Inflation and Exchange Rate Pass-Through*

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Abstract

This paper investigates exchange rate pass-through into consumer prices by considering the nature of the shock triggering currency movements. By individually estimating structural factor-augmented vector autoregression models for 55 countries, monetary policy shocks are shown to be associated with higher exchange rate pass-through measures compared to other domestic shocks, while global shocks have widely different effects across countries. Pass-through measures tend to be lower in countries that combine flexible exchange rate regimes and credible inflation targets, where central bank independence can greatly facilitate the task of stabilizing inflation by using the exchange rate as a buffer against external shocks. It is implied that exchange rate pass-through should be investigated by considering the nature of the shock that triggers currency movements and country characteristics that affect the response of prices.

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1 Introduction

Monetary authorities respond to currency movements to the extent that they impact consumer prices and thus inflation. This response requires information not only on the source of currency movements but also the economic characteristics of the country, because, for example, the risk of policy missteps is particularly elevated in emerging market and developing economies (EMDEs), where large currency movements are more frequent and central banks have a greater propensity to respond to them (Calvo and Reinhart, 2002; Ball and Reyes, 2008). This highlights the importance of correctly assessing the exchange rate pass-through (ERPT)—defined in this paper as the percentage increase in consumer prices associated with a 1 percent depreciation of the effective exchange rate, after one year following a specific shock.

The nature of the macroeconomic shock that triggers an exchange rate movement plays a key role in determining the size of the associated pass-through (Shambaugh, 2008; Comunale and Kunovac, 2017; and Forbes, Hjortsoe, and Nenova, 2018). This reflects the fact that shocks impacting the exchange rate concurrently affect activity, markups, productivity, and several other factors that influence price formation and inflation expectations. It is thus likely that the extent of estimated ERPTs will vary widely depending on the shock that triggers them—a possibility that most empirical studies have not considered. For instance, if the ERPT associated with monetary policy changes is higher than the one associated with other types of shocks, there is a risk that a central bank might underestimate the exchange rate channel of its actions and maintain an excessively tight (or loose) monetary policy stance relative to what is needed to stabilize inflation and output. This may lead to unnecessary fluctuations in activity and make the anchoring of inflation expectations more difficult to achieve over time. Moreover, these shocks triggering currency movements can interact with country characteristics (e.g., central bank credibility, trade openness, etc.) to amplify their impact on consumer prices, suggesting alternative monetary policy responses based on the information of shocks and country characteristics.

Against this background, this paper contributes to a recent strand of the literature that emphasizes the importance of identifying underlying shocks to assess the transmission of exchange rate movements to inflation and, therefore, to formulate the correct monetary policy response. Two main questions are asked. First, how does ERPT to inflation depend on the

underlying shock triggering the currency movement? Second, what country characteristics are associated with lower pass-throughs? Since aggregate-level *consumer* price data are employed to answer these questions, pass-through investigation in this paper is from a macroeconomic perspective that corresponds to important monetary policy implications.[1]

The formal investigation is achieved by using a series of factor-augmented vector autoregression (FAVAR) models, where both global and domestic variables are used to identify the corresponding shocks. This is achieved by initially constructing the global series of inflation and output growth, where dynamic factor models are used. The constructed global series are combined with global oil price growth as well as domestic series of inflation, output growth, interest rate and nominal effective exchange rates in FAVAR estimations at the country level. The identification is achieved by an efficient algorithm to combine sign and zero restrictions. Due to data availability, estimations are achieved for 55 countries, including 26 EMDEs. Following studies such as by Shambaugh (2008) and Forbes, Hjortsoe, and Nenova (2018), shock-specific ERPTs are estimated as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change, both following a specific shock. Since country-specific ERPTs are highly heterogenous, we further connect the empirical results to country-specific characteristics by paying particular attention to monetary policy frameworks, participation in global value chains (GVCs), and foreign-currency invoicing.

Compared to the existing literature, this paper first utilizes a rich set of results to shed new light on the heterogeneity of pass-through estimates by linking them to underlying shocks in a structural vector autoregression framework. This contrasts with traditional reduced-form approaches in the literature that estimate "average" pass-throughs based on conditioning variables. However, shocks can act concurrently on inflation and exchange rates, with varying implications for ERPTs. In a literature review, Goldberg and Knetter (1997) document that estimated exchange rate pass-throughs depend critically on how well identified the sources of the exchange rate movements are. The estimation of shock-specific pass-throughs thus refines the analysis of factors affecting the link between exchange rate movements and inflation.

Second, compared to the few preceding studies that have derived state-dependent estimates of ERPTs (Shambaugh, 2008; Comunale and Kunovac, 2017; Forbes, Hjortsoe, and

[1] For example, see Ben Cheikh and Rault (2017) for an excellent survey on the prevalence of microeconomic versus macroeconomic factors on ERPT.

Nenova, 2017; and Forbes, Hjortsoe, and Nenova, 2018), this paper investigates additional shocks. In particular, we look at the impact of three domestic shocks (monetary policy, demand, and supply), three global shocks (demand, supply, and oil price), and a residual exchange-rate shock capturing, among other factors, changing risk premiums. While global shocks mainly follow studies such as by Charnavoki and Dolado (2014) who investigate the effects of global shocks on commodity prices (with an application to Canada), domestic shocks mainly follow studies such as by Forbes, Hjortsoe, and Nenova (2018) who focus on the effects of monetary policy, demand, supply and exchange rate shocks on ERPT (with an application to the UK). Nevertheless, by having a unique FAVAR framework combining global and domestic developments, this paper achieves identification of these different shocks in a unified setup.

Finally, this paper connects country- and shock-specific ERPT estimates to the economic characteristics of countries such as their monetary policy frameworks, participation in GVCs, and foreign currency invoicing. Compared to previous studies, this is achieved by using data from a larger number of countries (55 of them), which is essential for a healthy cross-country comparison to identify the effects of country characteristics on ERPT estimates.[2]

The next section achieves a literature review on the link between inflation and exchange rate movements. Section 3 introduces the empirical model and data. Section 4 presents estimates of shock-specific ERPTs, and Section 5 demonstrates the importance of structural factors and country-specific characteristics. The conclusion discusses policy implications and suggests avenues for future research.

2 Literature review on exchange rate pass-through

Based on the main focus of this paper, this section provides a brief literature review by discussing the theoretical underpinnings of (partial) ERPTs to inflation, distinguishing between the shocks triggering currency movements, and connecting alternative ERPT estimates to country characteristics.

[2]In contrast, similar studies focusing on shock-specific ERPT measures have utilized data for a smaller number of countries; e.g., Shambaugh (2008) have used data for 11 countries, Forbes, Hjortsoe, and Nenova (2017) have used data for 26 countries, Comunale and Kunovac (2017) have used data for only Euro Area countries, Borensztein and Queijo Von Heideken (2016) have used data for a group of South American countries, and Ca'Zorzi, Hahn, and Sánchez (2007) have used data for 12 countries.

2.1 What are the theoretical underpinnings of partial exchange rate pass-throughs to inflation?

A rich literature has demonstrated that currency movements are only partially transmitted to domestic prices, with effects dissipating through the production chain. The pass-through to consumer prices goes through various channels, from direct effects through energy and other commodity prices, to indirect effects through import prices, wage formation, and profit markups (Bacchetta and Van Wincoop, 2003; Burstein and Gopinath, 2014; Ito and Sato, 2008; McCarthy, 2007). Even in the case of internationally traded goods, different forms of market segmentation may explain incomplete pass-through, because of various trade frictions or firms' ability to practice price discrimination across international locations. Nominal rigidities may also help explain the persistence of such deviations over time and lead to a declining ERPT across the production chain.

Price discrimination by firms. Producers' ability to have different pricing strategies across different segments of international markets is a key feature of most theoretical models of partial ERPTs. In particular, the pricing-to-market literature (originally developed by Krugman, 1986 and Dornbusch, 1987) places monopolistic firms at the center of international price discrimination. Exporters can adjust their markups over marginal cost across different destinations to take into account the demand conditions and price elasticities encountered in each market (Froot and Klemperer, 1988; Auer and Chaney, 2009). In general, models with heterogeneous consumers give rise to more flexible demand systems that allow for "optimal" international price discrimination with incomplete ERPTs (Goldberg and Hellerstein, 2008; Hellerstein, 2008; Goldberg and Verboven, 2001; Nakamura and Zerom, 2009).

Endogenous firm selection. International trade models of cross-border production networks have provided further rationale for partial ERPTs. In these models, macroeconomic shocks produce a new, endogenously determined distribution of firms, impacting pricing strategies and aggregate ERPTs (Bernard, Eaton, Jensen, and Kortum, 2003; Chaney, 2008; Eaton, Kortum, and Kramarz, 2011; Mayer, Melitz, and Ottaviano, 2014; Melitz and Ottaviano, 2008; Rodriguez-Lopez, 2011). More competitive and productive firms, which also tend to source more of their inputs internationally, have a larger market share, which lowers average pass-throughs and deepens global value chain integration (Amiti, Itskhoki,

and Konings, 2014; Soyres, Raphael, Frohm, Gunnella, and Pavlova, 2018; Gopinath and Neiman, 2014).

Nominal rigidities. Nominal rigidities in local-currency pricing can account for a less than full pass-through, even when markups are constant. When prices are sticky, the currency of invoices will determine the rate of pass-through (Choudhri and Hakura, 2015; Devereux, Engel, and Storgaard, 2004; Bacchetta and Van Wincoop, 2005; Gopinath and Itskhoki, 2010; Flodén and Wilander, 2006). In models with nominal price rigidities, producers opt to invoice in the currency of the origin or destination, depending on the desired ERPTs. Exporters facing stronger competition in the destination markets may choose to invoice in local currencies to keep prices stable relative to competitors, thus reducing the overall exchange rate pass-through.

Nontradable input costs. Local nontradable inputs are relatively immune to exchange rate movements, which tend to lower the exchange rate pass-through to consumer prices. In particular, distribution costs drive a significant wedge between producer and retail prices (Burstein, Neves, and Rebelo, 2003; Corsetti and Dedola, 2005; Berger, Faust, Rogers, and Steverson, 2012). Models with consumer search (Alessandria, 2009; Alessandria and Kaboski, 2011) and inventories (Alessandria, Kaboski, and Midrigan, 2010) work in a broadly similar fashion by creating a disconnect between the border and consumer prices of imported goods.

2.2 How do pass-throughs vary depending on the source of shocks?

Earlier studies have generally estimated ERPTs in reduced-form frameworks, treating exchange rate movements as exogenous rather than considering the underlying shocks behind such movements. A group of recent studies emphasizes that different shocks can be associated with widely different ERPTs.

Shambaugh (2008) takes this argument a step further by systematically categorizing exchange rate pass-throughs by the type of shock. He estimates a vector autoregression model with long-run identifying restrictions on industrial production, the real exchange rate, consumer prices, the nominal exchange rate, and import prices for 11 mostly advanced economies. ERPTs after one year are estimated for shocks to domestic supply, domestic demand, domestic prices, foreign prices, and import prices. A foreign price shock has a smaller pass-through rate, close to 0.5, as does a domestic demand shock, at around 0.4.

Forbes, Hjortsoe, and Nenova (2017) and Forbes, Hjortsoe, and Nenova (2018) apply a five-variable structural vector autoregression (SVAR) model with short- and long-term identifying restrictions to the United Kingdom and 26 small, open economies with *de facto* floating exchange rates during 1990-2015. They estimate sizable ERPTs in responses to domestic monetary policy shocks but modest ones in response to domestic demand shocks. Their estimates of ERPTs following global shocks (permanent and transitory) are quite heterogeneous across countries. Borensztein and Queijo Von Heideken (2016) follow a broadly similar approach for a group of South American countries; Comunale and Kunovac (2017) for Euro Area countries; Cunningham, Friedrich, Hess, Kim, et al. (2017) for a sample of advanced economies; and Ca'Zorzi, Hahn, and Sánchez (2007) for 12 emerging market and developing economies (EMDEs).

This paper contributes to this literature by estimating seven-variable FAVAR models for 55 countries, including 26 EMDEs, where identification is achieved by sign and zero restrictions using an efficient algorithm suggested by Arias, Rubio-Ramirez, and Waggoner (2018).

2.3 What are the key country characteristics affecting pass-throughs?

Many empirical studies focus on the relationship between estimated ERPTs and country characteristics. In general, greater openness to trade and financial transactions, less credible central banks, more volatile inflation and exchange rates, and lower levels of market competition are associated with higher ERPTs.

Various studies emphasize trade openness and the composition of imported goods (Campa and Goldberg, 2005; Campa and Goldberg, 2010), central bank credibility (Taylor, 2000; Gagnon and Ihrig, 2004; Choudhri and Hakura, 2006; Mishkin and Schmidt-Hebbel, 2007; Coulibaly and Kempf, 2010; Caselli and Roitman, 2016; Carriere-Swallow, Gruss, Magud, and Valencia, 2017), the degree of competition in product markets (Devereux, Tomlin, and Dong, 2015; Amiti, Itskhoki, and Konings, 2016), inflation volatility (Ca'Zorzi, Hahn, and Sánchez, 2007; Forbes, Hjortsoe, and Nenova, 2017), and exchange rate volatility (Campa and Goldberg, 2005). Other studies focus on microeconomic aspects of price-setting: nominal rigidities (Devereux and Yetman, 2002; Corsetti, Dedola, and Leduc, 2008), the role of foreign-currency pricing, especially in invoicing (Gopinath, Itskhoki, and Rigobon, 2010;

Gopinath, 2015; Devereux, Tomlin, and Dong, 2015), the dispersion of price changes (Berger and Vavra, 2015), and the frequency of price adjustments (Gopinath and Itskhoki, 2010).

This paper contributes to this literature by connecting ERPT estimates to country characteristics based on monetary policy framework and credibility, trade openness and participation in global value chains, and foreign-currency invoicing. This is achieved by using data from 55 countries, which is essential for a healthy cross-country comparison to identify the effects of country characteristics on ERPT estimates.

3 Empirical strategy

3.1 FAVAR model

The analysis of factors affecting the exchange rate pass-through to inflation rests on country-specific factor-augmented vector autoregression (FAVAR) models, consisting of global and domestic variables. The global block includes three variables: global inflation, global output growth, and oil price growth. The domestic block includes four country-specific variables: inflation, output growth, changes in nominal effective exchange rates, and monetary policy (or equivalent short-term) nominal interest rates.

In its structural form, the FAVAR model is represented by:

$$B_0 z_t = \alpha + \sum_{k=1}^{L} B_k z_{t-k} + \varepsilon_t$$

where ε_t is a vector of orthogonal structural innovations; z_t consists of global inflation $f_t^{\pi,global}$, global output growth $f_t^{Y,global}$, oil price growth Δop_t, country-specific inflation π_t^i, country-specific output growth Y_t^i, country-specific changes in nominal effective exchange rates XR_t^i, and country-specific monetary policy (or equivalent short-term) nominal interest rates I_t^i. The vector ε_t consists of seven global and domestic structural shocks (to be defined below). Postulating that B_0^{-1} in the econometric model has a recursive structure such that the reduced-form errors u_t can be decomposed according to $u_t = B_0^{-1}\varepsilon_t$, similar to Charnavoki and Dolado (2014), Forbes, Hjortsoe, and Nenova (2017), and Forbes, Hjortsoe, and Nenova

(2018), the imposed sign and short-term restrictions can be written as follows:

$$\begin{bmatrix} u_t^{Y,global} \\ u_t^{op} \\ u_t^{\pi,global} \\ u_t^{Y,domestic} \\ u_t^{\pi,domestic} \\ u_t^{I,domestic} \\ u_t^{XR} \end{bmatrix} = \begin{bmatrix} + & - & + & 0 & 0 & 0 & 0 \\ + & + & + & 0 & 0 & 0 & 0 \\ + & + & - & 0 & 0 & 0 & 0 \\ * & * & * & + & + & - & * \\ * & * & * & + & - & - & * \\ * & * & * & * & * & + & * \\ * & * & * & * & * & + & + \end{bmatrix} \begin{bmatrix} \varepsilon_t^{GlobalDemand} \\ \varepsilon_t^{OilPrice} \\ \varepsilon_t^{GlobalSupply} \\ \varepsilon_t^{DomesticDemand} \\ \varepsilon_t^{DomesticSupply} \\ \varepsilon_t^{MonetaryPolicy} \\ \varepsilon_t^{ExchangeRate} \end{bmatrix}$$

where $*$ stands for an unrestricted initial response. Although country-specific shocks do not affect global variables, global shocks can affect country-specific variables (without any sign or zero restrictions).[3]

The identification strategy is based on the following assumptions on global shocks, combining sign and short-term restrictions as shown above. A positive global demand shock triggers a simultaneous increase in global output growth, global inflation, and oil prices. A positive global supply shock leads to higher global output growth and oil prices but lower global inflation, where higher oil prices (due to higher oil demand) are dominated by other inflation-reducing mechanisms (e.g., technological improvements). A positive oil price shock induces an increase in oil prices and global inflation but a drop in global output growth. Finally, global shocks can have contemporaneous effects on domestic variables, but domestic shocks can only influence global variables with a lag.[4]

The identification strategy is also based on the following assumptions on domestic shocks: A positive country-specific supply or demand shock increases country-specific output growth. However, a country-specific supply shock reduces domestic inflation, whereas a country-specific demand shock increases it. A positive interest rate shock (corresponding to a contractionary monetary policy) initially increases the domestic interest rate and results in an appreciation of the domestic currency, while it decreases domestic output growth and inflation. Finally, a positive exchange rate shock (corresponding to an appreciation of the

[3] An alternative specification also assumes that positive domestic demand shocks lead to a contemporaneous increase in domestic interest rates. See Appendix Figures A.1-A.3 for the results with robustness exercises.

[4] One caveat is that country-specific shocks not affecting global variables may not be entirely realistic for large economies such as China or the U.S to the extent that they contribute to the global common factors (introduced below) at the time of a shock.

domestic currency) only assumes an increase in the exchange rate, while its impact on other domestic variables is left unrestricted. All country-specific shocks are assumed to affect country-specific variables on impact through the corresponding sign restrictions, although the robustness checks also consider such restrictions lasting for an alternative number of periods.

The system is estimated on a country-by-country basis using quarterly data with two lags, as in Charnavoki and Dolado (2014). The Bayesian estimation used searches for 1,000 successful draws of at least 2,000 iterations with 1,000 burn-ins. The results shown in the paper are based on the median of these 1,000 successful draws and 68 percent confidence sets at the country level, although alternative presentation methodologies (for example, the median target, as in Fry and Pagan, 2011) are considered as a robustness check. In the Bayesian estimation, Minnesota priors proposed by Litterman (1986) are used; since the Minnesota prior assumes that the variance-covariance matrix of residuals is known, we use the entire variance-covariance matrix of the vector autoregression estimated by ordinary least squares. For the actual estimation, the identification strategy through the algorithm introduced by Arias, Rubio-Ramirez, and Waggoner (2018) is used (without an importance sampler) to obtain draws that satisfy both sign and zero restrictions, where the standard Cholesky decomposition is employed together with an additional orthogonalization step that is necessary to produce a posterior draw from the correct distribution for structural vector autoregression coefficients.

The results for the role of global and domestic shocks in domestic inflation are presented as median point estimates across countries. Interquartile ranges indicate the range from the 25th to the 75th quartile of country-specific estimates. For presentational clarity, and consistent with other studies in the literature, the country-specific confidence sets are calculated but not presented.

3.2 Exchange rate pass-through definition

Following Shambaugh (2008), Forbes, Hjortsoe, and Nenova (2017), and Forbes, Hjortsoe, and Nenova (2018), for each country, ERPT is defined as the ratio of the cumulative response of country-specific inflation to the cumulative response of the nominal exchange rate changes, after one year following a given shock as in Forbes, Hjortsoe, and Nenova (2017). The sign of the ratio is inverted, so that a positive ERPT denotes a situation in which a currency

depreciation is accompanied by rising inflation. Since the Bayesian estimation results are based on 1,000 successful draws satisfying the sign restrictions, the country-specific ERPTs are represented as the median (and 68 percent confidence sets) of successful draw-specific ERPTs that are calculated for each successful draw individually before being used for a country-specific statistic.

3.3 Data

Due to data availability, the quarterly sample includes 29 advanced economies and 26 EMDEs with at least 10 years (40 quarters) of continuous data for the variables in the domestic block. The sample period differs across countries (see Appendix Table A.1 for details), but most of the empirical results are depicted for the quarterly period over 1998-2017 to achieve a proper comparison across countries.[5]

The following variable definitions are used as inputs into the FAVAR estimation. Global output growth is the global common factor of quarter-on-quarter, seasonally adjusted real gross domestic product (GDP) growth in a sample of 29 countries for 1971:1-2017:4.[6] Global inflation is the global common factor of seasonally-adjusted quarter-on-quarter headline consumer price index (CPI) inflation in a sample of 47 advanced economies and EMDEs.[7] Oil price growth is the quarter-on-quarter growth rate of nominal oil prices (average of Dubai, West Texas Intermediate, and Brent). Country-specific inflation is quarter-on-quarter, seasonally adjusted headline CPI inflation. Country-specific output growth is quarter-on-quarter, seasonally adjusted real GDP growth. Domestic interest rates are annualized three-month Treasury bill rates or monetary policy rates. Nominal effective exchange rate changes are the quarter-on-quarter changes in the trade-weighted nominal exchange rates against 52 currencies, as provided by the Bank for International Settlements. To ensure the stationarity

[5] A descriptive analysis examining the impact of large currency movements on consumer price inflation across countries and over time can be found in the working paper version of this paper (Ha, Stocker, and Yilmazkuday, 2019).

[6] The dynamic factor estimation of the global GDP factor requires a balanced panel throughout the full sample period. Thus, only a subset of countries is employed for this estimation.

[7] The number of countries in the estimation of the global output and inflation factors is based on data availability. We find that the estimates of global inflation and output factors do not change much when a balanced set of 25 countries is employed (see Figure A3). This indicates that our benchmark country sets for the global factors include a sufficiently large number of countries that explain the majority of global economic and financial activities.

of these series, long-term trends of all variables have been eliminated using the local mean method as in Stock and Watson (2012).

Global output growth and global inflation are estimated using the following single-factor dynamic factor models:

$$\pi_t^i = \beta_{global}^{\pi,i} f_t^{\pi,global} + e_t^{\pi,i}$$

and

$$Y_t^i = \beta_{global}^{Y,i} f_t^{Y,global} + e_t^{Y,i}$$

where π_t^i and Y_t^i are inflation and output growth in country i in quarter t, respectively, while $f_t^{\pi,global}$ and $f_t^{Y,global}$ are the global common factors for inflation and output growth in quarter t, respectively.

4 Estimated pass-through and underlying shocks

A recent strand of the literature on the exchange rate pass-through emphasizes the importance of identifying the underlying cause of currency movements (Shambaugh, 2008; Comunale and Kunovac, 2017; and Forbes, Hjortsoe, and Nenova, 2018). For example, a depreciation driven by monetary policy easing could be accompanied by larger increases in inflation, as it raises import prices in the short term and is associated with stronger aggregate demand (and, consequently, an increase in overall pricing pressures) over the medium term. In this case, the pass-through should be expected to be positive and large, as domestic and external forces contribute to higher inflation. In contrast, a depreciation associated with weaker domestic demand could be accompanied by lower inflation over time, as the impact of rising economic slack on domestic prices could outweigh that of higher import prices. In this case, the shock-specific pass-through could be negative. Therefore, the sensitivity of inflation to exchange rate movements can vary considerably depending on the macroeconomic environment and the source of the shocks. This section quantifies differences in pass-through ratios associated with various global and domestic shocks.

4.1 Exchange rate response to underlying shocks

Since pass-through ratios are defined in this framework as the relative response of consumer prices and the exchange rate to different global and domestic shocks, it is important first

to investigate the estimated impact of these shocks on the exchange rate. Empirical studies have shown that fundamentals have some, albeit limited, predictive power over exchange rate movements. These fundamentals include changes in relative business cycle positions, monetary policy stances, risk premiums, and terms of trade (Ca, Rubaszek, et al., 2018; Cheung, Chinn, Pascual, and Zhang, 2018). In particular, periods of domestic output or investment contraction are often associated with currency depreciations (Cordella and Gupta, 2015; Landon and Smith, 2009; Campa and Goldberg, 1999). Monetary policy easing can also lead to currency depreciations, as a declining interest rate differential with the rest of the world tends to put downward pressure on the domestic currency (Chinn and Meredith, 2005; Engel, 2016). Rising risk premiums and heightened sovereign default risks can also trigger such downward pressures (Foroni, Ravazzolo, and Sadaba, 2018). Finally, nominal exchange rates can respond to terms of trade shocks, particularly in commodity exporters with flexible currency regimes (Aizenman, Edwards, and Riera-Crichton, 2012; Schmitt-Grohe and Uribe, 2018).

Impulse responses from the FAVAR model provide a basis for disentangling the impacts of different types of domestic and global shocks on the exchange rate. The results described below are based on a one-year response of the nominal effective exchange rate to one-standard-deviation shocks. Medians and interquartile ranges of country-specific estimates are reported for different groups.[8]

Domestic shocks. Monetary policy tightening leads to currency appreciations in all advanced economies and EMDEs (Figure 1). Interest rate driven appreciations are estimated to be larger in EMDEs, particularly among countries with inflation-targeting central banks and in some commodity exporters (Brazil, Colombia, and South Africa). Stronger domestic demand causes currency appreciations as well, but the impact is statistically insignificant after one year in most cases.[9] Meanwhile, changes in domestic supply conditions have mixed effects. This is consistent with the literature arguing that productivity shocks have uncertain implications for currency movements (Alfaro, Cunat, Fadinger, and Liu, 2018; Corsetti, Dedola, and Leduc, 2008).

Global shocks. The median impact of global shocks on the exchange rate is close to zero across countries (Figure 2). Obviously, this result is not surprising, because one coun-

[8] An interquartile range is a range between the 25th to the 75th percentile of country estimates within each country group.

[9] In this paper, statistical inferences are based on 68 percent confidence intervals.

try's currency depreciation is, by definition, another's appreciation. Still, domestic currency appreciations are more likely to happen in the wake of a positive global demand shock, particularly among EMDEs. This could reflect the fact that the U.S. dollar, which remains the global currency of exchange, generally depreciates during global upturns. A weaker U.S. dollar, in turn, typically supports capital inflows and amplifies appreciations in EMDEs, particularly among countries with current account deficits (Avdjiev, Bruno, Koch, and Shin, 2019). A positive global supply-side shock has mixed effects, with currency depreciations observed among some EMDEs that run current account surpluses (for example, China) and appreciations among some commodity exporters (for example, Brazil, Colombia, Malaysia, and South Africa). Rising oil prices also tend to be associated with currency appreciations in oil-exporting economies and with depreciations in some oil importers.

Relative contributions of global and domestic shocks. On balance, domestic factors are the dominant drivers of exchange rate fluctuations, accounting for about two-thirds of currency movements in advanced economies and more than one-half in EMDEs (Figure 3). Although the direction and magnitude of the impact of global shocks vary substantially across countries, these shocks still explain around 7 percent of the variance of currency movements in the median advanced economy and up to 16 percent in the median EMDE. Forbes, Hjortsoe, and Nenova (2017) present similar results, but they attribute a larger share of currency movements to global shocks.[10] About 25 percent of currency movements are accounted for by other shocks, which encompass changes in sovereign and private sector risk premiums. Indeed, shifting expectations about sovereign default risks can have a significant impact on exchange rate dynamics (Alvarez, Atkeson, and Kehoe, 2009; Foroni, Ravazzolo, and Sadaba, 2018).

4.2 Inflation and exchange rate pass-through

Shock-specific ERPTs are calculated from country-specific FAVAR models as the ratio between the cumulative impulse response of inflation and the cumulative impulse response of the exchange rate to different shocks after one year. These conditional pass-through ratios can help establish a link between cross-country and time variations in the average ERPTs and various factors, such as different sensitivities to shocks, changes in the prevalence of some shocks, improved policy frameworks, or other structural factors.

[10] At around 30 percent, on average.

Median estimates of pass-through ratios are reported across different country groups, as well as interquartile ranges across these country groups.

Domestic shocks. Domestic shocks account for over half the variance of inflation and exchange rates in most countries but are associated with different ERPTs depending on their source.

Domestic monetary policy shocks are generally associated with large, positive ERPTs (for example, currency depreciations combined with monetary policy easing are accompanied by significant increases in inflation). Median values since 1998 are estimated to be +0.2 in advanced economies and +0.3 in EMDEs (Figure 4). Pass-through ratios are generally higher in small, open EMDEs that have less flexible exchange rate regimes or do not have inflation-targeting central banks (for example, Azerbaijan, Botswana, Honduras, Jordan, North Macedonia, and Morocco). The finding that EMDEs with inflation-targeting central banks tend to have lower than average ERPTs provides preliminary evidence that a credible commitment to price stability helps weaken the responsiveness of inflation to exchange rate movements.

In sharp contrast with monetary policy shocks, domestic demand shocks are associated with small, negative ERPTs for most countries (for example, a negative domestic demand shock tends to be associated with currency depreciation and declining inflation). Median values at around -0.07 are similar for advanced economies and EMDEs. Among EMDEs, the ERPT is generally more negative in countries with less flexible exchange rate regimes and without inflation-targeting central banks.

Domestic supply-side shocks are associated with positive ERPTs but with lower median values compared to monetary policy shocks (less than +0.1 in advanced economies and EMDEs). However, most of these estimates are insignificant, with wide variations across country groups.

Global shocks. Global shocks account for a smaller proportion of the variance of exchange rate movements and are associated with more variations in estimated ERPTs.

ERPTs associated with global demand shocks tend to be positive among EMDEs (for example, currency depreciation coupled with higher inflation), particularly in economies with less flexible exchange rate regimes and without inflation-targeting central banks (Figure 5). However, in several EMDEs, ERPTs are estimated to be negative (currency depreciation coupled with lower inflation), including among some energy exporters (for example, Azerbaijan

and Colombia). Estimated ERPTs are statistically insignificant in over one-fifth of advanced economies and one-third of EMDEs.

Oil price shocks tend to be associated with widely different ERPTs. The median ERPT is positive for many energy exporters (for example, Azerbaijan, Colombia, and Malaysia) but negative in advanced economies, except the United States (partly due to the negative correlation between the U.S. dollar and oil prices). The estimates are insignificant in over one-half of advanced economies and almost two-thirds of EMDEs.

Global supply shocks tend to generate large variations in ERPTs as well, with a negative median estimate for advanced economies and a positive one for EMDEs. However, the estimates are insignificant for nearly three-quarters of advanced economies and about two-thirds of EMDEs.

Other shocks. The FAVAR models attribute nearly a quarter of currency movements to residual shocks that may be linked to shifting risk premiums and other unmeasured factors. The median ERPT associated with such shocks is close to zero for advanced economies and EMDEs (Figure 6). However, it tends to be negative in EMDEs with less flexible exchange rate regimes, indicating that the direct effect of exchange rate changes on import prices is more than offset by other factors in those countries.

Past empirical studies disentangling the impacts of different types of shocks on exchange rates and inflation have reached broadly similar conclusions. For instance, Forbes, Hjortsoe, and Nenova (2017) estimate a five-variable SVAR model with short- and long-term identifying restrictions using a sample of 26 small, open economies with *de facto* floating exchange rates. They report relatively large, positive ERPTs in response to domestic monetary policy shocks but modest ones for responses to domestic supply shocks and negative ERPTs for domestic demand shocks. They also find that pass-throughs associated with global shocks vary considerably in magnitude and direction. Shambaugh (2008) tests for cross-country differences in shock-specific ERPTs and concludes that domestic demand shocks have a smaller pass-through relative to other types of shocks.

Average pass-through. To facilitate a comparison with other empirical studies, a weighted average of shock-specific pass-through ratios is computed, using shares of currency movements accounted for by each type of shock as weights. This summary measure reflects the average sensitivity of inflation to exchange rate movements over the entire estimation period.

Overall, average ERPTs are estimated to have declined in advanced economies and EMDEs in recent decades. The median estimate for advanced economies averaged +0.08 since 1970 but was close to zero over 1998-2017 (Figure 7). For EMDEs, the median value averaged +0.15 since 1970, but declined to +0.08 over 1998-2017.

Among larger EMDEs, the average ERPT in China is estimated at +0.08 since 1998, somewhat below previously reported estimates (Jiang and Kim, 2013; Shu and Su, 2009; Wang and Li, 2010). For India, the average ERPT is estimated at +0.14, broadly in line with previous studies (Bhattacharya, Patnaik, and Shah, 2008; Forbes, Hjortsoe, and Nenova, 2017; Kapur and Behera, 2012). For Brazil, the average ERPT is estimated at +0.06 since 1998, toward the lower end of other studies (Forbes, Hjortsoe, and Nenova, 2017; Ghosh, 2013; Nogueira and LeÃşn-Ledesma, 2009). For South Africa, the ERPT is estimated at +0.07, broadly in line with the evidence presented by Kabundi and Mbelu (2018).

5 Pass-through to inflation and structural factors

Our findings confirm that the nature of the shocks behind exchange rate movements plays a critical role in determining the direction and magnitude of the exchange rate pass-through to inflation. Country characteristics matter as well. Monetary policy frameworks and structural factors, such as the degree of international trade integration and foreign-currency invoicing, can make domestic prices more or less sensitive to exchange rate fluctuations. In EMDEs, improvements in monetary policy frameworks are credited for being a major force in pushing average ERPTs down over the past two decades.

Monetary policy framework and credibility. The empirical literature has generally found ERPTs to be smaller among advanced economies and in EMDEs with inflation-targeting or more credible central banks (Carriere-Swallow, Gruss, Magud, and Valencia, 2017; Gagnon and Ihrig, 2004; Reyes, 2007; Schmidt-Hebbel and Tapia, 2002). Over the past two decades, an increasing number of central banks have adopted inflation targets and enhanced their credibility, which has helped reduce ERPTs (Mishkin and Schmidt-Hebbel, 2007; Coulibaly and Kempf, 2010). This tendency has been observed across EMDEs, including in many economies in Asia (Prasertnukul, Kim, and Kakinaka, 2010), Latin America (Ghosh, 2013), and Eastern Europe and Central Asia (Maria-Dolores, 2010; Yunculer, 2011).

More generally, countries with lower inflation and less volatile exchange rates have been found to have lower average pass-throughs as well (Forbes, Hjortsoe, and Nenova, 2017).

The consequences of inflation-targeting frameworks and greater central bank credibility and independence are discernible in estimated ERPTs for domestic and global shocks.[11] In particular, the ERPT associated with domestic monetary policy shocks is smaller in EMDEs with more independent centrals banks (Figure 8). An improvement of the central bank independence index from one standard deviation below the sample mean to one standard deviation above it can reduce the pass-through ratio associated with monetary policy shock by half. In countries with more independent central banks, inflation responds less to exchange rate movements triggered by global demand and oil price shocks as well. This implies that countries with flexible exchange rates can better absorb external shocks through currency adjustments without threatening price stability.

Trade openness and participation in global value chains. The feedback between trade openness and exchange rate pass-through is multifaceted. A larger share of foreign products in domestic markets implies a potentially larger role for exchange rate movements in driving aggregate inflation (Benigno, Faia, et al., 2016; Soto and Selaive, 2003). This would be consistent with a higher average ERPT in more open economies. However, increased foreign competition in domestic markets will tend to reduce the pricing power of domestic firms, which will tend to reduce the ERPT (Auer, 2015; Berman, Martin, and Mayer, 2012; Gust, Leduc, and Vigfusson, 2010). More competitive or productive firms also tend to have larger market shares and source more of their inputs internationally (Gopinath and Neiman, 2014), further contributing to a decrease in the ERPT (Amiti, Itskhoki, and Konings, 2014).

The degree of GVC integration could play an important role as well. By fragmenting production and increasing the share of intermediate goods in total trade, higher GVC integration could weaken the response of import and export prices to exchange rate movements. Such an effect has been identified in advanced economies and EMDEs (Amiti, Itskhoki, and Konings, 2014; Soyres, Raphael, Frohm, Gunnella, and Pavlova, 2018; Georgiadis, Gräb, and Khalil, 2017).[12]

[11] The central bank independence index is borrowed from Dincer and Eichengreen (2014).

[12] For instance, using a structural two-country model, Georgiadis, Gräb, and Khalil (2017) show that the sensitivity of an economy's local-currency production costs to exchange rate changes rises as the country participates more in GVCs by importing a larger share of its intermediate inputs. The increased sensitivity of the economy's local-currency production costs to exchange rate changes translates into a lower sensitivity of its foreign-currency export prices to exchange rate changes. As the economy's foreign-currency export price

Several economies in East Asia and Pacific and Eastern Europe and Central Asia have high GVC integration and low average pass-throughs; however, a clear link between GVC integration and pass-throughs could not be established, partly reflecting the correlation between GVC participation and other variables associated with trade openness (Figure 9; Chinn et al., 2014).

Foreign-currency invoicing. Having a large share of imports invoiced in a foreign currency could amplify the sensitivity of import and export prices to exchange rate movements (Devereux, Tomlin, and Dong, 2015; Gopinath, 2015). The ERPT to import and export prices has been found to be particularly elevated for countries with a high share of imports priced in U.S. dollars (Gopinath, Boz, Casas, Diez, Gourinchas, and Plagborg-Moller, 2016; Korhonen and Wachtel, 2006). More generally, domestic prices in highly dollarized economies tend to react more to currency movements relative to other countries, since tradable and nontradable goods are priced in a foreign currency (Carranza, Galdon-Sanchez, and Gomez-Biscarri, 2009; Reinhart, Rogoff, and Savastano, 2014; Sadeghi, Feshari, Marvasti, and Ghanbari, 2015). However, the selection of the pricing currency could itself depend on the desired level of the exchange rate pass-through, preserving the causal relationship (Gopinath, Itskhoki, and Rigobon, 2010).

A significantly larger share of foreign-currency (and U.S. dollar) invoicing in most EMDEs relative to advanced economies could partly help explain a difference in average ERPTs across these two groups. However, the relationship between the size of the pass-through and the share of imports invoiced in foreign currencies appears to be tenuous (Figure 10).[13] For instance, EMDEs with a higher share of foreign-currency invoicing and more elevated ERPTs are also characterized by less flexible currency regimes, and the absence of an inflation-targeting central bank. Overall, the share of foreign-currency invoicing is merely a secondary factor explaining cross-country differences in estimated ERPTs.

equals its trading partner's local-currency import price, an increase in the economy's GVC participation implies a fall in its trading partner's exchange rate pass-through to local-currency import prices.

[13] Share of imports invoiced in foreign currency based on data for 50 countries have been borrowed from Gopinath (2015).

6 Conclusion

Monetary authorities in EMDEs have long been worried that significant exchange rate fluctuations could jeopardize price stability and force disruptive monetary policy responses. To alleviate these concerns, some countries adopted managed currency arrangements or leaned against undesirable currency movements with aggressive policy changes—a practice that has been dubbed "fear of floating" (Calvo and Reinhart, 2002; Ball and Reyes, 2008). However, a lack of exchange rate flexibility can amplify global shocks, encourage speculative attacks, and make it more difficult to anchor inflation expectations credibly. This in turn tends to increase the sensitivity of inflation to exchange rate movements, constraining the effectiveness of monetary policy and, as a result, limiting the adjustment of relative prices and the efficacy of expenditure-switching mechanisms as a buffer against global shocks.

This underscores the importance of properly evaluating the exchange rate pass-through to inflation under various circumstances and identifying the factors affecting it. Such an evaluation is of fundamental importance to formulating the appropriate and proportionate monetary policy response to currency movements. Accordingly, this paper investigates the relationship between inflation and exchange rate movements, contingent on the nature of the underlying shocks. The paper uses FAVAR models to compute seven shock-specific pass-through ratios for each country. These ratios are then grouped and aggregated to identify common patterns.

Domestic shocks are found to be a dominant driver of exchange rate fluctuations across most countries but are associated with significantly different pass-throughs to inflation, depending on their characteristics. In particular, domestic monetary shocks are generally accompanied by higher than average pass-throughs, particularly in countries with less flexible exchange rate regimes and without inflation-targeting central banks. In contrast, domestic demand shocks are typically associated with negative and mostly insignificant pass-through ratios, due to the offsetting effects of growth and exchange rate channels (for example, weakening domestic demand giving rise to currency depreciation and declining inflation). Global shocks accounted for a smaller proportion of exchange rate movements and are associated with considerable heterogeneity of the estimated ERPTs, depending on country characteristics and the source of the shock.

Differences in shock-specific ERPTs could have important implications for monetary policy. For example, the exchange rate pass-through during an initial economic recovery phase could be low, reflecting the predominance of domestic demand shocks. However, appreciation caused by monetary policy tightening could be associated with a significantly larger degree of pass-through. Failing to take these factors into account may lead central banks to tighten policy more than needed to stabilize inflation, creating unnecessary fluctuations in activity.

Monetary policy frameworks and other country-specific characteristics affecting the sensitivity of domestic prices to currency fluctuations matter as well. In particular, a credible commitment to maintaining low and stable inflation has been one of the key factors behind the weak pass-through of even sizable depreciations to inflation in advanced economies and EMDEs over the past two decades. Looking at the cross-section of ERPT estimates for EMDEs, an improvement of the central bank independence index from one standard deviation below the sample mean to one standard deviation above the sample mean could potentially reduce the pass-through ratio associated with domestic monetary policy shocks by half. This highlights a self-reinforcing feedback between central bank credibility and price stability.

There is also evidence for a downward trend in ERPT estimates (over time), which can be connected to the improvement in central bank policies and more solid anchoring of inflation expectations. Other structural factors, including growing integration in GVCs, may have played a role as well, but the analysis is not able to account for the cross-country differences in ERPTs.

Future research could investigate more formally the relationship between estimated ERPTs and structural factors, such as the degree of value chain participation and foreign-currency invoicing practices in EMDEs. This could take the form of event studies around significant policy or other structural changes. The analysis of shock-specific pass-through could also be extended to different inflation measures, for example, import prices, producer prices, the gross domestic product deflator, and core consumer price inflation.[14] This could shed more light on the source of incomplete pass-through to consumer price inflation and help guide monetary policy decisions. Finally, nonlinearities in the exchange rate pass-through

[14]For example, see studies such as by Dwyer and Lam (1995) who decompose ERPT into the first-stage pass-through (considering the effects of currency movements on import prices) versus second-stage pass-through (considering the effects of import prices on consumer prices).

could be further investigated, looking at the direction and size of the various shocks under consideration.[15]

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[15] For example, studies such as by Shintani, Terada-Hagiwara, and Yabu (2013) or Cheikh and Zaied (2020) focus on the role of inflation environment, while those by Correa and Minella (2010), Nogueira Jr and León-Ledesma (2011) or Donayre and Panovska (2016) focus on the role of business cycles or economic crises.

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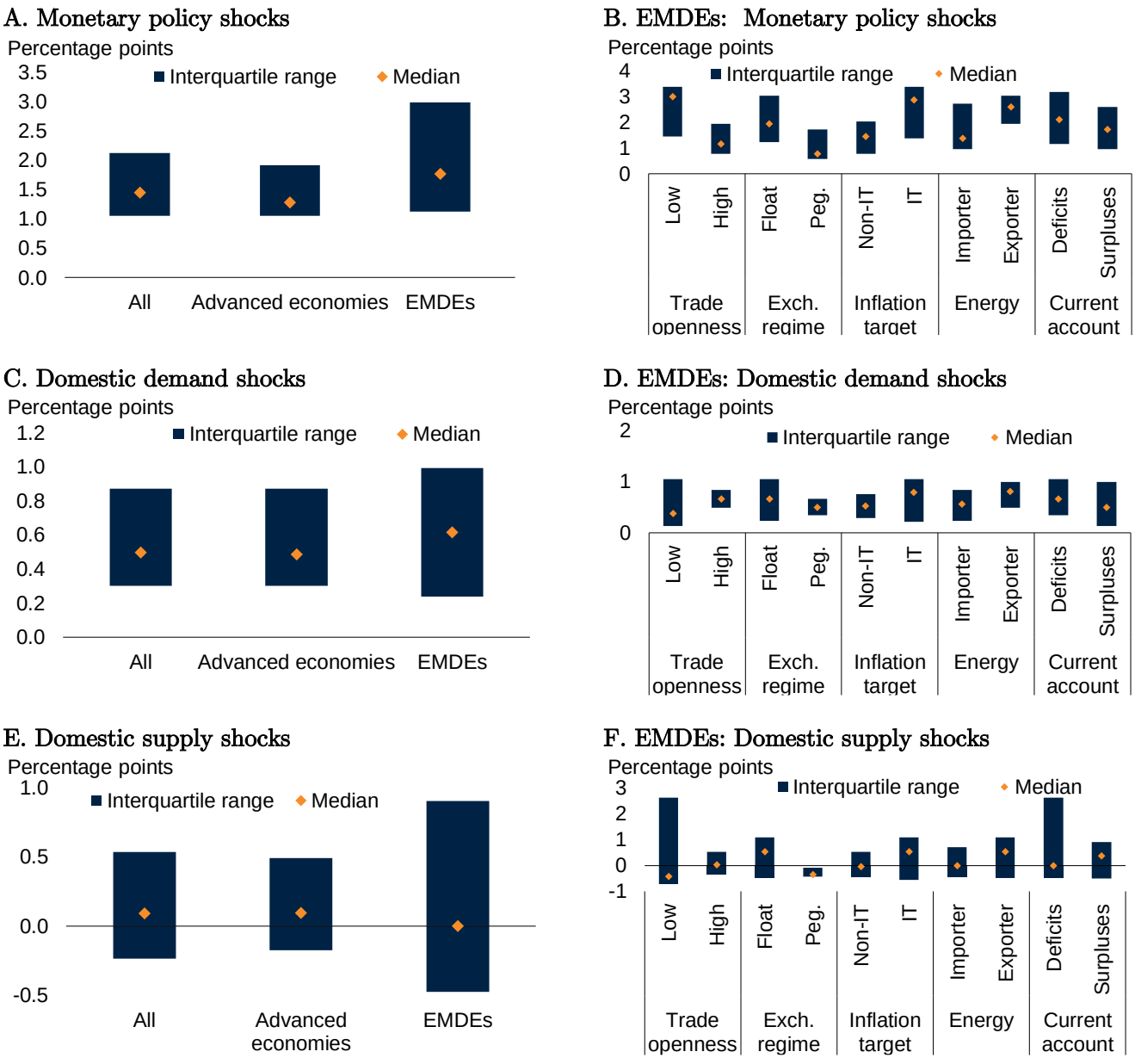
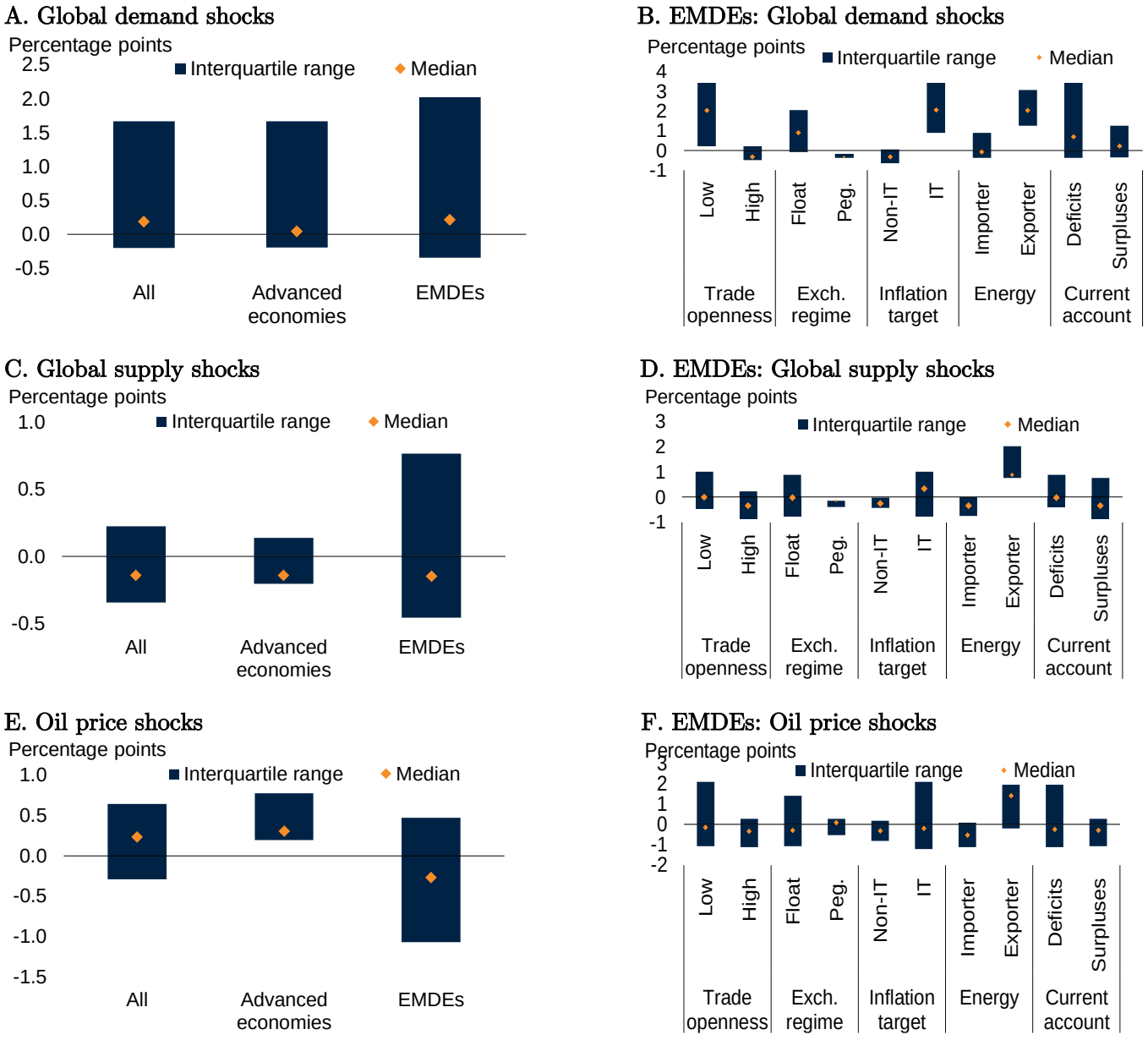
Figure 1 – Exchange rate responses to domestic shocks



Note: One-year impulse responses of the exchange rate to domestic shocks (monetary policy, domestic demand, and domestic supply) from country-specific factor-augmented vector autoregression models estimated for 29 advanced economies and 26 EMDEs over 1998-2017. Bars show the interquartile range and markers represent the median across countries. A positive number indicates an appreciation. EMDEs = emerging market and developing economies; IMF = International Monetary Fund; IT = inflation targeting.

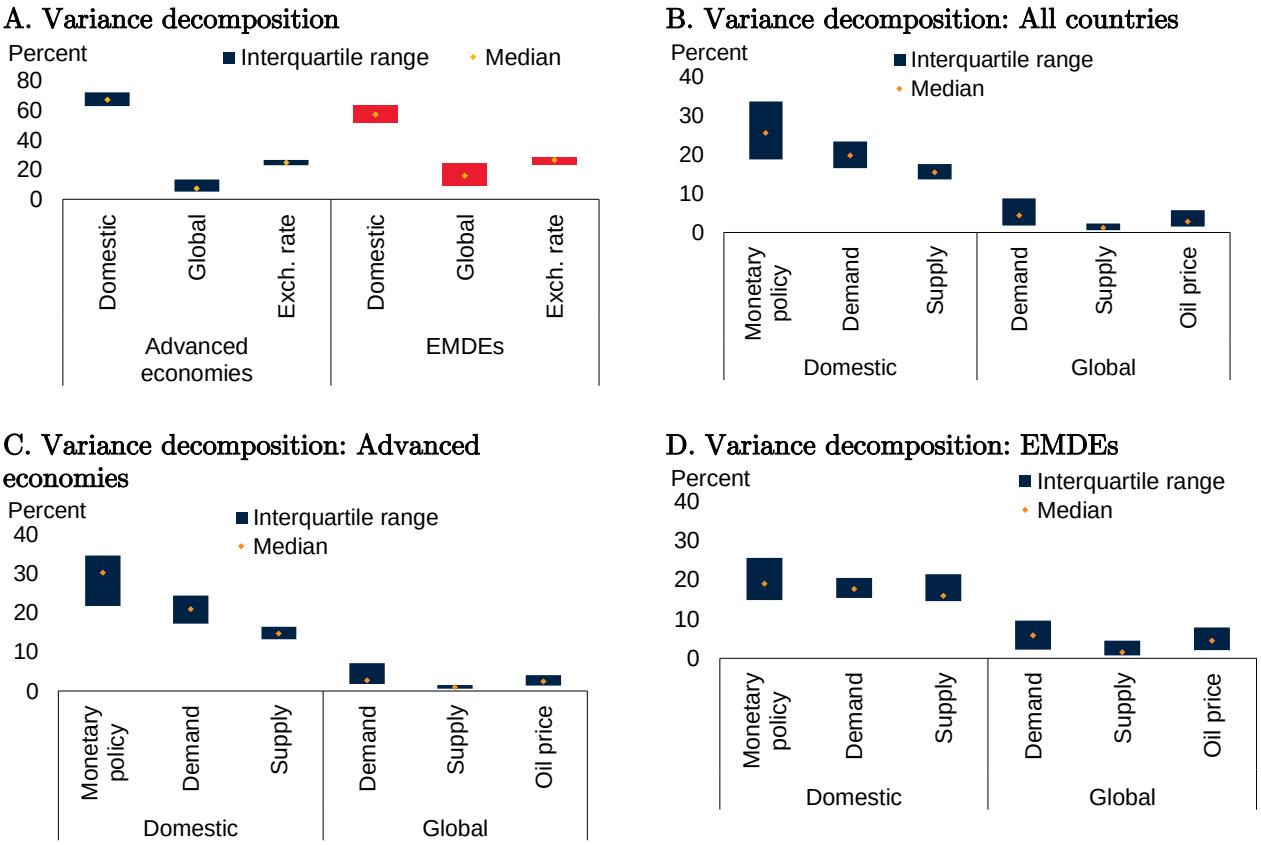
B.D.F. Countries with "high" trade openness are defined as those with above median trade-to-GDP ratios; all others are considered to have "low" trade openness. Exchange rate and IT regimes are based on IMF classifications. Energy exporters are defined according to World Bank classifications; all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

Figure 2 – Exchange rate responses to global shocks



Note: One-year impulse response of the exchange rate to global shocks (demand, supply, and oil prices) from country-specific factor-augmented vector autoregression models estimated for 29 advanced economies and 26 EMDEs over 1998-2017. Bars show the interquartile range and markers represent the median across countries. A positive number indicates an appreciation. EMDEs = emerging market and developing economies; IT = inflation targeting.
B.D.F. Countries with "high" trade openness are defined as those with above median trade-to-GDP ratios; all others are considered to have "low" trade openness. Exchange rate and IT regimes are based on IMF classifications. Energy exporters are defined according to World Bank classifications; all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

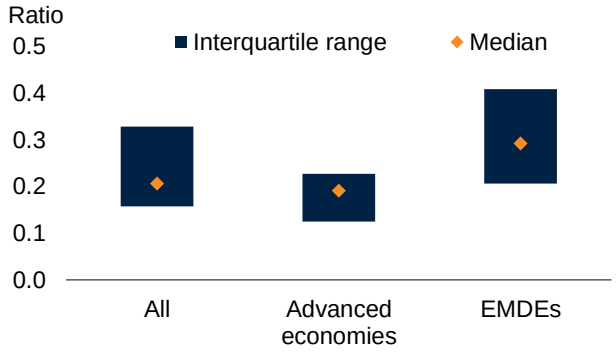
Figure 3 – Variance decompositions of exchange rate movements



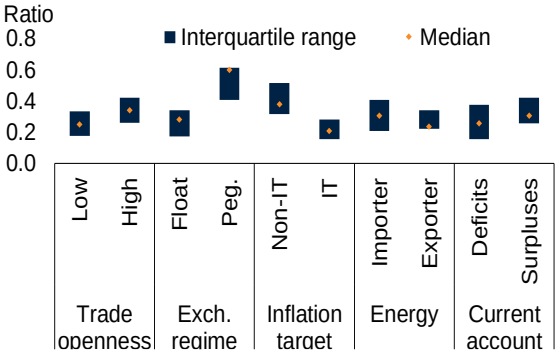
Note: Median share of country-specific exchange rate variance accounted for by global, domestic, and exchange rate shocks based on country-specific factor-augmented vector autoregression models estimated for 29 advanced economies and 26 EMDEs over 1998-2017. Bars show the interquartile range and markers represent the median across economies. EMDEs = emerging market and developing economies.

Figure 4 – Pass-through associated with domestic shocks

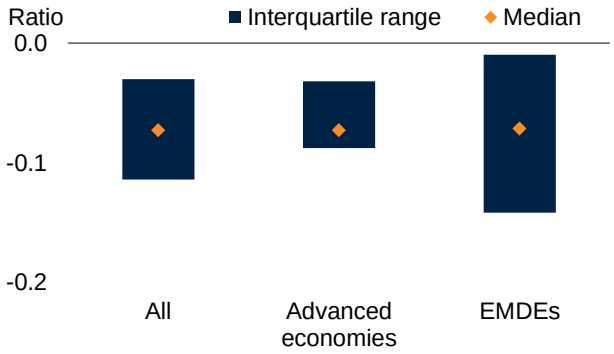
A. Monetary policy shocks



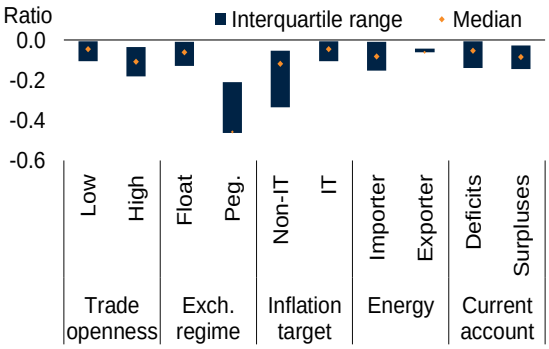
B. EMDEs: Monetary policy shocks



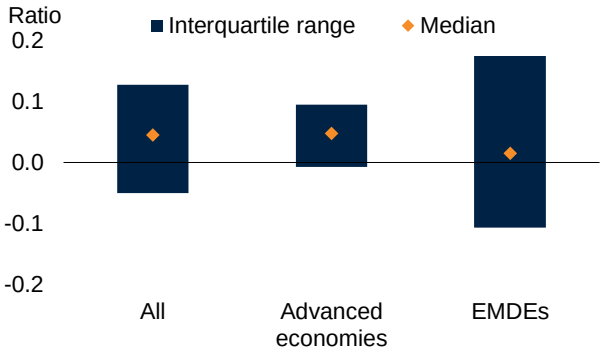
C. Domestic demand shocks



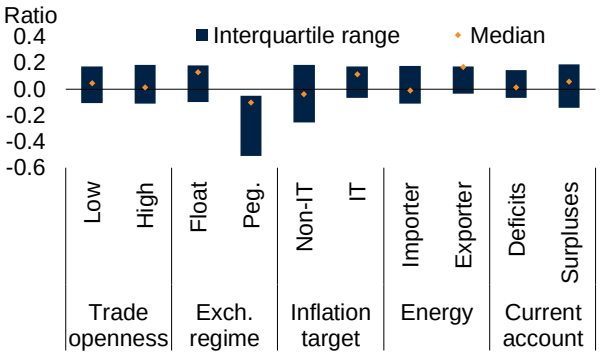
D. EMDEs: Domestic demand shocks



E. Domestic supply shocks

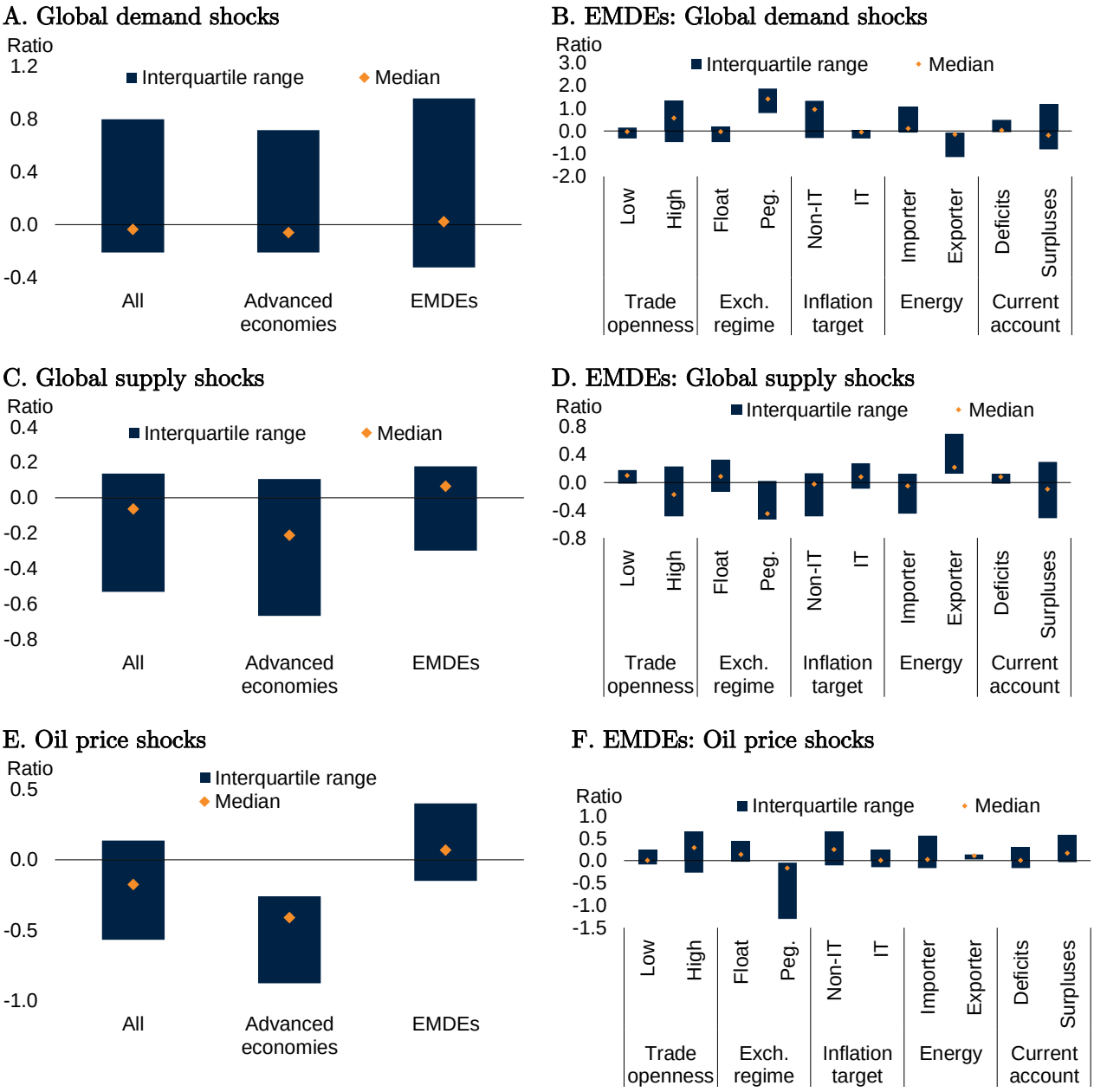


F. EMDEs: Domestic supply shocks



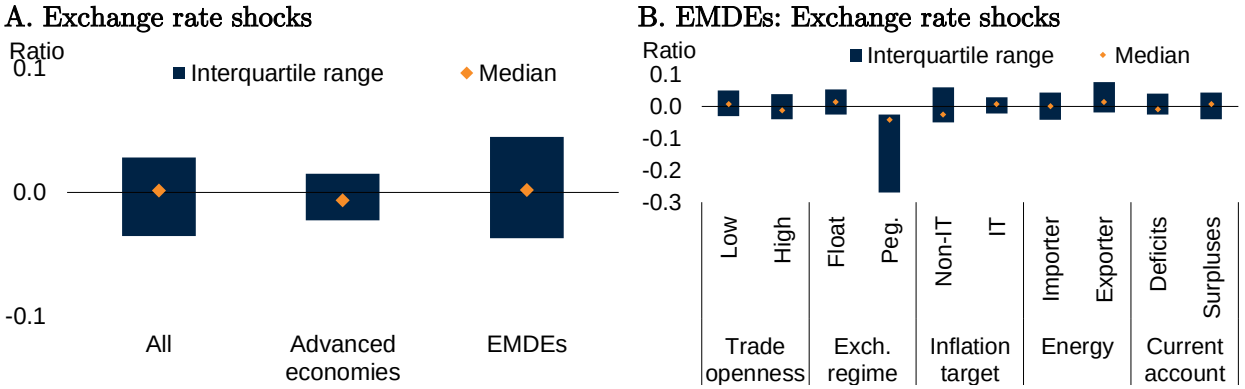
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. EMDEs = emerging market and developing economies; IT = inflation targeting.
B.D.F. Countries with "high" trade openness are defined as those with above median trade-to-GDP ratios; all others are considered to have "low" trade openness. Exchange rate and IT regimes are based on IMF classifications. Energy exporters are defined according to World Bank classifications; all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

Figure 5 – Pass-through associated with global shocks



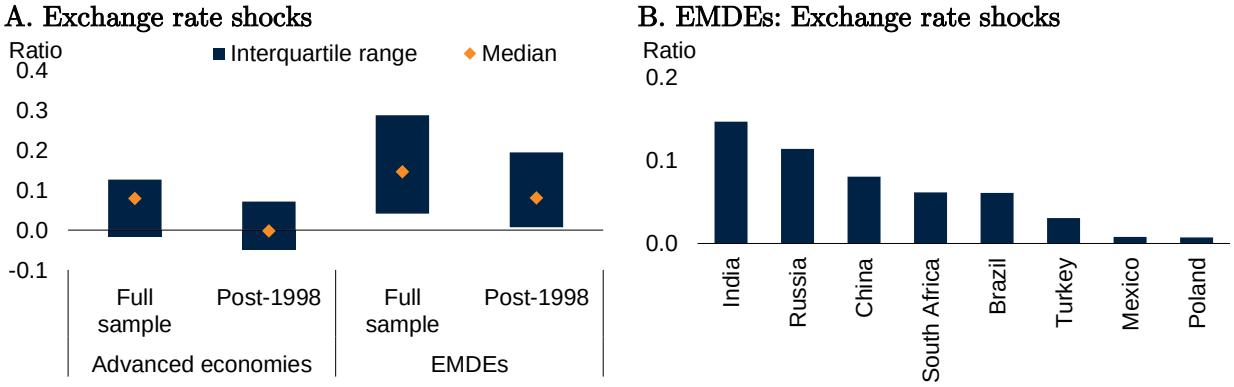
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. EMDEs = emerging market and developing economies; IT = inflation targeting.
B.D.F. Countries with "high" trade openness are defined as those with above median trade-to-GDP ratios; all others are considered to have "low" trade openness. Exchange rate and IT regimes are based on IMF classifications. Energy exporters are defined according to World Bank classifications; all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

Figure 6 – Pass-through associated with exchange rate shocks



Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. EMDEs = emerging market and developing economies; IT = inflation targeting. B. Countries with "high" trade openness are defined as those with above median trade-to-GDP ratios; all others are considered to have "low" trade openness. Exchange rate and IT regimes are based on IMF classifications. Energy exporters are defined according to World Bank classifications; all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

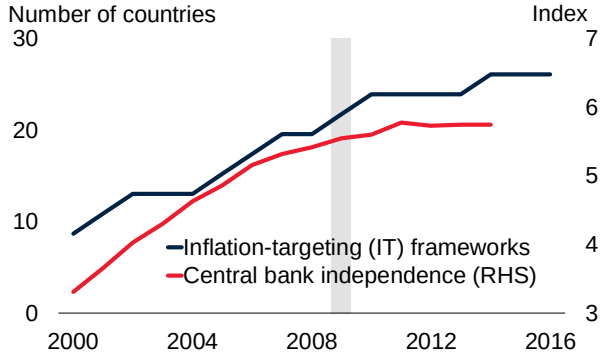
Figure 7 – Average pass-through



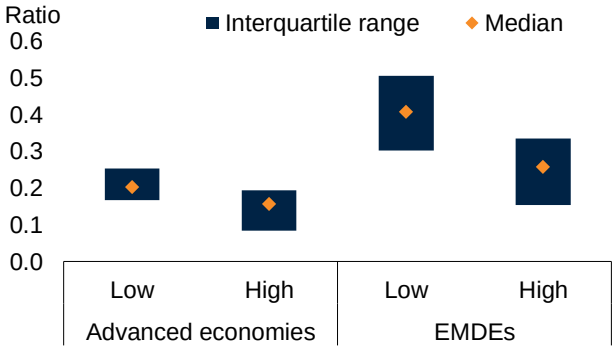
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. Shock-specific pass-throughs are aggregated using shares of currency movements accounted for by each type of shock as weights. EMDEs = emerging market and developing economies.
A. Full sample estimations are over 1971 to 2017 but can vary at the country level depending on data availability.

Figure 8 – Central bank credibility and pass-through

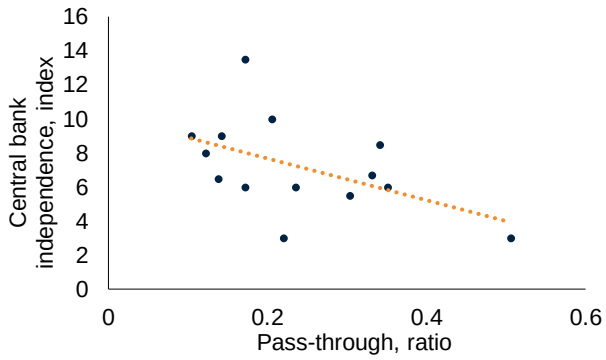
A. Central bank independence and inflation targeting frameworks



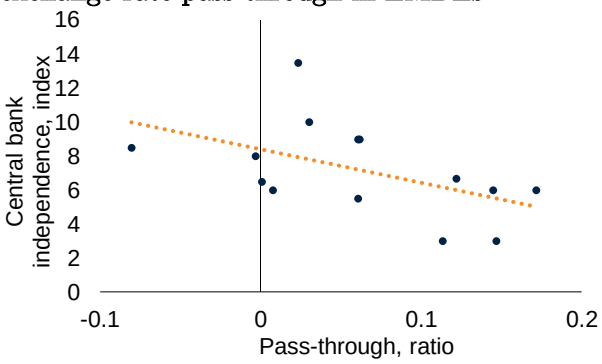
B. Central bank independence and exchange rate pass-through from monetary policy shocks



C. Central bank independence and exchange rate pass-through from monetary policy shocks in EMDEs

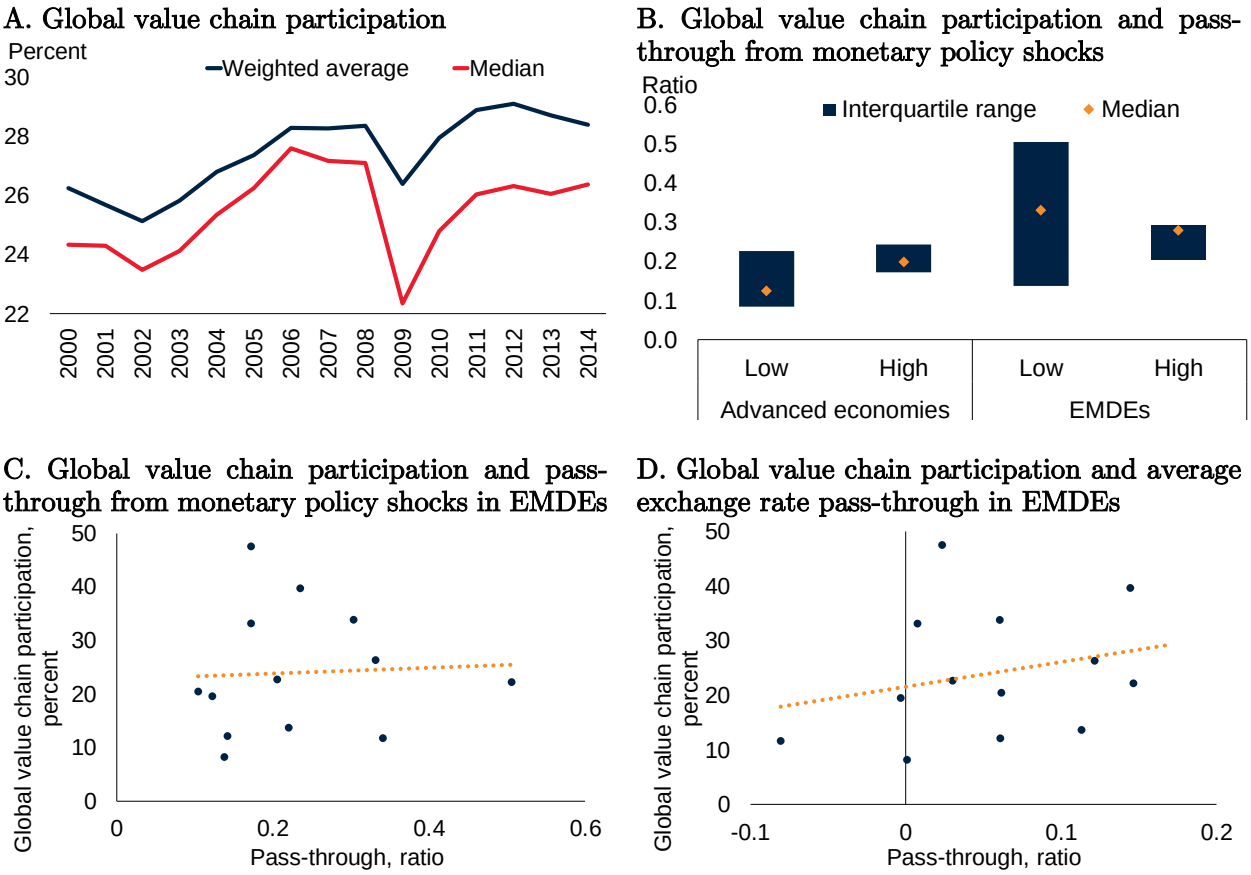


D. Central bank independence and average exchange rate pass-through in EMDEs



Note: An increase in the central bank independence index means greater central bank independence. Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. EMDEs = emerging market and developing economies; ERPTR = exchange rate pass-through ratio; IT = inflation targeting.
B. Low and high central bank independence are defined as below or above the sample average.
C.D. The sample only includes EMDEs with floating exchange rate regimes according to the IMF classification.
D. Shock-specific pass-throughs are aggregated using shares of currency movements accounted for by each type of shock as weights.

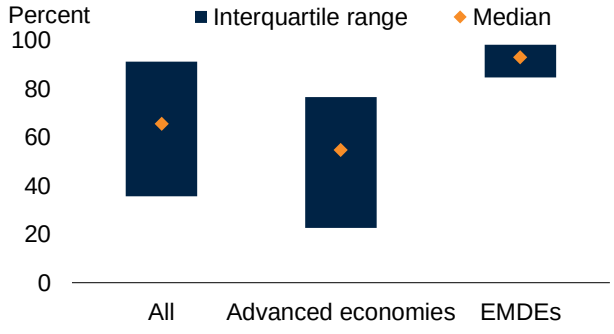
Figure 9 – Global value chain participation and pass-through



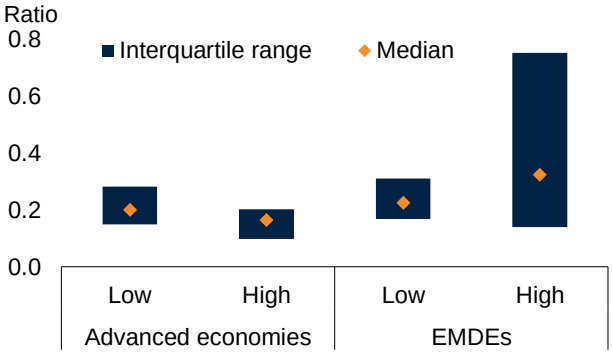
Source: OECD; World Bank.
Note: Global value chain data are from the OECD-WTO TiVA database. The selected indicator is foreign value added as a percent of gross exports. Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from
factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. EMDEs = emerging market and developing economies; OECD = Organisation for Economic Co-operation and Development; TiVA = Trade in Value Added; WTO = World Trade Organization.
B. Low and high value chain participation are defined as below or above the sample average.
C.D. The sample only includes EMDEs with floating exchange rate regimes according to the IMF classification.
D. Shock-specific pass-throughs are aggregated using shares of currency movements accounted for by each type of shock as weights.

Figure 10 – Foreign-currency import invoicing and pass-through

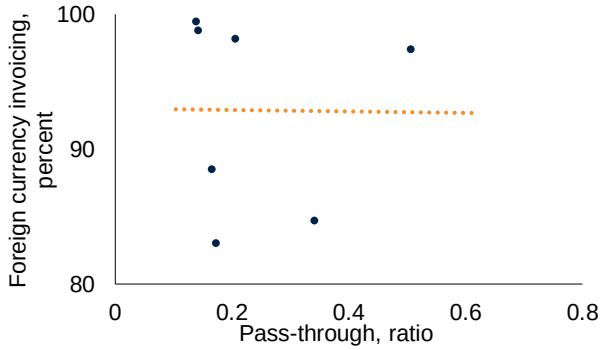
A. Share of imports invoiced in foreign currency



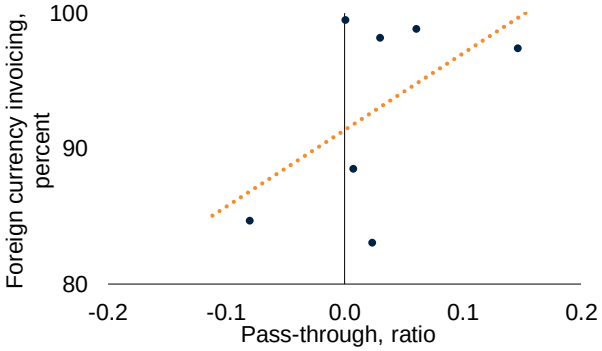
B. Share of foreign-currency invoicing and pass-through from monetary policy shocks



C. Share of foreign-currency invoicing and pass-through from monetary policy shocks in EMDEs

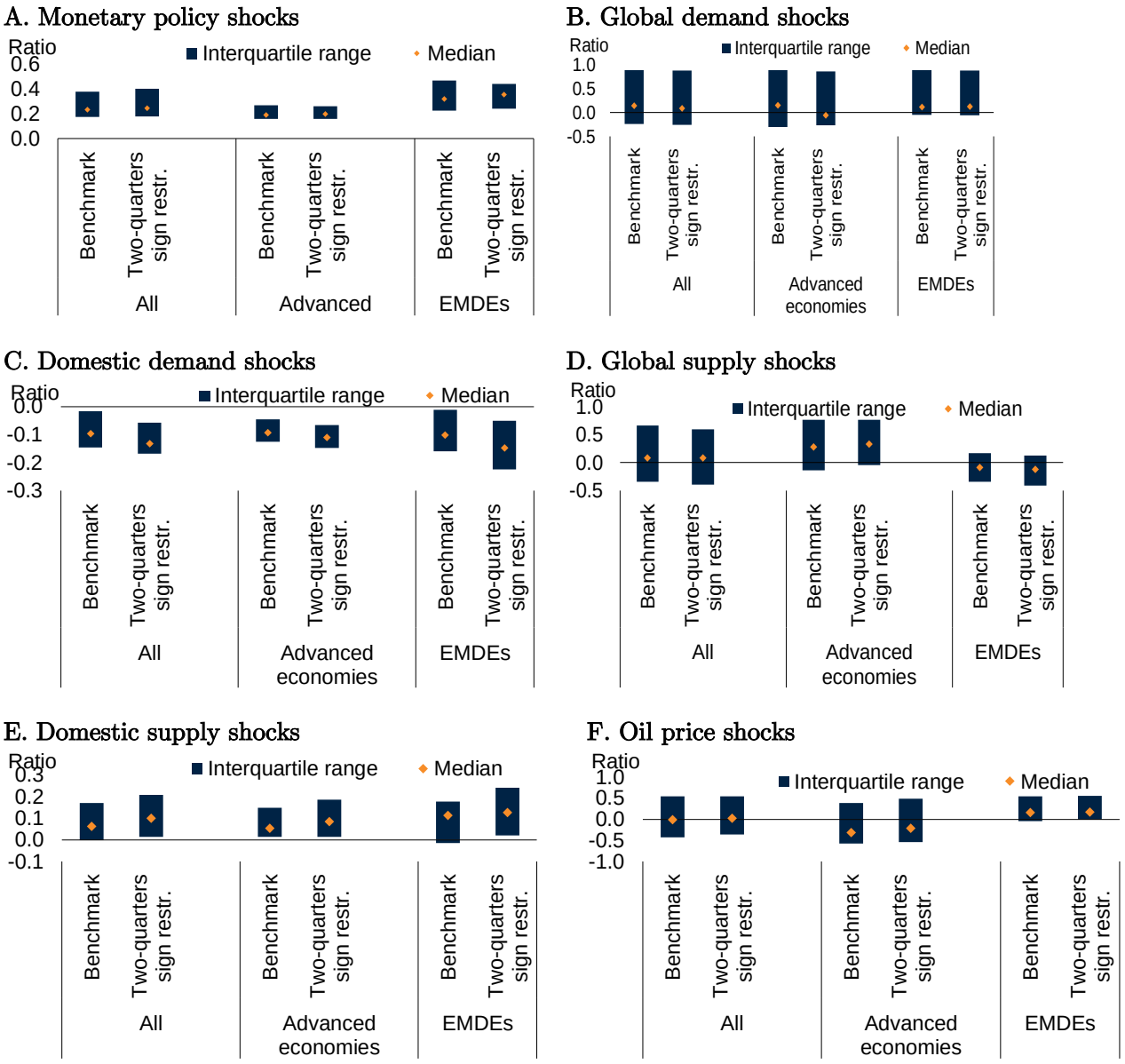


D. Share of foreign-currency invoicing and average exchange rate pass-through in EMDEs



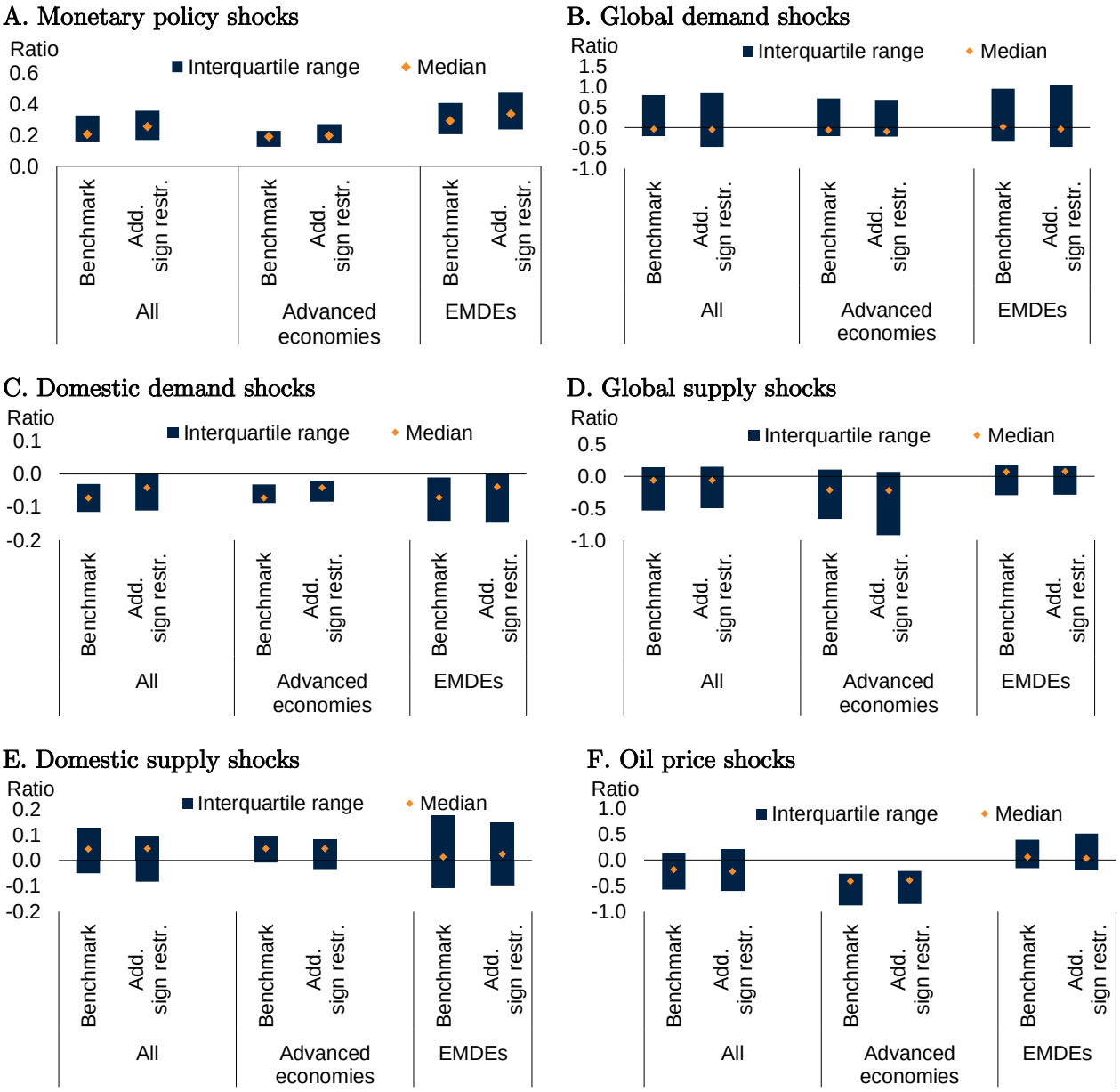
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. EMDEs = emerging market and developing economies; ERPTR = exchange rate pass-through ratio.
B. Low and high share of foreign-currency invoicing are defined as below or above the sample average.
C.D. The sample only includes EMDEs with floating exchange rate regimes according to the IMF classification.
D. Shock-specific pass-throughs are aggregated using shares of currency movements accounted for by each type of shock as weights.

Appendix Figure A.1 – One versus two-quarter sign restrictions



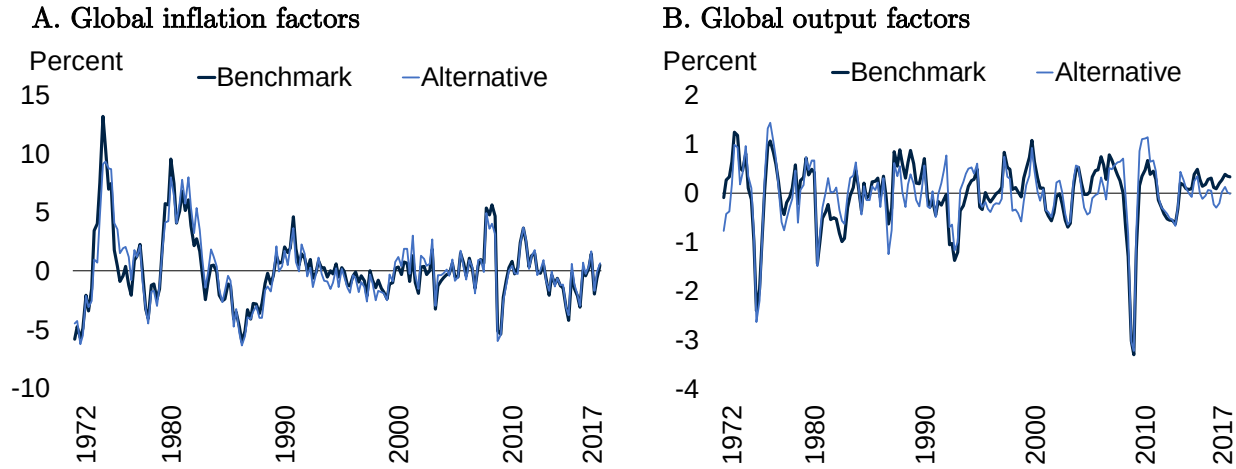
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change to shocks from country-specific factor-augmented vector autoregression models estimated for 55 economies (29 advanced economies and 26 EMDEs) over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. In the alternative specification, sign restrictions are applied to the current quarter and next quarter. EMDEs = emerging market and developing economies.

Appendix Figure A.2 – Additional sign restriction to identify domestic demand shocks



Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change to shocks from country-specific factor-augmented vector autoregression models estimated for 55 economies (29 advanced economies and 26 EMDEs) over 1998-2017. A positive pass-through means that a currency depreciation is associated with higher inflation. Bars show the interquartile range and markers represent the median across countries. In the alternative specification, an additional sign restriction was imposed, assuming that a positive domestic demand shock leads to a contemporaneous increase in domestic interest rates. EMDEs = emerging market and developing economies.

Appendix Figure A.3 – Alternative measures of global inflation and global output growth



Notes. "Benchmark" indicates global inflation factor (extracted from 47 countries) and global output growth factor (extracted from 29 countries), respectively, using seprate dynamic factor models. "Alternative" indicates global factors for inflation and output growths based on a balanced set of 25 countries.

Appendix Table A.1 – List of countries and sample periods

Country	Sample period	Country	Sample period
Australia	1970:2 - 2017:4	India	1993:3 - 2017:4
Austria	1990:1 - 2017:4	Israel	1985:3 - 2017:4
Azerbaijan	2005:3 - 2017:4	Italy	1979:2 - 2017:4
Belgium	1970:2 - 2017:4	Jordan	1999:3 - 2017:4
Bulgaria	1994:4 - 2017:4	Japan	1989:3 - 2017:4
Brazil	1998:3 - 2017:4	Korea, Republic of	1991:3 - 2017:4
Botswana	1994:4 - 2017:4	Luxembourg	1999:3 - 2017:4
Canada	1970:2 - 2017:4	Mexico	1989:1 - 2017:4
Switzerland	1970:3 - 2017:4	North Macedonia	2008:1 - 2017:4
Chile	1986:3 - 2017:4	Malta	1999:3 - 2017:4
China	1984:4 - 2017:4	Malaysia	2004:4 - 2017:4
Colombia	1994:4 - 2017:4	Morocco	1995:4 - 2017:4
Costa Rica	1997:3 - 2017:4	Netherlands	1982:3 - 2017:4
Czechia	1992:4 - 2017:4	Norway	1979:2 - 2017:4
Germany	1970:2 - 2017:4	New Zealand	1974:3 - 2017:4
Denmark	1970:2 - 2017:4	Philippines	1987:3 - 2017:3
Dominican Republic	2004:3 - 2017:3	Poland	1992:1 - 2017:4
Egypt, Arab Rep.	2002:4 - 2017:2	Portugal	1986:2 - 2017:4
Spain	1977:3 - 2017:4	Russian Federation	2000:1 - 2017:4
Finland	1987:3 - 2017:4	Slovak Republic	1996:1 - 2017:4
France	1970:2 - 2017:4	Slovenia	2002:3 - 2017:4
United Kingdom	1970:2 - 2017:4	South Africa	1981:3 - 2017:4
Greece	1994:4 - 2017:4	Sweden	1983:3 - 2017:4
Honduras	2005:4 - 2017:4	Thailand	2000:4 - 2017:4
Hungary	1995:4 - 2017:4	Tunisia	2000:4 - 2017:4
Indonesia	1990:3 - 2017:4	Turkey	2007:1 - 2017:4
Ireland	1984:3 - 2017:4	United States	1970:2 - 2017:4
Iceland	1988:3 - 2017:4		