidance reveal that the monetary policy stance is very relevant for the overall interaction of exchange rates with prices throughout the pricing chain. In general, the weaker the reaction of the standard policy rule to inflation fluctuations, the stronger the consequences of forward guidance on imported inflation.

6.3 The APP and its effects on the exchange rate

In addition to forward guidance on its policy rate, in order to address the risks of an overly prolonged period of low inflation, the ECB adopted a set of additional non-standard measures under the umbrella of the expanded APP. In an integrated global financial system, non-standard monetary policy measures trigger large cross-border capital flows (portfolio rebalancing channel). Expectations of compressed term premia can offset, or mitigate, the impact of changes in expectations about future short-term rates on exchange rates. This is due to the fact that asset purchases are monetary policy actions that can be anticipated by market participants, just like changes in key policy rates. However, unlike standard monetary policy, they have direct implications for the expected supply of and demand for internationally traded bonds and, hence, for the level of the exchange rate that, all other things being equal, clears the resulting capital flows. Dedola et al. (2018) document empirically the effectiveness of the ECB’s non-standard monetary policies on the exchange rate and their transmission to prices and economic activity. They find that the response of exchange rates is due predominantly to risk premia and signalling, but with relatively muted effects on inflation and output.

Coenen et al. (2018) extend the New Area-Wide Model with a financial sector in order to gauge the effects of the expanded APP as announced in January 2015. In their set-up, asset purchases are inflationary (as measured by consumer price inflation) and boost economic activity. Importantly, the nominal exchange rate depreciates. Therefore, inflation and the nominal exchange rate move in the same direction. Although the authors do not measure exchange rate pass-through following asset purchases, their results point towards a non-negligible pass-through of the exchange rate to consumer prices. However, this outcome is driven mainly by the assumption of PCP, as opposed to the LCP assumption that was maintained in the models originally simulated in Section 4 of this paper. Similarly, Bokan et al. (2016) simulate the EAGLE-FLI model to assess the impact of the expanded APP. Focusing on the ECB's private sector purchase programme (PSPP), the results are similar in terms of output and inflation in the euro area to those of Coenen et al. (2018). Asset purchases are expansionary leading to inflationary pressures, while the exchange rate also moves towards the same direction as consumer prices, namely it depreciates. However, the EAGLE-FLI model is richer in terms of the regions considered and also rests on different assumptions regarding export pricing. In particular, the model assumes LCP. As a result, the model predicts a lower cumulative pass-through of the nominal exchange rate to consumer and import prices.

Darracq Pariès and Papadopoulou (2019) extend the six-region multi-country global DSGE model of Darracq Pariès et al. (2016) with credit and exchange rate channels of central bank asset purchases in order to explore the country-specific macroeconomic transmission of the ECB's PSPP with a rich financial sector and global portfolio frictions. Simulations based on the initial PSPP (as announced in January 2015) and subject to an ELB constraint show that global portfolio frictions have a significant influence on the magnitude of the macroeconomic multipliers and the typology of the transmission mechanism. The presence of global portfolio frictions triggers a stronger exchange rate depreciation and weakens the strength of the bank-centric term spread channel, therefore leading to a smaller and less persistent compression of sovereign yields, and a reduced peak easing effect on bank lending rate spreads, resulting in the investment boom being less credit intensive. With regard to consumption, heterogeneous import content across regions generates asymmetric profiles across countries owing to varying imported inflation effects. Overall, the expansionary impact on output and inflation increases, with the additional stimulus stemming from the trade channels of the exchange rate depreciation. Lastly, the improved macroeconomic conditions as a result of the larger exchange rate depreciation imply a significant shortening of the period where the ELB binds, therefore bringing the lift-off date forward. Although the authors do not measure explicitly the exchange rate pass-through to consumer prices after the PSPP, similar to Coenen et al. (2018) the results point towards that being non-negligible.

Box 6
The exchange rate as a non-standard policy measure: the Czech case

Prepared by Jan Brůha (Česká národní banka)

During the economic slowdown that followed the global economic crisis, two European countries – the Czech Republic and Switzerland – used the exchange rate floor as a tool of unconventional monetary policy. In both cases, the introduction of the floor meant there was a significant depreciation in the exchange rate and therefore these episodes are of interest for the study of the impact of exchange rate movements on prices and inflation. This box describes the Czech experience.

After the outbreak of the Great Recession in 2008, Česká národní banka gradually eased the monetary conditions by lowering its policy rate. The rate hit "technical zero" in autumn 2012, and thereafter the bank used forward guidance to further ease the monetary conditions. This, however, was not sufficient, as the 2013 inflation forecasts were predicting that inflation would turn negative in 2014. Thus, on 7 November 2013 Česká národní banka introduced an exchange rate floor for the Czech koruna: it committed to keeping the CZK/EUR exchange rate weaker than the floor of 27

CZK/EUR. The rationale behind that decision was to prevent the risk of deflation in a zero-lower-bound environment where policy rates could not be lowered any further.

The introduction of the exchange rate floor caused the Czech koruna to depreciate from 25.8 to 27 CZK/EUR (i.e. by about 5%) in just a few hours after the floor had been announced. From then on, the exchange rate was weaker than, or close to, the floor. The floor was perceived as a credible and long-lasting commitment. Despite the introduction of the floor, inflation remained very low and well below the inflation target. This was attributed to strong deflationary tendencies in the euro area and to a fall in food and energy commodity prices. These factors outweighed the effects of the weakening of the nominal exchange rate. Owing to the low, below-target inflation and the threat that a sustained period of low inflation might affect inflation expectations, the duration of the exchange rate floor was prolonged several times and it was maintained until April 2017.

Although inflation remained low, this does not mean that the floor did not increase it: without the floor, inflation may have been even lower. Several studies have investigated the effect of this 5% depreciation on inflation. Using a difference-in-difference estimator, Caselli (2017) finds that the floor drove up consumer inflation in 2014 and 2015 by around 0.5 percentage points to 1.0 percentage points depending on the model specification. These numbers are confirmed by Brůha and Tonner (2017) using the synthetic control method. The DSGE model simulations performed by Brůha and Tonner (2017) suggest even higher effects: 1.2 percentage points in 2014 and 1.8 percentage points in 2015.

Even the lowest estimates of 0.5 percentage points mean that, without the floor, inflation would have been negative – the introduction of the floor prevented deflation and therefore this policy action can be retrospectively be viewed as having been successful. Moreover, the estimates are higher than 0.2 percentage points for consumer inflation, which is what Česká národní banka's main model implies for a temporary 5% depreciation in normal times (i.e. in times when policy offsets inflation shocks).

All in all, the strong effects of the exchange rate floor on inflation suggest that the exchange rate can be successfully used as a monetary policy tool in small open economies in times when these economies face a deflation risk in a low interest rate environment. The effects of the exchange rate on inflation are stronger and longer lasting than what would be suggested by the ERPT during normal times.

7 Conclusions and implications for tools in the monetary policy process

What are the lessons learned for the policymaker? Do the results and insights in this paper have useful implications for the policy process, including inflation forecasting? All central banks run inflation-forecasting exercises, in which exchange rates can play an important role. The exchange rate itself is typically assumed to be a random walk, hence is kept fixed over the forecast horizon. This section briefly provides insights into how best to incorporate the impact of exchange rate changes into inflation projections.

One overarching result of the studies summarised in this paper is that simple reduced-form regressions cannot be trusted to provide rules of thumb. This is not just because of the conceptual problems associated with shock-dependence and with the reaction of monetary policy, which are explained in Sections 4 to 6. Empirical estimations conducted for this paper revealed that the results generated by "run of the mill" reduced-form regressions based on macro data are very sensitive to specification, in particular in terms of the lag length and the estimation sample. Different methodologies can also provide results that are quantitatively quite different, even if they broadly agree qualitatively.

What is the practical modelling lesson to be drawn? If the object of interest is the structural parameter in the pricing equation, then using micro data and having instruments to identify exchange rate shocks is necessary for estimating the impact of exchange rate changes on the pricing of imports. In order to evaluate the final impact on consumer prices, it is very important to use models that enable the effect of all shocks and the monetary policy response to interact. DSGEs do this in a fully structural way and also make it easier to gauge the sensitivity of the results to assumptions about some structural features of the economy, which are summarised by specific parameters. VARs are constrained on the sequence of the reactions and may give more useful results if the restrictions used to identify them are disciplined by the common patterns found in the DSGE, not only in terms of the signs, but also the timing.

In terms of specific results, and with the caveat of the sensitivity of reduced-form results to samples and specifications, the results of the cross-country empirical studies show a very muted response of HICPX inflation to exchange rate changes. Does this mean that the exchange rate does not have much strength as a monetary policy transmission channel? In addition to the discussion in Section 6.1 on how to interpret seemingly low empirical estimates and the role of monetary policy, it is important to note that exchange rate changes also affect inflation via the expectation channel. In this respect, the Results of the third special questionnaire for participants in the ECB Survey of Professional Forecasters (2019) are quite reassuring: in answer to the question "What would be the impact on your forecasts of a permanent 10% increase in the EUR/USD exchange rate?", the average reply was an upward effect on inflation of 0.2 percentage points after a year and 0.4 percentage points after two and three years.[66]

[66] These figures differ from those reported in the ECB article on the special questionnaire because they are calculated only on respondents who gave an answer for all three horizons.

An additional original contribution of this paper is a survey conducted among the national central banks (NCBs) of the European System of Central Banks (ESCB). The aim of the survey was to gain insights into the models used to construct the baseline projections and whether (and how) they account for some of the aspects investigated in the previous sections. Specific questions addressed the issue of non-linearity, integration in GVCs and shock-dependence (the results are summarised in Box 7).

The models surveyed do not incorporate non-linearity, except in some cases in relation to the non-linearity in the treatment of the oil price, which encompasses the USD/EUR exchange rate. This is not a major concern in the light of the results of this paper, as non-linearity seems to be rather occasional than pervasive in the results across countries. The main lesson to be drawn by forecasters is that, in the case of large sharp exchange rate movements, it could be worth making a judgement call, if not on the baseline, on the balance of risks.

An important caveat of the models used to produce projections across the ESCB is that none of them take into account integration in GVCs.[67] To account for GVC integration in the models is extremely difficult given the complexity of the data requirements, however ignoring it may lead to biased results. This is confirmed by the sensitivity analysis performed with the DSGE for the euro area by the Nationale Bank van België/Banque Nationale de Belgique, which has a flavour of GVC integration by accounting for international production-sharing, albeit without accounting for higher-order network effects. The simulations that exclude the observed import content of exports and production in the euro area yield higher PERR for consumer prices, i.e. GVCs reduce the pass-through.

This integration in GVCs must also be viewed in conjunction with the predominant use of very few international currencies, mostly only the US dollar and the euro, in the invoicing of international trade. The data challenge in quantifying these effects exactly is big, but the qualitative results suggest that structural models might overestimate the ERPT in their pricing equations by not taking into account the endogeneity of partners' local costs to changes in the euro exchange rate, which is one of the two dominant invoicing currencies.

At the same time, the large proportion of pricing in US dollar and the euro in invoicing may cast doubt on the use of trade-weighted effective exchange rates, or at least call for the parallel computation of invoice-weighted exchange rates. Practically, when the effective exchange rate moves because of sharp changes in a non-dominant currency, this may warrant again a judgement call diminishing its expected effect. This might be the case, especially when emerging market economy currencies move sharply, for example the Turkish lira's volatility from August to November 2018. Unfortunately, the scope for going further in this direction in the short term is limited by data availability.

One big concern that had been raised in the past few years in policy circles is that of the shock-dependence of ERPT. This went as far as calling for abandoning any rule of thumb, whereas some authors tried to argue that the rules should be redefined in terms of relative contributions of shocks to movements in the exchange

67 This was the case at the time of the survey (which was conducted in the course of 2018).

rate. The analysis presented in this paper cautions against this temptation given not only theoretical considerations but also, more pragmatically, the difficulties in finding robust results on exactly what shocks drive macroeconomic variables at any point in time.

The use of large semi-structural models for inflation projections insures, at least partly, against the danger of rules of thumb. Rich models are equipped to capture these effects as long as they are used in their entirety and not in part. The practice of also using DSGEs and VARs as satellite models or to cross-check the projections also insures against biased estimations of the effect of exchange rates.

Finally, the comparison of the co-movement between exchange rates and inflation under standard monetary policy and forward guidance has illustrated that the duality of the exchange rate as a source of shocks and a transmission channel of policy makes it difficult to rely on simple empirical regularities when assessing the impact of a given exchange rate movement. This again supports the case for using structural models for scenario analysis and for enhancing them where possible, adding some of the structural features highlighted above.

Box 7
Underlying characteristics of the main models used for the Eurosystem macroeconomic projection exercises

Prepared by Matthias Hartmann (Deutsche Bundesbank)

This box summarises the responses to a survey among national central banks (NCBs) in the European System of Central Banks (ESCB). The survey was conducted with the aim of shedding light on how policy models currently used across the ESCB for macroeconomic projection exercises account for the exchange rate pass-through (ERPT) to the domestic economy. Overall, the responses of 26 NCBs indicate that exchange rates are mostly exogenous variables in the models that focus on the domestic economy and that most models entail similar mechanisms of ERPT. Important transmission channels include import prices, energy (mostly oil) prices, measures of competitiveness and producer prices. The potential dependency of ERPT on the shocks underlying the exchange rate changes is in most cases addressed by means of judgement. Asymmetries and non-linearities were reported in a few cases, i.e. the models mostly feature different elasticities for different levels of the oil price in euro

Out of the 26 responses, most NCBs (21) said that they use so-called traditional macroeconometric models to construct their macroeconomic projections, while the others use DSGE models as the main tool. Nineteen of these models include the respective economies' effective exchange rate, whereas the bilateral exchange rate against the US dollar enters 15 NCB models. The estimation samples of the models mostly cover relatively recent data; however, the start dates of the sample periods differ, the earliest being 1975 and the latest 2012.

In most models, the exchange rate is treated as exogenous. Most of the others embed the exchange rate via uncovered interest parity conditions, partly by also allowing for persistence in the exchange rate or an influence of global demand conditions. In one case, a variant of a currency peg is mentioned.

The influence of exchange rates on inflation in the NCBs' models can be narrowed down to a small number of channels. The NCBs' answers show that five particular channels of influence are most frequently present in the models. These include (i) the import price channel (mentioned

19 times); (ii) the foreign exporters' price channel (23); (iii) the energy price channel (7); (iv) the domestic demand channel (primarily via household expenditure), ultimately affecting the output gap and inflation via the Phillips curve (12); and (v) a further type of Phillips curve channel with producer prices as the primary source of marginal costs (9). Only five NCB models entail specifications for intermediate goods. Mark-ups were mentioned in four cases. Furthermore, two NCBs stated that their models feature profits. A distribution sector was not highlighted as part of any model.

Only about one-third of the participating NCBs stated that they incorporate some sort of asymmetry and non-linearity when modelling ERPT. First, from a total of eight NCBs mentioning the importance of asymmetries, four regard ERPT as being dependent on agents' perceptions about the duration of the underlying shocks. These shocks might be regarded as either permanent or transitory or also as mere noise, as opposed to being of a more fundamental nature. This results in a signal-extraction problem that should have an impact on the ERPT mechanism. Second, the impact of shocks to the bilateral (versus the US dollar) exchange rate on inflation and GDP growth depends on the level of the oil price (in euro) when the shock occurs. This is due to the high share of taxes in the final consumer price of petrol. Third, some NCBs use judgement to account for a range of potential additional influences on ERPT in their projections.

Bibliography

Adolfson, M., Laséen, S., Christiano, L., Trabandt, M. and Walentin, K. (2013), “Ramses II – Model Description”, *Occasional Paper Series*, No 12, Sveriges Riksbank, February.

Amiti, M., Itskhoki, O. and Konings, J. (2014), “Importers, Exporters, and Exchange Rate Disconnect”, *American Economic Review*, Vol. 104, No 7, July, pp. 1942-1978.

Andrle, M., Hlédik, T., Kameník, O. and Vlček, J. (2009), “Implementing the New Structural Model of the Czech National Bank”, *Working Paper Series*, No 2/2009, Česká národní banka, September.

Antoniades, A. and Zaniboni, N. (2016), “Exchange Rate Pass-Through into Retail Prices”, *International Economic Review*, Vol. 57, No 4, November, pp. 1425-1447.

Auer, R.A. and Schoenle, R.S. (2016), “Market structure and exchange rate pass-through”, Journal of International Economics, Vol. 98, January, pp. 60-77.

Auer, R., Chaney, T. and Sauré, P. (2017), “Quality Pricing-to-Market”, *BIS Working Papers*, No 657, Bank for International Settlements, August.

Bacchetta, P. and van Wincoop, E. (2005), “A theory of the currency denomination of international trade”, *Journal of International Economics*, Vol. 67, No 2, December, pp. 295-319.

Ben Cheikh, N. (2012a), “Non-linearities in exchange rate pass-through: Evidence from smooth transition models”, *Economics Bulletin*, Vol. 32, No 3, pp. 2530-2545.

Ben Cheikh, N. (2012b), “Asymmetric exchange rate pass-through in the euro area: new evidence from smooth transition models”, *Economics*, *The Open-Access, Open-Assessment E-Journal*, Discussion Paper, No 2012-36, July.

Ben Cheikh, N., Ben Zaied, Y., Bouzgarrou, H. and Nguyen, P. (2018), “Nonlinear Exchange rate pass-through: does business cycle matter?”, *Journal of Economic Integration*, Vol. 33, No 2, June, pp. 1234-1260.

Ben Cheikh, N. and Rault, C. (2017), “Investigating first-stage exchange rate pass-through: Sectoral and macro evidence from euro area countries”, *World Economy*, Vol. 40, No 12, May, pp. 2611-2638.

Berger, D., Caballero, R. and Engel, E. (2017), “Missing Aggregate Dynamics: On the Slow Convergence of Lumpy Adjustment Models”, *Working Paper Series*, No 446, Department of Economics, University of Chile, July.

Berman, N., Martin, P. and Mayer, T. (2012), “How do Different Exporters React to Exchange Rate Changes”, *Quarterly Journal of Economics*, Vol. 127, No 1, January, pp. 437-492.

Berner, E. (2010), “Exchange rate pass-through: new evidence from German micro data”, *International Economics*, Vol. 124, No 4, April, pp. 75-100.

Bokan, N. et al. (2016), “EAGLE-FLI – A macroeconomic model of banking and financial interdependence in the euro area”, *Working Paper Series*, No 1923, ECB, Frankfurt am Main, June.

Bolt, W., Mavromatis, K. and van Wijnbergen, S. (2019), "The global macroeconomics of a trade war: The EAGLE model on the US-China trade conflict," *CEPR Discussion Papers*, No 13495, Centre for Economic Policy Research, London.

Borin, A., Linarello, A., Mattevi, E. and Zevi, G. (2018), “Fluttuazioni del cambio e valuta di fatturazione: evidenze dalle imprese esportatrici italiane”, *Questioni di Economia e Finanza*, No 473, Banca d’Italia, December.

Boz, E., Gopinath, G. and Plagborg-Møller, M. (2017), “Global trade and the dollar”, *Working Paper*, No 23988, National Bureau of Economic Research, November.

Brůha, J. and Tonner, J. (2017), “An Exchange Rate Floor as an Instrument of Monetary Policy: An Ex-post Assessment of the Czech Experience”, *Working Paper Series*, No 4, Česká národní banka, September.

Burlon, L., Notarpietro, A. and Pisani, M. (2018), “Exchange rate pass-through into euro area inflation. An estimated structural model”, *Temi di discussione (Working papers)*, No 1192, Banca d’Italia, September.

Burstein, A., Eichenbaum, M. and Rebelo, S. (2005) “Large Devaluations and the Real Exchange Rate” Journal of Political Economy, Vol.113, No 4, August, pp. 742-784.

Burstein, A., Neves, J.C. and Rebelo, S. (2003) “Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations”, *Journal of Monetary Economics*, Vol. 50, No 6, September, pp. 1189-1214.

Bussière, M. (2013), “Exchange rate pass-through to trade prices: The role of non-linearities and asymmetries”, *Oxford Bulletin of Economics and Statistics*, Vol. 75, No 5, pp. 731-758.

Bussière, M., Gaulier, G. and Steingress, W. (2016), “Global trade flows, revisiting the exchange rate elasticities”, *Working Paper Series*, No 608, Banque de France, November.

Campa, J. and Goldberg, L. (2008), “Pass-Through of Exchange Rates to Consumption Prices: What has Changed and Why?”, International Financial Issues in the Pacific Rim: Global Imbalances, Financial Liberalization, and Exchange Rate Policy, National Bureau of Economic Research, pp. 139-176.

Campa, J., Goldberg, S. and González-Mínguez, J. (2005), “Exchange-rate pass-through to import prices in the euro area”, *Working Paper*, No 11632, National Bureau of Economic Research, September.

Campa, J., González-Mínguez, J. and Sebastia-Barriel, M. (2008), “Non-Linear Adjustment of Import Prices in the European Union”, *Working Paper*, No 0635, Banco de España; *Working Paper*, No 347, Bank of England, April.

Carrière-Swallow, Y., Gruss, B., Magud, N. and Valencia, F. (2016), “Monetary Policy Credibility and Exchange Rate Pass-Through”, *IMF Working Papers*, No 16/240, International Monetary Fund, Washington D.C., December.

Casas, C., Díez, F., Gopinath, G. and Gourinchas, P.-O. (2017), “Dominant Currency Paradigm: A New Model for Small Open Economies”, *IMF Working Papers*, No 17/264, International Monetary Fund, Washington D.C., November.

Casseli, F. (2017), “Did the Exchange Rate Floor Prevent Deflation in the Czech Republic?”, *IMF Working Papers*, No 17/206, International Monetary Fund, Washington D.C., September.

Chen, N., Chung, W. and Novy, D. (2019), “Vehicle Currency Pricing and Exchange Rate Pass-Through”, *CESifo Working Papers*, No 7695, CESifo Group Munich, June.

Chen, N. and Juvenal, L. (2016), “Quality, trade, and exchange rate pass-through”, *Journal of International Economics*, Vol. 100, May, pp. 61-80.

Choudhri, E., Faruqee, H. and Hakura, D. (2005), “Explaining the exchange rate pass-through in different prices”, *Journal of International Economics*, Vol. 65, No 2, March, pp. 349-374.

Clancy, D., Jacquinot, P. and Lozej, M. (2016), “Government expenditure composition and fiscal policy spillovers in small open economies within a monetary union”, *Journal of Macroeconomics*, Vol. 48, June, pp. 305-326.

Coenen, G., Karadi, P., Schmidt, S. and Warne, A. (2018), “The New Area-Wide Model II: an extended version of the ECB’s micro-founded model for forecasting and policy analysis with a financial sector”, *Working Paper Series*, No 2200, ECB, Frankfurt am Main, November.

Coibion, O., Gorodnichenko, Y. and Ulate, M. (2018), “The Cyclical Sensitivity in Estimates of Potential Output”, *Brooking Papers on Economic Activity*, September.

Colavecchio, R. and Rubene, I. (2020), “Non-linear exchange rate pass-through to euro area inflation: a local projection approach”, *Working Paper Series*, No 2362, ECB, Frankfurt am Main, January.

Comunale, M. (2015), “Financial cycle measures for 41 countries: a new database”, *Occasional Paper Series* , No 9, Lietuvos bankas.

Comunale, M. (2020), “Shock dependence of exchange rate pass-through: a comparative analysis of BVARs and DSGEs”, *Working Paper Series*, No 75/2020, Lietuvos bankas, March.

Comunale, M. and Kunovac, D. (2017), “Exchange rate pass-through in the euro area”, *Working Paper Series*, No 2003, ECB, Frankfurt am Main, January.

Conti, A.M., Neri, S. and Nobili, A. (2017), “Low inflation and monetary policy in the euro area”, *Working Paper Series*, No 2005, ECB, Frankfurt am Main, January.

Corsetti, G. and Dedola, L. (2005), “A macroeconomic model of international price discrimination” *Journal of International Economics*, Vol. 67, No 1, September, pp. 129-155.

Corsetti, G., Dedola, L. and Leduc, S. (2008), “High exchange-rate volatility and low pass-through”, *Journal of Monetary Economics*, Vol. 55, No 6, September, pp. 1113-1128.

Cramer, J. and Krueger, A.B. (2016), “Disruptive change in the taxi business: The case of Uber”, *American Economic Review*, Vol. 106, No 5, May, pp. 177-182.

Darracq Pariès, M., Jacquinot, P. and Papadopoulou, N. (2016), “Parsing financial fragmentation in the euro area: a multi-country DSGE perspective”, *Working Paper Series*, No 1891, ECB, Frankfurt am Main, April.

Darracq Pariès, M. and Papadopoulou, N. (2019), “On the credit and exchange rate channels of central bank asset purchases in a monetary union”, *Working Paper Series*, No 2259, ECB, Frankfurt am Main, March.

De Soyres, F., Frohm, E., Gunnella, V. and Pavlova, E. (2018), “Bought, Sold, and Bought Again: The Impact of Complex Value Chains on Export Elasticities”, *Policy Research Working Paper*, No WPS 8535, The World Bank, Washington D.C., July.

De Walque, G., Jeanfils, P., Lejeune, T., Rychalovska, Y. and Wouters, R. (2017), “An estimated two-country EA-US model with limited exchange rate pass-through”, *Working Papers*, No 317, Nationale Bank van België/Banque Nationale de Belgique, Brussels, March.

De Walque, G., Lejeune, T., Rannenberg, A. and Wouters, R. (forthcoming), “Low pass-through and high spillovers in NOEM: what does help and what does not”, *Working Papers*, Nationale Bank van België/Banque Nationale de Belgique, Brussels.

Dedola, L., Georgiadis, G., Gräb, J. and Mehl, A. (2018), “Does a big bazooka matter? Central bank balance-sheet policies and exchange rates”, *Working Paper Series*, No 2197, ECB, Frankfurt am Main, November.

Dekle, R. and Ryoo, H. (2007), “Exchange rate fluctuations, financing constraints, hedging, and exports: Evidence from firm level data”, *Journal of International Financial Markets, Institutions and Money*, Vol. 17, No 5, December, pp. 437-451.

Delatte, A.-L. and López-Villavicencio, A. (2012), “Asymmetric exchange rate pass-through: Evidence from major countries”, *Journal of Macroeconomics*, Vol. 34, No 3, July, pp. 833-844.

Demian, C. and di Mauro, F. (2015), “The exchange rate, asymmetric shocks and asymmetric distributions”, *Working Paper Series*, No 1801, ECB, Frankfurt am Main, June.

Devereux, M.B., Dong, W. and Tomlin, B. (2017), “Importers and exporters in exchange rate pass-through and currency invoicing”, Journal of International Economics, Vol. 105, March, pp. 187-204.

Dieppe, A. et al. (2018), “ECB-Global: introducing ECB’s global macroeconomic model for spillover analysis”, *Economic Modelling*, Vol. 72, pp. 78-98.

European Central Bank (2018), “Measures of underlying inflation”, *Economic Bulletin*, Issue 4.

European Central Bank (2019), “Results of the third special questionnaire for participants in the ECB Survey of Professional Forecasters”, Frankfurt am Main, February.

European Central Bank Working Group on Global Value Chains (2019), “The impact of global value chains on the euro area economy”, *Occasional Paper Series*, No 221, ECB, Frankfurt am Main, April

Feenstra, R.C., Gagnon, J.E. and Knetter, M.M. (1996), “Market share and exchange rate pass-through in world automobile trade”, *Journal of International Economics*, Vol. 40, No 1-2, pp. 187-207.

Forbes, K., Hjortsoe, I. and Nenova, T. (2017), “Shocks versus structure: explaining differences in exchange rate pass-through across countries and time”, *Discussion Papers*, No 50, Bank of England, June.

Forbes, K., Hjortsoe, I. and Nenova, T. (2018), “The shocks matter: improving our estimates of exchange rate pass-through”, *Journal of International Economics*, Vol. 114, September, pp. 255-275.

Friberg, R. and Wilander, F. (2008), “The currency denomination of exports – a questionnaire study”, Journal of International Economics, Vol. 75, No 1, May, pp. 54-69.

Gaggl, P. (2009), “The Role of Exchange Rate Movements for Prices in the Euro Area”, Monetary Policy and the Economy, Issue 2, Oesterreichische Nationalbank, June.

Gagnon, J.E. and Ihrig, J. (2004), “Monetary policy and exchange rate pass-through”, *International Journal of Finance and Economics*, Vol. 9, No 4, pp. 315-338.

Georgiadis, G., Gräb, J. and Khalil, M. (2019), “Global value chain participation and exchange rate pass-through”, *Working Paper Series*, No 2327, ECB, Frankfurt am Main, November.

Goldberg, L. and Campa, J. (2010), “The Sensitivity of the CPI to Exchange Rates: Distribution Margins, Imported Inputs, and the Trade Exposure”, *Review of Economics and Statistics*, Vol. 92, No 2, May, pp. 392-407.

Goldberg, L. and Tille, C. (2016), “Micro, macro, and strategic forces in international trade invoicing: Synthesis and novel patterns”, *Journal of International Economics*, Vol. 102, September, pp. 173-187.

Gomes, S., Jacquinot, P. and Pisani, M. (2012), “The eagle: a model for policy analysis of macroeconomic interdependence in the euro area”, *Economic Modelling*, Vol. 29, No 5, September, pp. 1686 – 1714.

Gopinath, G. (2015), “The International Price System”, *Working Paper*, No 21646, National Bureau of Economic Research, November.

Gopinath, G., Itskhoki, O. and Rigobon, R. (2010), “Currency Choice and Exchange Rate Pass-Through”, *American Economic Review*, Vol. 100, No 1, March, pp. 304-336.

Hagemejer, J., Hałka, A. and Kotłowski, J. (2020), “Global value chains and exchange rate pass through: the role of non-linearities”, *Working Papers*, No 324, Narodowy Bank Polski.

Hahn, E. (2003), “Pass-Through of External Shocks to Euro Area Inflation”, *Working Paper Series*, No 243, ECB, Frankfurt am Main, July.

Hahn, E. (2007), “The impact of exchange rate shocks on sectoral activity and prices in the euro area”, *Working Paper Series*, No 796, ECB, Frankfurt am Main, August.

Hoffmann, M., Kliem, M., Krause, M., Moyen, S. and Sauer, R. (2020), “Rebalancing the euro area: Is wage adjustment in Germany the answer?”, *Discussion Papers*, No 17/2020, Deutsche Bundesbank, Frankfurt am Main.

Hüfner, F. and Schröder, M. (2003), “Exchange rate pass-through to consumer prices: a European perspective”, *Aussenwirtschaft*, Vol. 58, No 3, pp. 383-412.

Imbs, J. and Méjean, I. (2015), “Elasticity Optimism”, *American Economic Journal: Macroeconomics*, Vol. 7, No 3, July, pp. 43-83.

Imbs, J., Mumtaz, H., Ravn, M.O. and Rey, H. (2005), “PPP Strikes Back: Aggregation and the Real Exchange Rate”, Quarterly Journal of Economics, Vol. 120, No 1, January, pp. 1-43.

International Monetary Fund (2016), “Exchange Rate Pass-Through in Latin America”, *International Monetary Fund, Regional Economic Outlook: Western Hemisphere*, April.

Inoue, A. and Rossi, B. (2019), “The effects of conventional and unconventional monetary policy on exchange rates”, *Journal of International Economics*, Vol. 118, May, pp. 419-447.

Jarociński, M. and Karadi, P. (2020), “Deconstructing Monetary Policy Surprises—The Role of Information Shocks”, *American Economic Journal: Macroeconomics*, (forthcoming).

Jašová, M., Moessner, R. and Takáts, E. (2016), “Exchange rate pass-through: What has changed since the crisis?”, *BIS Working Papers*, No 583, Bank for International Settlements, September.

Jordà, Ò. (2005), “Estimation and Inference of Impulse Responses by Local Projections”, *American Economic Review*, Vol. 95, No 1, March pp. 161-182.

Klenow, P.J. and Malin, B.A. (2010), “Microeconomic Evidence on Price-Setting”, in Friedman, B. and Woodford, M. (eds.), Handbook of Monetary Economics, Elsevier, pp. 231-284.

Kristoffersen, M.S. and Spange, M. (2016), “Exchange rate pass-through to Danish import and consumer prices”, *Monetary Review*, Danmarks Nationalbank, May.

Landolfo, L. (2007), “Modelling the impact of external factors on the euro area’s HICP and real economy—A focus on pass-through and the trade balance”, *Working Paper Series*, No 789, ECB, Frankfurt am Main, July.

Lane, P. and Stracca, L. (2018), “Can appreciation be expansionary? Evidence from the euro area”, *Economic Policy*, Vol. 33, No 94, April, pp. 225-264.

Lee, K.C., Pesaran, M.H. and Pierse, R.G. (1990), “Testing for Aggregation Bias in Linear Models”, *The Economic Journal*, Vol. 100, No 400, pp. 137-150.

Leiva, D., Martínez-Martín, J. and Ortega, E. (2020), “Exchange rate shocks and inflation comovement in the euro area”, *Working Paper Series*, No 2383, ECB, Frankfurt am Main, March.

Leslie, P. (2004), “Price discrimination in Broadway theater”, *RAND Journal of Economics*, Vol. 35, No 3, pp. 520-541.

Lindé, J., Nessén, M., Söderström, U. (2009), “Monetary policy in an estimated open-economy model with imperfect pass-through”, *International Journal of Finance and Economics*, Vol. 14, No 4, October, pp. 301-333.

McLeay, M. and Tenreyro, S. (2019), “Optimal Inflation and the Identification of the Phillips Curve”, *NBER Macroeconomics Annual*, Vol. 34.

Melitz, M. and Ottaviano, G. (2008), “Market size, trade, and productivity”, *Review of Economic Studies*, Vol. 75, No 1, pp. 295-316.

Nagengast, A., Bursian, D. and Menz, J. (2020), “Dynamic pricing and exchange rate pass-through: Evidence from transaction-level data”, *Discussion Papers*, No 16/2020, Deutsche Bundesbank, Frankfurt am Main.

Osbat, C., Sun, Y. and Wagner, M. (2019), “Sectoral exchange rate pass-through in the euro area”, *Working Paper Series*, ECB, Frankfurt am Main, (forthcoming).

Özyurt, S. (2016), “Has the exchange rate pass through recently declined in the euro area?”, *Working Paper Series*, No 1955, ECB, Frankfurt am Main, September.

Schmitz, M. et al. (2012), “Revisiting the effective exchange rates of the euro”, *Occasional Paper Series*, No 134, ECB, Frankfurt am Main, June.

Senaj M. and Vyskrabka, M. (2011), “European taxes in a laboratory”, *Working Paper Series*, No 2/2011, Národná banka Slovenska, December.

Shambaugh, J. (2008), “A new look at pass-through”, *Journal of International Money and Finance*, Vol. 27, No 4, June, pp. 560-591.

Stavins, J. (2001), “Price discrimination in the airline market: The effect of market concentration”, *Review of Economics and Statistics*, Vol. 83, No 1, February, pp. 200-202.

Strasser, G. (2013), “Exchange rate pass-through and credit constraints”, *Journal of Monetary Economics*, Vol. 60, No 1, January, pp. 25-38.

Taylor, J. (2000), “Low inflation, pass-through, and the pricing power of firms”, *European Economic Review*, Vol. 44, No 7, June, pp. 1389-1408.

Abbreviations

APP	Asset purchase programme
BVAR	Bayesian vector autoregression model
CPI	Consumer price index
DCP	Dominant currency pricing
DIICC	Direct and indirect import content in consumption
DSGE	Dynamic stochastic general equilibrium model
ELB	Effective lower bound
ERPT	Exchange rate pass-through
ESCB	European System of Central Banks
FG	Forward guidance
HICP	Harmonised index of consumer prices
HICPX	HICP excluding food and energy
GVC	Global value chain
LCP	Local currency pricing
NCB	National Central Bank
NEER	Nominal effective exchange rate
PCP	Producer currency pricing
PERR	Price-to-exchange rate ratio
$PERR_h^F$	Price-to-exchange rate ratio for import prices at the border
$PERR_h^{Fr}$	Price-to-exchange rate ratio for import prices at the retail level
$PERR_h^C$	Price-to-exchange rate ratio for total consumer prices
PSPP	Private sector purchase programme
SVAR	Structural vector autoregression model
UIP	Uncovered interest rate parity
VAR	Vector autoregression
WIOD	World Input-Output Database

Acknowledgements

Editors

Eva Ortega
Banco de España)

Chiara Osbat
European Central Bank

Coordinators

Section 1 — **Eva Ortega**, Banco de España; **Chiara Osbat**, European Central Bank

Section 2 — **Ieva Rubene**, European Central Bank

Section 3 — **Vanessa Gunnella**, European Central Bank

Section 4 — **Massimiliano Pisani**, Banca d’Italia

Section 5 — **Mariarosaria Comunale**, Lietuvos bankas

Section 6 — **Jan Brůha**, Česká národní banka; **Kostas Mavromatis**, De Nederlandsche Bank

Section 7 — **Eva Ortega**, Banco de España; **Chiara Osbat**, European Central Bank

Contributors

Justas Dainauskas
European Central Bank

Vanessa Gunnella
European Central Bank

José Emilio Gumiel
European Central Bank

Chiara Osbat
European Central Bank

Martino Ricci
European Central Bank

Ieva Rubene
European Central Bank

Gregory de Walque
Nationale Bank van België/Banque Nationale de Belgique

Jana Jonckheere
Nationale Bank van België/Banque Nationale de Belgique

Thomas Lejeune
Nationale Bank van België/Banque Nationale de Belgique

Jan Brůha
Česká národní banka

Jaromír Tonner
Česká národní banka

Mark Strøm Kristoffersen
Danmarks Nationalbank

Dirk Bursian
Deutsche Bundesbank

Matthias Hartmann
Deutsche Bundesbank

Mathias Hoffmann
Deutsche Bundesbank

Jan-Oliver Menz
Deutsche Bundesbank

Arne Nagengast
Deutsche Bundesbank

Stefan Schaefer
Deutsche Bundesbank

Dmitry Kulikov
Eesti Pank

Matija Lozej
Central Bank of Ireland

Jonathan Rice
Central Bank of Ireland

Luca Zavalloni
Central Bank of Ireland

Marianthi Anastasatou
Bank of Greece

Danilo Leiva
Banco de España

Jaime Martínez-Martín
Banco de España and European Central Bank

Eva Ortega
Banco de España

Hadrien Camatte
Banque de France

Antoine Sigwalt
Banque de France

Davor Kunovac
Hrvatska narodna banka

Enes Đozović
Hrvatska narodna banka

Antonio Maria Conti
Banca d'Italia

Massimiliano Pisani
Banca d'Italia

Niki Papadopoulou
Central Bank of Cyprus

Andrejs Bessonovs
Latvijas Banka

Ginters Buss
Latvijas Banka

Héctor Cárcel
Lietuvos bankas

Mariarosaria Comunale
Lietuvos bankas

Roberta Colavecchio
Banque centrale du Luxembourg

Péter Quittner
Magyar Nemzeti Bank

Brian Micallef
Central Bank of Malta

Ian Borg
Central Bank of Malta

Kostas Mavromatis
De Nederlandsche Bank

Irina Stanga
De Nederlandsche Bank

Friedrich Fritzer
Oesterreichische Nationalbank

Aleksandra Hałka
Narodowy Bank Polski

Jan Przystupa
Narodowy Bank Polski

Tudor Grosu
Banca Naţională a României

Milan Damjanović
Banka Slovenije

Martin Zeleznik
Národná banka Slovenska

Juha Kilponen
Suomen Pankki – Finlands Bank

Mikko Sariola
Suomen Pankki – Finlands Bank

Vesna Corbo
Sveriges Riksbank

Mårten Löf
Sveriges Riksbank

Marilena Angeli
Bank of England

BANCO DE ESPAÑA PUBLICATIONS

OCCASIONAL PAPERS

1801 ANA ARENCIBIA PAREJA, ANA GÓMEZ LOSCOS, MERCEDES DE LUIS LÓPEZ and GABRIEL PÉREZ QUIRÓS: A short-term forecasting model for the Spanish economy: GDP and its demand components.

1802 MIGUEL ALMUNIA, DAVID LÓPEZ-RODRÍGUEZ and ENRIQUE MORAL-BENITO: Evaluating the macro-representativeness of a firm-level database: an application for the Spanish economy.

1803 PABLO HERNÁNDEZ DE COS, DAVID LÓPEZ RODRÍGUEZ and JAVIER J. PÉREZ: The challenges of public deleveraging. (There is a Spanish version of this edition with the same number).

1804 OLYMPIA BOVER, LAURA CRESPO, CARLOS GENTO and ISMAEL MORENO: The Spanish Survey of Household Finances (EFF): description and methods of the 2014 wave.

1805 ENRIQUE MORAL-BENITO: The microeconomic origins of the Spanish boom.

1806 BRINDUSA ANGHEL, HENRIQUE BASSO, OLYMPIA BOVER, JOSÉ MARÍA CASADO, LAURA HOSPIDO, MARIO IZQUIERDO, IVAN A. KATARYNIUK, AITOR LACUESTA, JOSÉ MANUEL MONTERO and ELENA VOZMEDIANO: Income, consumption and wealth inequality in Spain. (There is a Spanish version of this edition with the same number).

1807 MAR DELGADO-TÉLLEZ and JAVIER J. PÉREZ: Institutional and economic determinants of regional public debt in Spain.

1808 CHENXU FU and ENRIQUE MORAL-BENITO: The evolution of Spanish total factor productivity since the Global Financial Crisis.

1809 CONCHA ARTOLA, ALEJANDRO FIORITO, MARÍA GIL, JAVIER J. PÉREZ, ALBERTO URTASUN and DIEGO VILA: Monitoring the Spanish economy from a regional perspective: main elements of analysis.

1810 DAVID LÓPEZ-RODRÍGUEZ and CRISTINA GARCÍA CIRIA: Estructura impositiva de España en el contexto de la Unión Europea.

1811 JORGE MARTÍNEZ: Previsión de la carga de intereses de las Administraciones Públicas.

1901 CARLOS CONESA: Bitcoin: a solution for payment systems or a solution in search of a problem? (There is a Spanish version of this edition with the same number).

1902 AITOR LACUESTA, MARIO IZQUIERDO and SERGIO PUENTE: An analysis of the impact of the rise in the national minimum wage in 2017 on the probability of job loss. (There is a Spanish version of this edition with the same number).

1903 EDUARDO GUTIÉRREZ CHACÓN and CÉSAR MARTÍN MACHUCA: Exporting Spanish firms. Stylized facts and trends.

1904 MARÍA GIL, DANILO LEIVA-LEON, JAVIER J. PÉREZ and ALBERTO URTASUN: An application of dynamic factor models to nowcast regional economic activity in Spain.

1905 JUAN LUIS VEGA (COORD.): Brexit: current situation and outlook.

1906 JORGE E. GALÁN: Measuring credit-to-GDP gaps. The Hodrick-Prescott filter revisited.

1907 VÍCTOR GONZÁLEZ-DÍEZ and ENRIQUE MORAL-BENITO: The process of structural change in the Spanish economy from a historical standpoint. (There is a Spanish version of this edition with the same number).

1908 PANA ALVES, DANIEL DEJUÁN and LAURENT MAURIN: Can survey-based information help assess investment gaps in the EU?

1909 OLYMPIA BOVER, LAURA HOSPIDO and ERNESTO VILLANUEVA: The Survey of Financial Competences (ECF): description and methods of the 2016 wave.

1910 LUIS JULIÁN ÁLVAREZ: El índice de precios de consumo: usos y posibles vías de mejora.

1911 ANTOINE BERTHOU, ÁNGEL ESTRADA, SOPHIE HAINCOURT, ALEXANDER KADOW, MORITZ A. ROTH and MARIE-ELISABETH DE LA SERVE: Assessing the macroeconomic impact of Brexit through trade and migration channels.

1912 RODOLFO CAMPOS and JACOPO TIMINI: An estimation of the effects of Brexit on trade and migration.

1913 ANA DE ALMEIDA, TERESA SASTRE, DUNCAN VAN LIMBERGEN and MARCO HOEBERICHTS: A tentative exploration of the effects of Brexit on foreign direct investment vis-à-vis the United Kingdom.

1914 MARÍA DOLORES GADEA-RIVAS, ANA GÓMEZ-LOSCOS and EDUARDO BANDRÉS: Ciclos económicos y *clusters* regionales en Europa.

1915 MARIO ALLOZA and PABLO BURRIEL: La mejora de la situación de las finanzas públicas de las Corporaciones Locales en la última década.

1916 ANDRÉS ALONSO and JOSÉ MANUEL MARQUÉS: Financial innovation for a sustainable economy. (There is a Spanish version of this edition with the same number).

2001 ÁNGEL ESTRADA, LUIS GUIROLA, IVÁN KATARYNIUK and JAIME MARTÍNEZ-MARTÍN: The use of BVARs in the analysis of emerging economies.

2002 DAVID LÓPEZ-RODRÍGUEZ and M.ª DE LOS LLANOS MATEA: Public intervention in the rental housing market: a review of international experience. (There is a Spanish version of this edition with the same number).

2003 OMAR RACHEDI: Structural transformation in the Spanish economy.

2004 MIGUEL GARCÍA-POSADA, ÁLVARO MENÉNDEZ and MARISTELA MULINO: Determinants of investment in tangible and intangible fixed assets.

2005 JUAN AYUSO and CARLOS CONESA: Una introducción al debate actual sobre la moneda digital de banco central (CBDC).

2006 PILAR CUADRADO, ENRIQUE MORAL-BENITO and IRUNE SOLERA: A sectoral anatomy of the spanish productivity puzzle.

2007 SONSOLES GALLEGO, PILAR L'HOTELLERIE-FALLOIS and XAVIER SERRA: La efectividad de los programas del FMI en la última década.

2008 RUBÉN ORTUÑO, JOSÉ M. SÁNCHEZ, DIEGO ÁLVAREZ, MIGUEL LÓPEZ and FERNANDO LEÓN: Neurometrics applied to banknote and security features design.

2009 PABLO BURRIEL, PANAGIOTIS CHRONIS, MAXIMILIAN FREIER, SEBASTIAN HAUPTMEIER, LUKAS REISS, DAN STEGARESCU and STEFAN VAN PARYS: A fiscal capacity for the euro area: lessons from existing fiscal-federal systems.

2010 MIGUEL ÁNGEL LÓPEZ and M.ª DE LOS LLANOS MATEA: El sistema de tasación hipotecaria en España. Una comparación internacional.

2011 DIRECTORATE GENERAL ECONOMICS, STATISTICS AND RESEARCH: The Spanish economy in 2019.

2012 MARIO ALLOZA, MARIEN FERDINANDUSSE, PASCAL JACQUINOT and KATJA SCHMIDT: Fiscal expenditure spillovers in the euro area: an empirical and model-based assessment.

2013 DIRECCIÓN GENERAL DE ECONOMÍA Y ESTADÍSTICA: El mercado de la vivienda en España entre 2014 y 2019.

2014 ÓSCAR ARCE, IVÁN KATARYNIUK, PALOMA MARÍN and JAVIER J. PÉREZ: Thoughts on the design of a european Recovery Fund.

2015 MIGUEL OTERO IGLESIAS and ELENA VIDAL MUÑOZ: Las estrategias de internacionalización de las empresas chinas.

2016 EVA ORTEGA and CHIARA OSBAT: Exchange rate pass-through in the euro area and EU countries.

BANCO DE ESPAÑA
Eurosistema

Unidad de Servicios Generales I
Alcalá, 48 - 28014 Madrid
E-mail: publicaciones@bde.es
www.bde.es