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Abstract

The degree to which domestic prices adjust to exchange rate movements is key to understanding inflation dynamics, and hence to guiding monetary policy. However, the exchange rate pass-through to inflation varies considerably across countries and over time. By estimating structural factor-augmented vector-autoregressive models for 47 countries, this paper brings to light two fundamental factors accounting for these variations: the nature of the shock triggering currency movements and country-specific characteristics. The empirical results in this paper are three-fold. First, an empirical investigation demonstrates that different domestic and global shocks can be associated with widely different pass-through ratios. Second, country characteristics matter, including policy frameworks that govern monetary policy responses, as well as other structural features that affect an economy's sensitivity to currency fluctuations. Pass-through ratios tend to be lower in countries that combine flexible exchange rate regimes and credible inflation targets. Finally, the empirical results suggest that central bank independence can greatly facilitate the task of stabilizing inflation following large currency movements and allows fuller use of the exchange rate as a buffer against external shocks.

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1. Introduction

The expected impact of currency movements on consumer prices should determine how the central bank reacts to them. In particular, monetary authorities might look beyond a shift in price levels but may choose to respond if the impact on inflation is persistent. The risk of policy missteps if the exchange rate pass-through to inflation is not properly evaluated 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 ratio (ERPTR)—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.

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 and/or nominal rigidities may explain incomplete pass-through (see Appendix 1 for a literature review).

Many structural factors have been associated with a lower sensitivity of domestic prices to exchange rate movements, including the degree of competition among importing and exporting firms (Amiti, Itskhoki, and Konings 2016), the frequency of price adjustments (Devereux and Yetman 2003; Corsetti, Dedola, and Leduc 2008; Gopinath and Itskhoki 2010), the composition of trade (Campa and Goldberg 2010), the level of participation in global value chains (GVCs; Georgiadis, Gräb, and Khalil 2017), the share of trade invoiced in foreign currencies (Casas et al. 2017; Gopinath 2015), and the use of currency hedging instruments (Amiti, Itskhoki, and Konings 2014). A credible monetary policy framework that supports well-anchored inflation expectations has also been viewed as an effective way to reduce the pass-through to consumer prices (Carriere-Swallow et al. 2016; Gagnon and Ihrig 2004; Reyes 2004; Schmidt-Hebbel and Tapia 2002; Taylor 2000).

Beyond structural factors and country characteristics, 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 (Comunale and Kunovac 2017; Forbes, Hjortsoe, and Nenova 2017; Shambaugh 2008). 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 ERPTRs will vary widely depending on the shock that triggers them—a possibility that most empirical studies have not taken into account.

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. For instance, if the ERPTR 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.

Against this background, this paper examines the following questions. First, how have exchange rate movements impacted inflation over time? Second, how does the pass-through to inflation depend on the underlying shock triggering the exchange rate movement? Third, what country characteristics are associated with lower pass-throughs?

To answer these questions, the paper first examines the extent of the comovement between inflation and exchange rates across 34 advanced economies and 138 EMDEs, including event studies of significant depreciation and appreciation episodes. Second, from a series of factor-augmented vector autoregression (FAVAR) models, the paper estimates the impact of various global and domestic shocks on exchange rates and inflation, deriving shock-specific pass-through ratios.[1] The models are estimated from a subsample of 55 countries, including 26 EMDEs. Third, it investigates how country characteristics affect pass-through ratios, paying particular attention to monetary policy frameworks, participation in GVCs, and foreign-currency invoicing.

The main conclusions are as follows. Large depreciation episodes continue to be associated, on average, with more significant increases in consumer price inflation in EMDEs than in advanced economies. Unconditional pass-throughs tend to increase with the size of the depreciation in both country groups. In addition, the relationship between inflation and currency movements depends on the nature of the underlying shock. Monetary policy shocks are associated with a higher exchange rate pass-through compared to other domestic shocks, and global shocks have widely different effects. Finally, country characteristics matter for pass-through rates. Pass-throughs are generally lower in countries with more flexible exchange rate regimes and a credible commitment to an inflation target. This, in turn, facilitates the central bank's task of stabilizing inflation and makes exchange rate movements a more effective buffer against external shocks.

The contribution of this paper to the literature is threefold. First, it utilizes a rich set of results to shed new light on the heterogeneity of pass-through estimates across countries and over time.

Second, this paper supplements a burgeoning empirical literature linking exchange rate pass-through to underlying shocks in a structural vector autoregression (SVAR) model framework. This contrasts with traditional reduced-form approaches that estimate "average" pass-throughs based on conditioning variables. The estimation of shock-specific pass-throughs refines the analysis of factors affecting the link between exchange rate movements and inflation.

Third, compared to the few preceding studies that have derived state-dependent estimates of ERPTRs (Forbes, Hjortsoe, and Nenova 2017, 2018; Shambaugh 2008), this paper investigates additional shocks and uses a larger sample of countries. It looks at the impact of three domestic shocks (monetary policy, demand, and supply), three global shocks (demand, supply, and oil price), and a residual shock capturing, among other factors, changing risk premiums. A unique FAVAR framework combining global and domestic developments allows identification of these different shocks in a unified setup. Moreover, the identification strategy uses an efficient algorithm to combine sign and zero restrictions, preserving a certain level of agnosticism (Arias, Rubio-

[1] 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 three domestic shocks (monetary policy, domestic demand, and domestic supply), three global shocks (global demand, global supply, and oil prices), and one residual shock (risk premium).

Ramirez, and Waggoner 2014). Finally, compared to previous studies, this paper is more focused on EMDE-specific characteristics, including monetary policy frameworks, participation in GVCs, and foreign currency invoicing.

The next sections offer key stylized facts about the link between inflation and exchange rate movements. Section 3 introduces empirical model and data. Section 4 present estimates of shock-specific ERPTRs, and Section 5 demonstrate the importance of structural factors and country-specific characteristics. The conclusion discusses policy implications and suggests avenues for future research.

2. Stylized facts: Exchange rate movements and inflation

This section examines the historical relationship between changes in the nominal effective (trade-weighted) exchange rate and consumer price inflation. A depreciation (decline in the effective exchange rate) is expected to cause the domestic price of imports to rise and, depending on a host of factors, higher consumer prices (a positive pass-through). The first step in this descriptive analysis examines the impact of large currency movements on consumer price inflation in cross-country event studies. The second step examines the stability of the relationship between inflation and currency movements over time.

2.1. Inflation and exchange rate movements: Event study

The event study presented in this section explores episodes of large exchange rate fluctuations, defined as quarterly movements in excess of 5 percent across 34 advanced economies and 138 EMDEs. The rationale for focusing on large currency fluctuations is twofold. First, such episodes are more likely to induce detectable changes in prices throughout the entire production chain. This helps trace factors influencing the exchange rate pass-through across countries. Second, such an event study allows the estimation of the pass-through conditional on the size and direction of the exchange rate movement. A common assumption in the literature is that the relationship between exchange rate movements and inflation is linear and symmetric. However, prices may respond differently to large changes in the exchange rate, and depreciations may generate an asymmetric reaction relative to appreciations. Computing unconditional pass-throughs associated with different types of exchange rate movements can help disentangle these effects.

Overall, depreciations of between 5 and 10 percent per quarter have been associated with a low unconditional pass-through over the past two decades (Figure 1). Median estimates of the same quarter pass-through are close to zero in advanced economies and around +0.1 for EMDEs (a 10 percent depreciation in the median EMDE triggers a 1 percent increase in consumer prices after one quarter). Depreciations of between 10 and 20 percent in a given quarter were generally accompanied by a higher pass-through, with median values of +0.1 for advanced economies and +0.2 for EMDEs. Depreciations in excess of 20 percent were associated with pass-throughs of around +0.4 in both groups of countries, but these events have been far less common recently, which reduces the reliability of the estimated pass-throughs.

The event study also confirms a broad-based decline in the pass-through among EMDEs over the past two decades. For depreciations of between 5 and 10 percent, the median pass-through in EMDEs fell by a factor of three from 1980-98 to 1998-2017. This decline came with a reduction in the frequency and severity of currency depreciations. Prior to 1998, large depreciation episodes in EMDEs clustered around periods of U.S. dollar appreciation, often associated with a tightening

of U.S. monetary policy. In some cases, these led to full-blown currency or debt crises, particularly in Latin America during the 1980s and the early to mid-1990s, and in Asia during the second half of the 1990s. The reduced frequency of large depreciations and lower unconditional pass-throughs over the past two decades may have common causes: enhanced monetary and fiscal policy frameworks, more flexible exchange rate regimes, accumulations of foreign exchange reserves, lower current account deficits, and better external debt management (Frankel, Parsley, and Wei 2005). Unconditional pass-throughs remained higher among EMDEs with less flexible exchange rate regimes (those devaluing from currency pegs or other forms of currency arrangements) and those without inflation targeting central banks.

Appreciation episodes are generally associated with positive, but lower, pass-throughs compared to depreciations of the same magnitude, with median values of +0.02 for advanced economies and EMDEs for appreciations of between 5 and 10 percent, and only slightly higher for appreciations of between 10 and 20 percent (Figure 2). These results may indicate that currency appreciations induce a weaker response from import and consumer prices compared to similar-size depreciations (Brun-Aguerre, Fuertes, and Greenwood-Nimmo 2017). However, large currency appreciations are also rare events, making rigorous conclusions about asymmetric effects difficult to establish in this context. Overall, the results appear to point to the presence of nonlinearities in the relationship between exchange rate movements and inflation, including in EMDEs (Caselli and Roitman 2016).

2.2. Inflation and exchange rate correlation: Evolution over time

Although the declining sensitivity of inflation to exchange rate movements has been extensively documented, this relationship is generally assumed to be stable in the short term. However, there is growing evidence that pass-throughs can vary considerably even over short periods of time, making inference from average values unreliable and potentially misleading for policy evaluation and forecasting purposes.

This instability in pass-through rates can be illustrated by plotting rolling correlation rates between exchange rate movements and consumer price inflation over time (Figure 3).[2] For advanced economies, the median correlation rate became increasingly positive during the late 1990s (+0.4 in 2000), during the mid-2000s (+0.2 in 2007), and again during the mid-2010s (+0.5 in 2014). These were periods marked by unusually large monetary policy shocks or heightened uncertainty over policy actions, providing some evidence of stronger exchange rate pass-through to inflation during such episodes. In contrast, correlation rates were close to zero during the recovery in the early 2000s and turned significantly negative during the global financial crisis (-0.5 in 2008-09). They were also close to zero during the latest synchronized upturn in 2017-18. These were periods dominated by shifts in domestic or global demand conditions, which appear to be associated with a lower sensitivity of inflation to exchange rate movements.[3] These trends were largely shared across countries, as reflected in similar swings in the upper and lower bands of the interquartile range of country estimates.[4]

[2] Using a three-year window of the bivariate correlation between the nominal effective exchange rate depreciation rate in one quarter and the inflation rate in the next quarter. For advanced economies and EMDEs, correlation rates tend to peak after one quarter, indicating that exchange rate movements have the strongest impact on inflation with a one-quarter lag.

[3] Sharp movements in oil prices around the global financial crisis also affected the correlation between exchange rate movement and domestic inflation trends around that period.

[4] Range between the 25th and 75th percentile of country estimates.

Among EMDEs, the median correlation also moved close to zero during the economic recovery in the early 2000s and during the global financial crisis, but it became increasingly positive after 2010 amid deteriorating supply-side conditions in many countries, including commodity exporters facing the end of the commodity supercycle (Baffes et al. 2015).

A wide range of cross-country and time variation in the correlation between exchange rates and inflation is consistent with the notion that different shocks as well as country-specific characteristics can shape the response of inflation to currency movements. These two factors—the source of shocks and country characteristics—are discussed in the next two sections.

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

$$B_0 y_t = \alpha + \sum_{i=1}^{L} B_i Y_{t-i} + \varepsilon_t$$

where ε_t is a vector of orthogonal structural innovations; y_i consists of global inflation ($f_t^{\pi,\,global}$), global output growth ($f_t^{Y,\,global}$), oil price growth (Δop), country-specific inflation (π^{i}_t), country-specific output growth (Y^{i}_t), country-specific changes in nominal effective exchange rates (XR^{i}_t), and country-specific monetary policy (or equivalent short-term) nominal interest rates (I^{i}_t). 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) and Forbes, Hjortsoe, and Nenova (2017, 2018), the imposed sign and short-term restrictions can be written as follows:

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

where * stands for an unrestricted initial response. Although country-specific shocks do not affect

global variables in the first four quarters, global shocks can affect country-specific variables (without any sign or zero restrictions).

The identification strategy is based on the following assumptions, 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.[5] A positive global supply shock leads to higher global output growth and oil prices but lower global inflation. 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.

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 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.[6]

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 (2014) is used, 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 example, Forbes, Hjortsoe, and Nenova 2017). For presentational clarity, and consistent with other studies in the literature, the country-specific confidence sets are calculated but not presented.

[5] Global shocks are derived from a separate tri-dimensional vector autoregression model that incorporates global output growth, global inflation, and oil price changes, following the approach of Charnavoki and Dolado (2014) and Uhlig (2005).

[6] An alternative specification also assumes that positive domestic demand shocks lead to a contemporaneous increase in domestic interest rates. See Appendix 2 for the results with robustness exercises.

3.2. Exchange rate pass-through definition

Following Shambaugh (2008) and Forbes, Hjortsoe, and Nenova (2017), for each country, the exchange rate pass-through ratio (ERPTR) is defined as the ratio of the response of country-specific inflation to the response of the nominal exchange rate changes following a given shock. The sign of the ratio is inverted, so that a positive ERPTR denotes a situation in which a currency depreciation is accompanied by rising inflation.

As in Forbes, Hjortsoe, and Nenova (2017) and others, the ERPTR is calculated based on one-year cumulative impulse response functions of the endogenous variables. Since the Bayesian estimation results are based on 1,000 successful draws satisfying the sign restrictions, the country-specific ERPTRs are represented as the median (and 68 percent confidence sets) of successful draw-specific ERPTRs (ERPTRs are calculated for each successful draw individually before being used for a country-specific statistic).

3.3. Data

The 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, but the sample period differs across countries (see Table 1 for details). Long-term trends of the variables are eliminated using the local mean method, as in Stock and Watson (2012).

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 GDP growth in a sample of 29 countries for 1971:1-2017:4.[7] Global inflation is the global common factor of quarter-on-quarter headline CPI inflation (seasonally adjusted) in a sample of 47 advanced economies and EMDEs.[8] 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.

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

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

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

[7] 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.

[8] 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 the same group of countries is employed.

where π^{i}_{t} and y^{i}_{t} 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 (Comunale and Kunovac 2017; Forbes, Hjortsoe, and Nenova 2017, 2018; Shambaugh 2008). 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'Zorzi and Rubaszek 2018; Cheung et al. 2017). 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, Riera-Crichton 2012; Schmitt-Grohé 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.[9]

Domestic shocks. Monetary policy tightening leads to currency appreciations in all advanced economies and EMDEs (Figure 4). Interest rate driven appreciations are estimated to be larger in EMDEs, particularly among countries with inflation targeting central banks and in some

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

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.[10] 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 et al. 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 5). Obviously, this result is not surprising, because one country'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 et al. 2018). 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 6). Although the direction and magnitude of the impact of global shocks varies 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.[11] 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 ERPTRs are calculated from country-specific FAVAR models as the ratio between the impulse response of inflation and the 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 ERPTRs and various factors, such as different sensitivities to shocks, changes in the prevalence of some shocks, improved policy frameworks, or other structural factors.

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 ERPTRs depending on their source.

[10] In this paper, statistical inferences are based on 68 percent confidence intervals.
[11] At around 30 percent, on average.

Domestic monetary policy shocks are generally associated with large, positive ERPTRs (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 7). 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, the former Yugoslav Republic of Macedonia, and Morocco). The finding that EMDEs with inflation targeting central banks tend to have lower than average ERPTRs 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 ERPTRs 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 ERPTR 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 ERPTRs 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 ERPTRs.

ERPTRs 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 8). However, in several EMDEs, ERPTRs are estimated to be negative (currency depreciation coupled with lower inflation), including among some energy exporters (for example, Azerbaijan and Colombia). Estimated ERPTRs 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 ERPTRs. The median ERPTR 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 ERPTRs 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 ERPTR associated with such shocks is close to zero for advanced economies and EMDEs (Figure 9). 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 (Box 5.1). 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 ERPTRs in response to domestic monetary policy shocks but modest ones for responses to domestic supply shocks and negative ERPTRs 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 ERPTRs 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 ERPTRs 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 10). For EMDEs, the median value averaged +0.15 since 1970, but declined to +0.08 over 1998-2017.

Among larger EMDEs, the average ERPTR 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 ERPTR 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 the Russian Federation, it is measured at +0.11, consistent with findings of the Central Bank of the Russian Federation (2014). For Brazil, the average ERPTR is estimated at +0.06 since 1998, toward the lower end of other studies (Forbes, Hjortsoe, and Nenova 2017; Ghosh 2013; Nogueira and Leon-Ledesmab 2009). For South Africa, the ERPTR is estimated at +0.07, broadly in line with the evidence presented in 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 ERPTRs down over the past two decades.

Monetary policy framework and credibility. The empirical literature has generally found ERPTRs to be smaller among advanced economies and in EMDEs with inflation targeting or more credible central banks (Carriere-Swallow et al. 2016; Gagnon and Ihrig 2004; Reyes 2004; 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 ERPTRs (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; Yüncüler 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 ERPTRs for domestic and global shocks. In particular, the ERPTR associated with domestic monetary policy shocks is significantly smaller in EMDEs with more independent centrals banks (Figure 11). 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 and Faia 2016; Soto and Selaive 2003). This would be consistent with a higher average ERPTR 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 ERPTR (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 ERPTR (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; de Soyres et al. 2018; Georgiadis, Gräb, and Khalil 2017).[12]

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 12; Chinn 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 ERPTR 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 (Casas et al. 2017; 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 et al. 2015). However, the selection

[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 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.

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 ERPTRs 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 13). For instance, EMDEs with a higher share of foreign-currency invoicing and more elevated ERPTRs 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 ERPTRs.

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.

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.

Overall, 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 ERPTRs, depending on country characteristics and the source of the shock.

Differences in shock-specific ERPTRs 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 ERPTR 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.

Overall, the downward trend in exchange rate pass-through presented in this paper can be connected to 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 pass-through ratios.

Future research could investigate more formally the relationship between estimated ERPTRs 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. 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 could be further investigated, looking at the direction and size of the various shocks under consideration.

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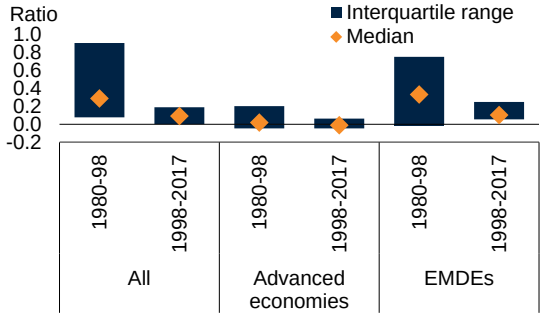
TABLE 1 List of countries and sample periods

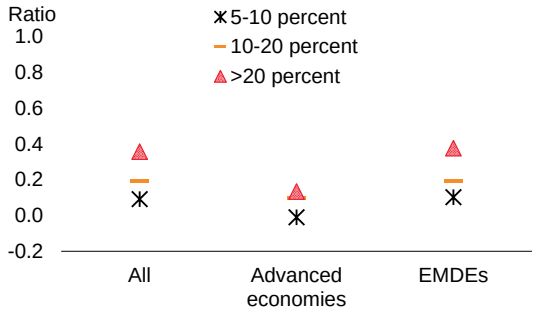
Country	Sample period	Country	Sample period
Australia	1970:2 - 2017:4	India	1993:3 - 2017:4
Austria	1990:1 - 2017:4	Israel	1985:3 - 2017:4
Azerbaijan	2005:3 - 2017:4	Italy	1979:2 - 2017:4
Belgium	1970:2 - 2017:4	Jordan	1999:3 - 2017:4
Bulgaria	1994:4 - 2017:4	Japan	1989:3 - 2017:4
Brazil	1998:3 - 2017:4	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	Macedonia, FYR	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
Czech Republic	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 - 2007:3
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		

FIGURE 1 Pass-through during significant currency depreciations

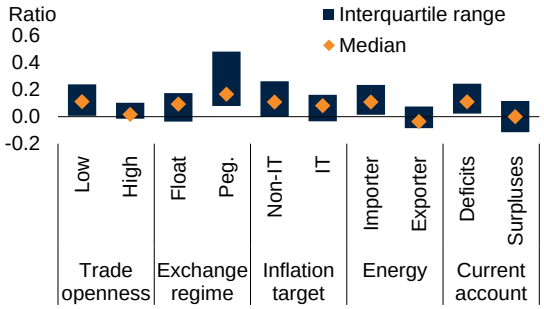
A. Unconditional pass-through from depreciations of 5 to 10 percent



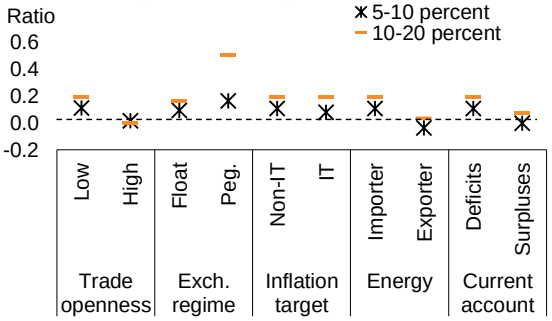
B. Unconditional pass-through from different depreciation episodes, 1998-2017



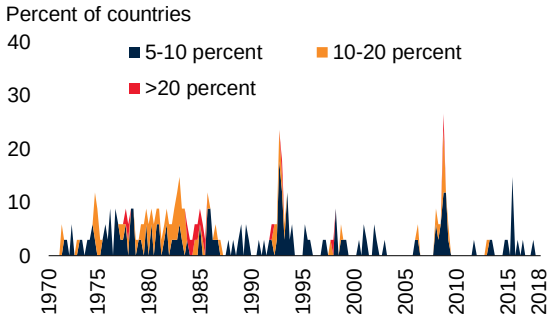
C. EMDEs: Unconditional pass-through from depreciations of 5 to 10 percent, 1998-2017



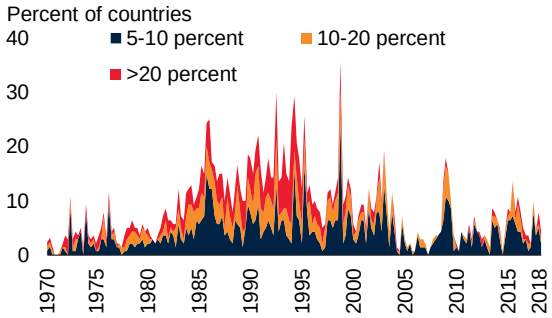
D. EMDEs: Unconditional pass-through from different depreciation episodes, 1998-2017



E. Frequency of significant exchange rate depreciations: Advanced economies



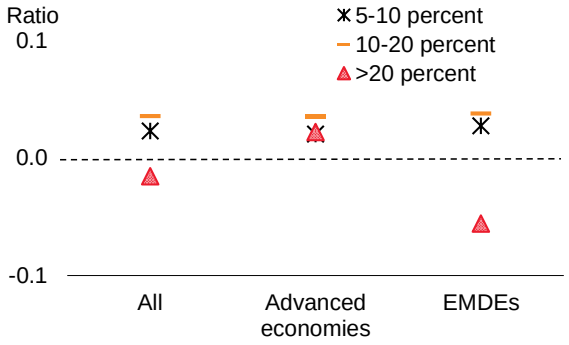
F. Frequency of significant exchange rate depreciations: EMDEs



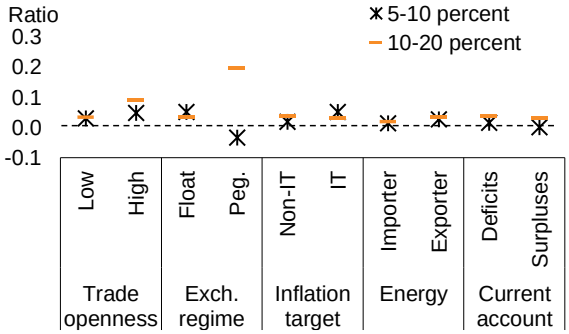
Note: Depreciations are defined as negative quarterly changes in the nominal effective exchange rate. The sample comprises 34 advanced economies and 138 EMDEs. EMDEs = emerging market and developing economies; IMF = International Monetary Fund; IT = inflation targeting.
A.-D. Pass-throughs are defined as the change in consumer prices after one quarter divided by the depreciation of the nominal effective exchange rate. The markers refer to the median pass-through.
A.C. The bars show the interquartile range of pass-throughs.
C.D. 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 as in World Bank (2018); 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 Pass-through during significant currency appreciations

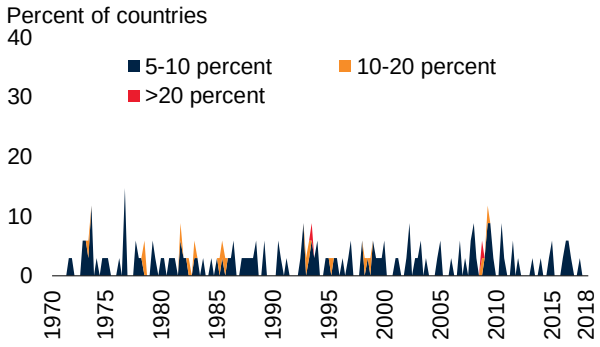
A. Unconditional pass-through from different appreciation episodes, 1998-2017



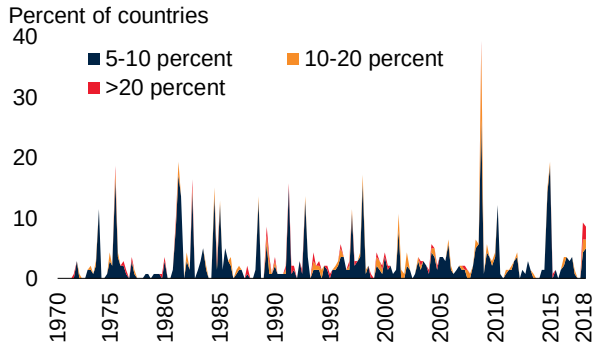
B. EMDEs: Unconditional pass-through from different appreciation episodes, 1998-2017



C. Frequency of significant exchange rate appreciations: Advanced economies

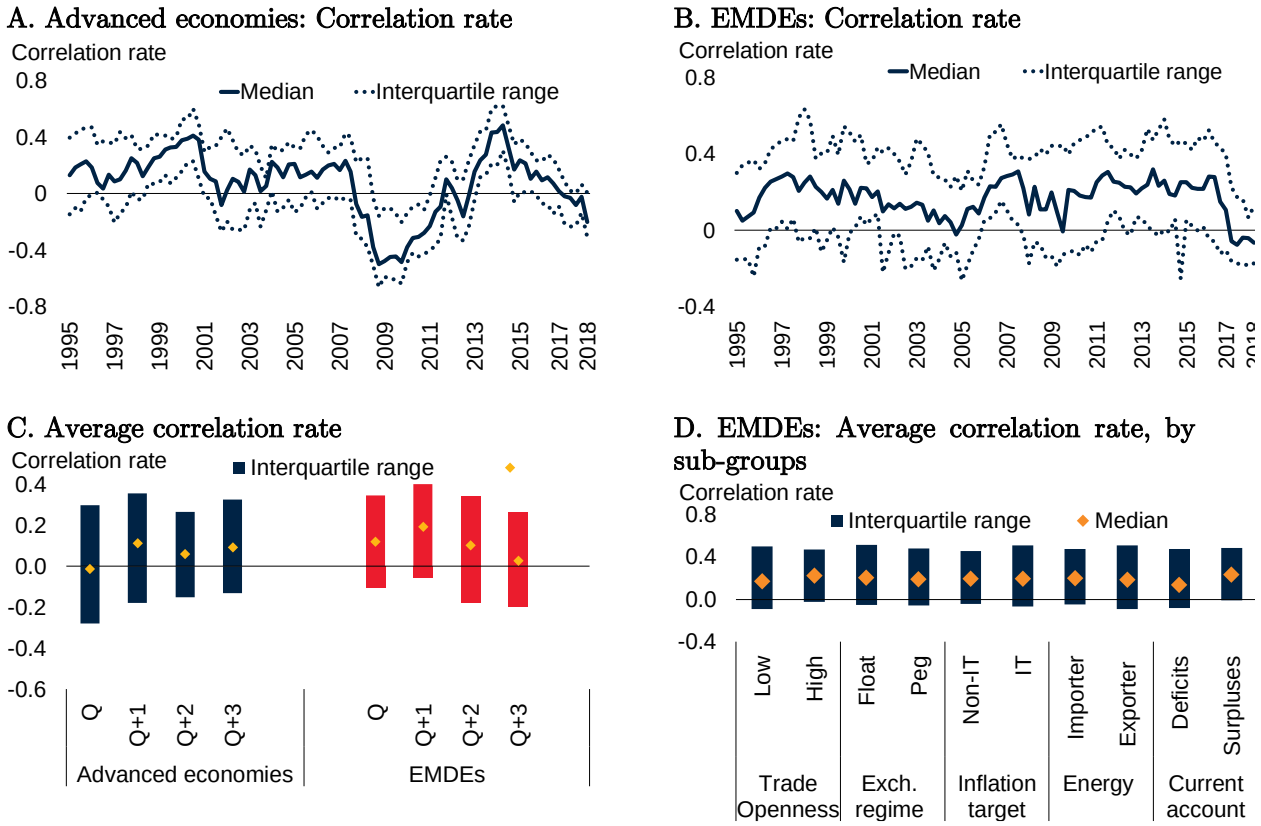


D. Frequency of significant exchange rate appreciations: EMDEs



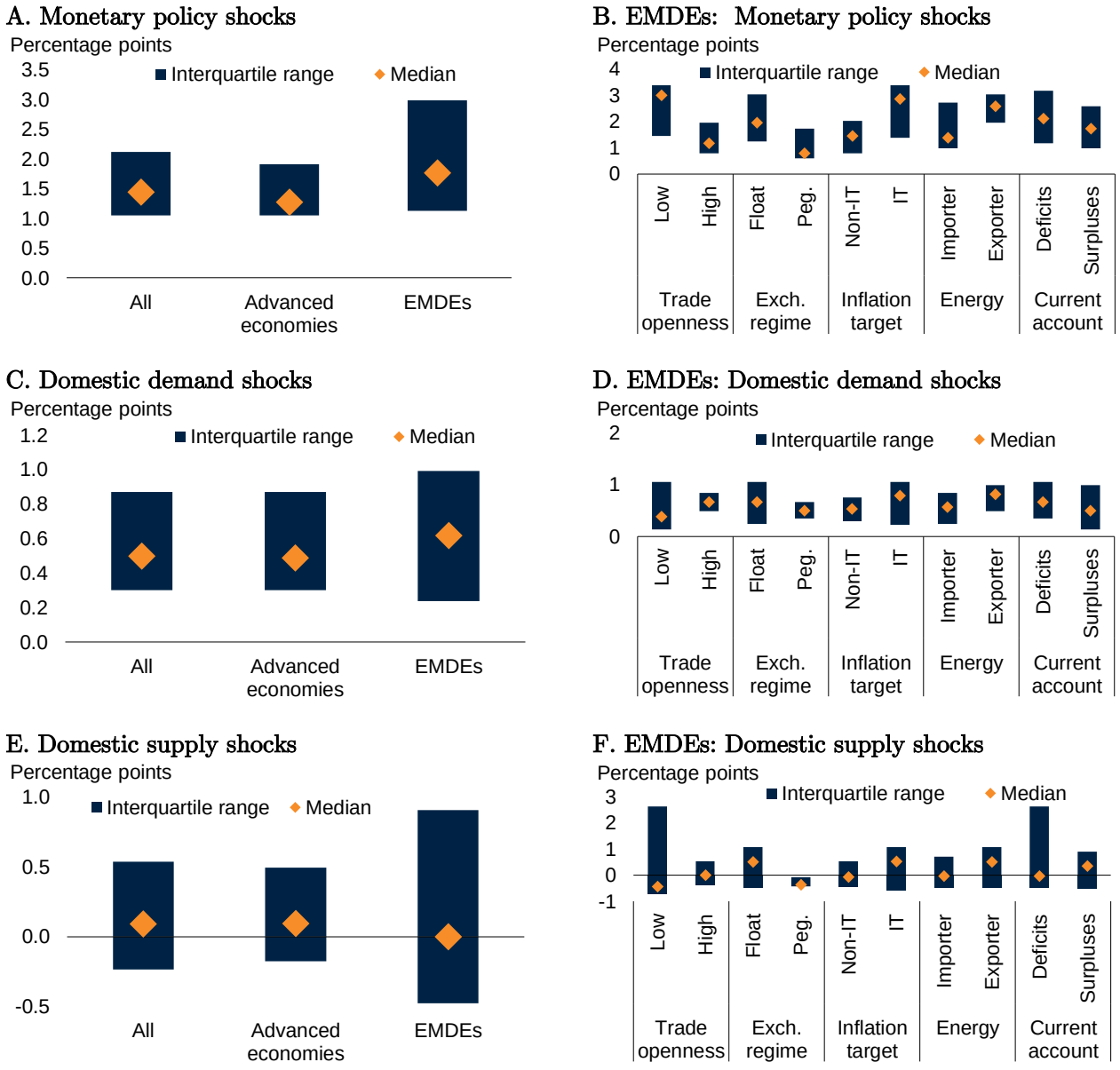
Note: Appreciations are defined as positive quarterly changes in the nominal effective exchange rate. The sample comprises 34 advanced economies and 138 EMDEs. EMDEs = emerging market and developing economies; GDP = gross domestic product; IMF = International Monetary Fund; IT = inflation targeting.
A.B. Pass-throughs are defined as the change in consumer prices after one quarter divided by the cumulative depreciation of the nominal effective exchange rate following significant depreciation episodes. The markers refer to the median pass-through associated with different appreciation episodes.
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. Energy exporters are defined as in World Bank (2018); 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 Correlations between inflation and nominal effective exchange rate changes



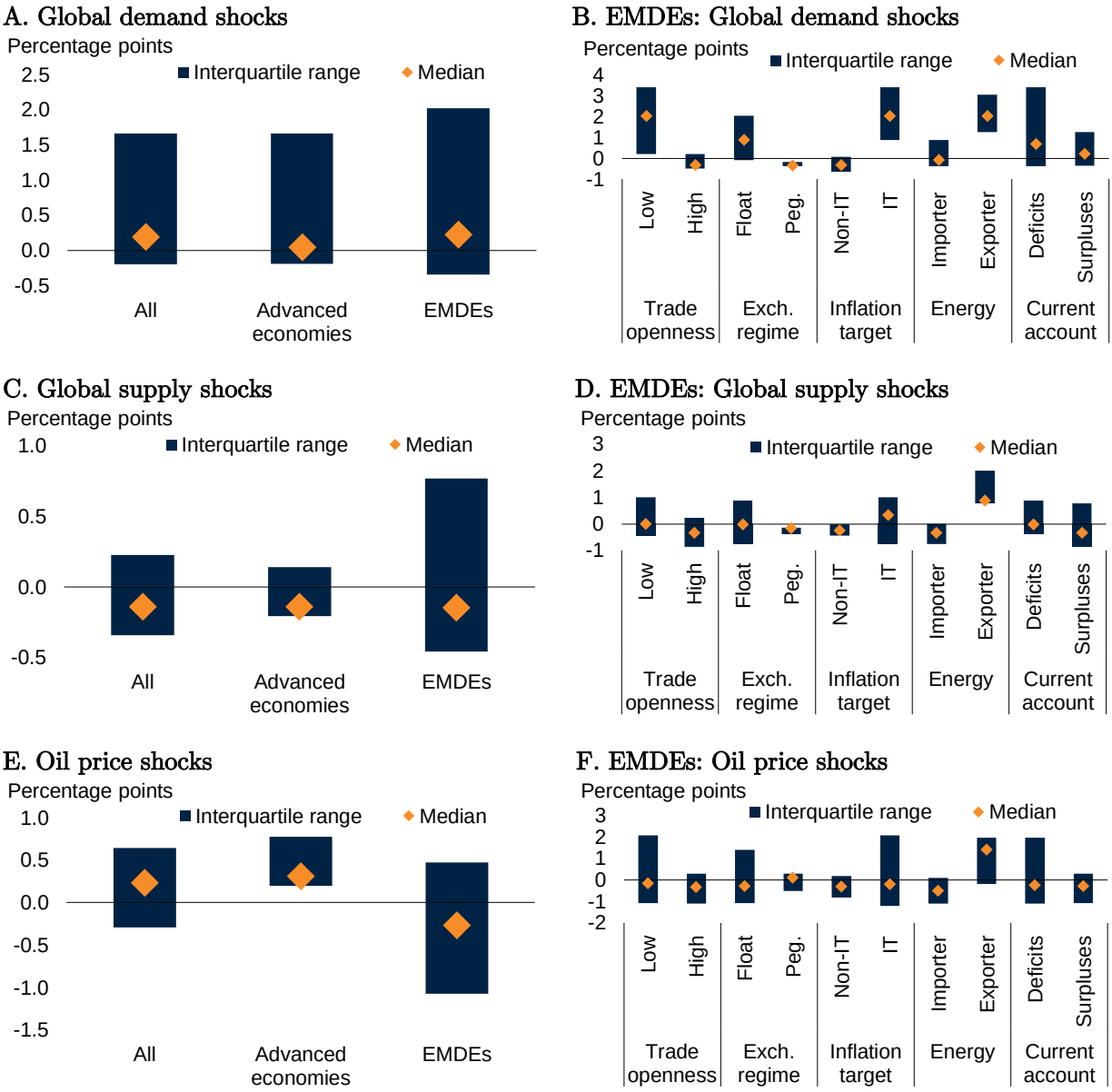
Note: EMDEs = emerging market and developing economies; GDP = gross domestic product; IMF = International Monetary Fund; IT = inflation targeting.
A.B.D. Correlation over a three-year rolling window between inflation and nominal effective exchange rate depreciations after one quarter. The sample includes 51 economies. The median and interquartile range are for three-year window correlation during 1995-2018.
C. Q, Q+1, Q+2, and Q+3 represent the correlation between inflation and nominal effective exchange rate depreciations over the same quarter and after one, two, and three quarters, respectively.
D. 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 as in World Bank (2018); 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 4 Exchange rate responses to domestic shocks



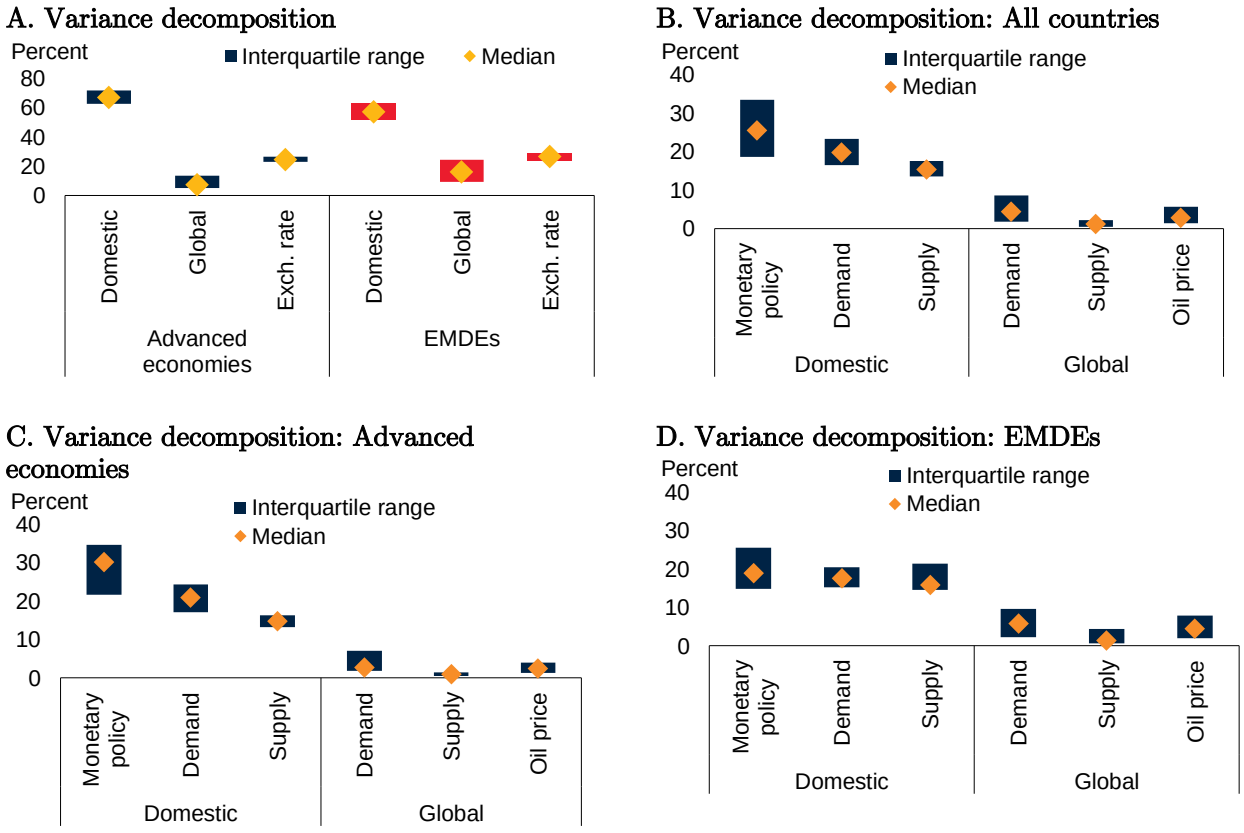
Note: One-year impulse responses of the exchange rate to domestic shocks (monetary policy, domestic demand, and domestic supply) from country-specific factor-augmented vector autoregression models estimated for 29 advanced economies and 26 EMDEs over 1998-2017. Bars show the interquartile range and markers 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 (see the Appendix for details). Energy exporters are defined as in World Bank (2018); 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 Exchange rate responses to global shocks



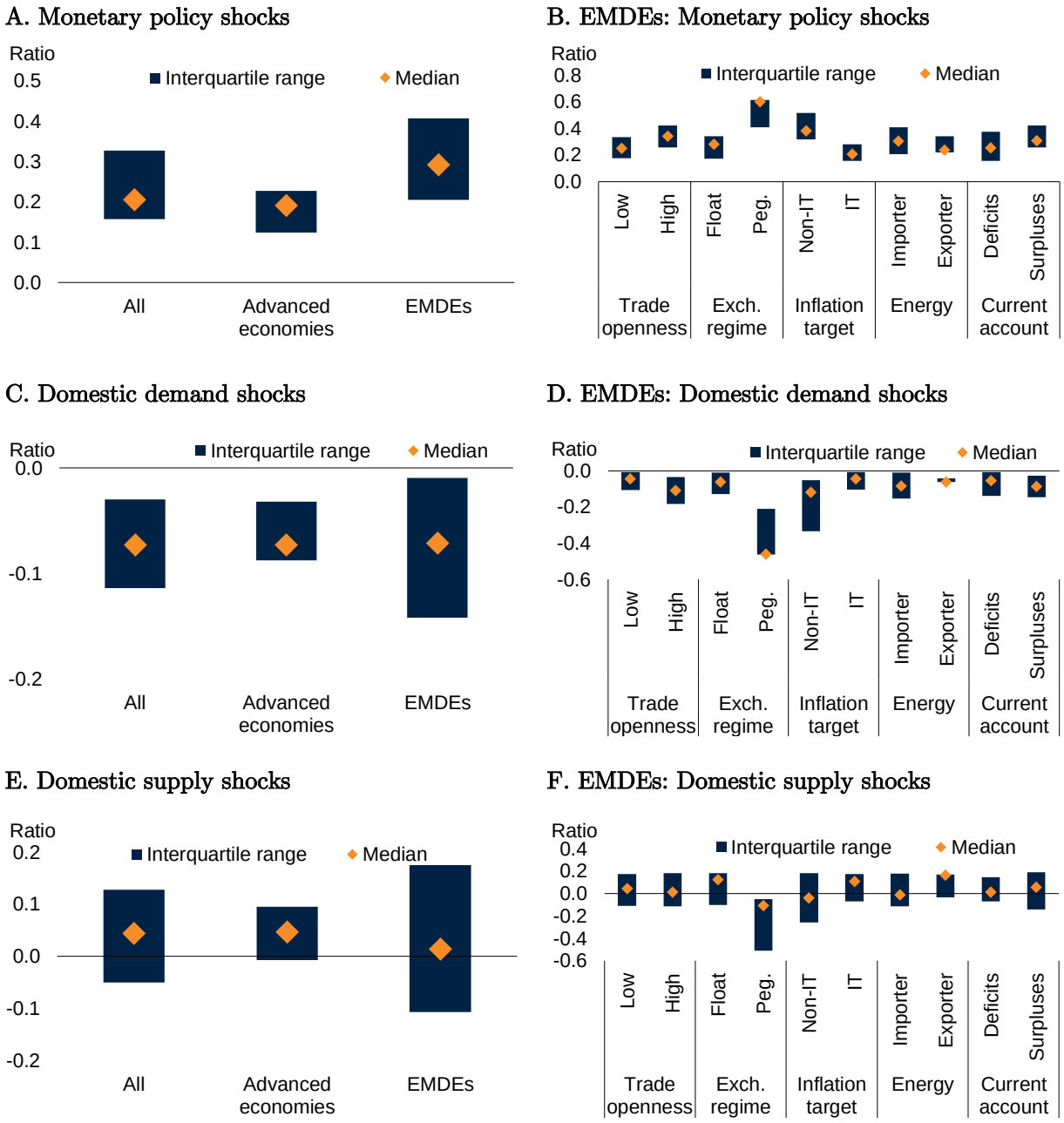
Note: One-year impulse response of the exchange rate to global shocks (demand, supply, and oil prices) from country-specific factor-augmented vector autoregression models estimated for 29 advanced economies and 26 EMDEs over 1998-2017. Bars show the interquartile range and markers represent the median 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 (see the Appendix for details). Energy exporters are defined as in World Bank (2018); 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 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.

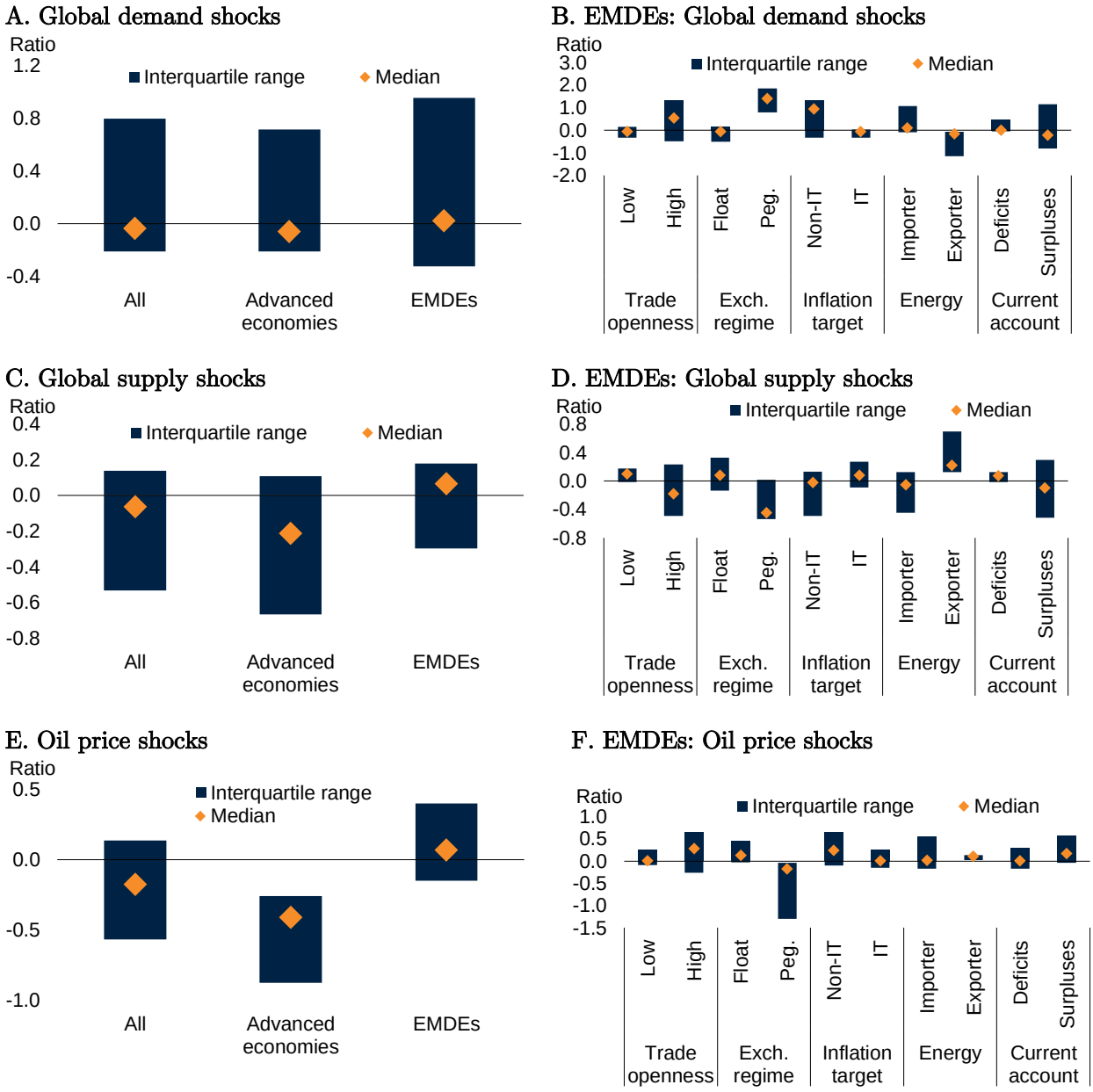
FIGURE 7 Pass-through associated with domestic shocks



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.

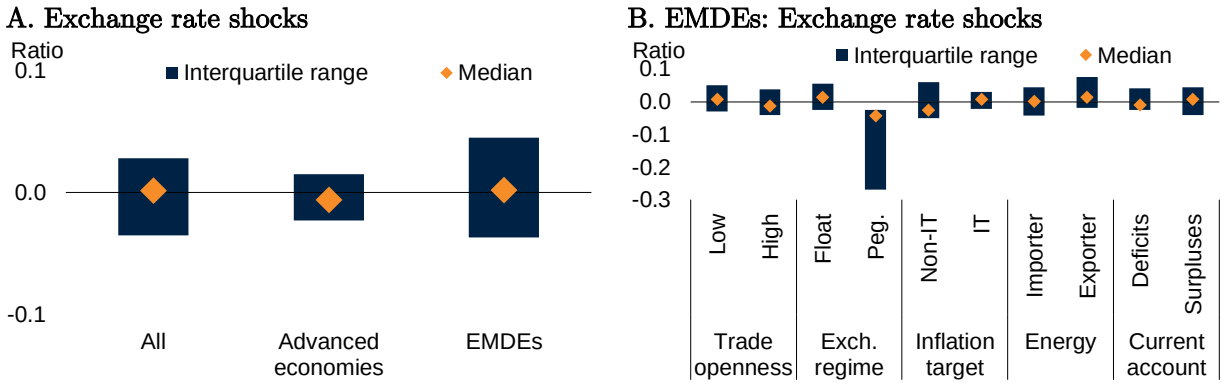
B.D.F. Countries with "high" trade openness are defined as those with above median trade-to-GDP ratios; all others are considered to have "low" trade openness. Exchange rate and IT regimes are based on IMF classifications. Energy exporters are defined as in World Bank (2018); all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

FIGURE 8 Pass-through associated with global shocks



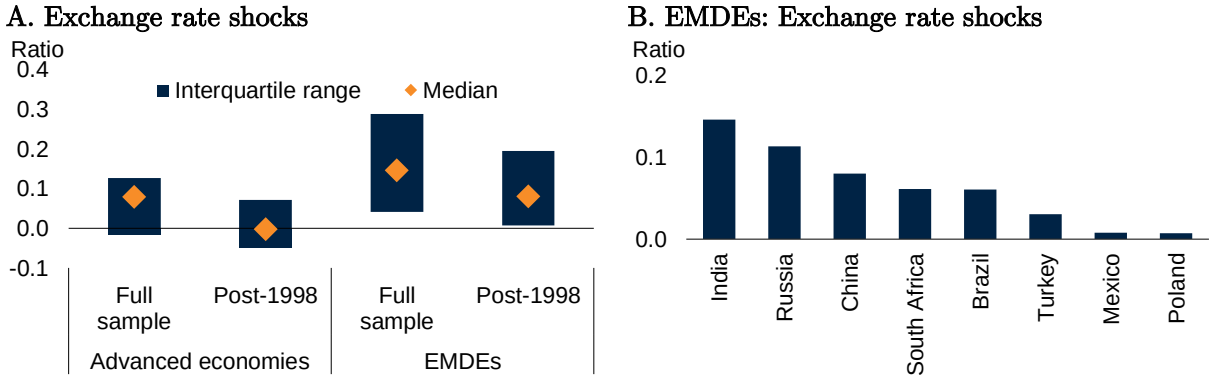
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. 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 as in World Bank (2018); 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 9 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 as in World Bank (2018); all other countries are considered energy importers. Countries with current account deficits are those with a negative average current account balance over 1998-2017.

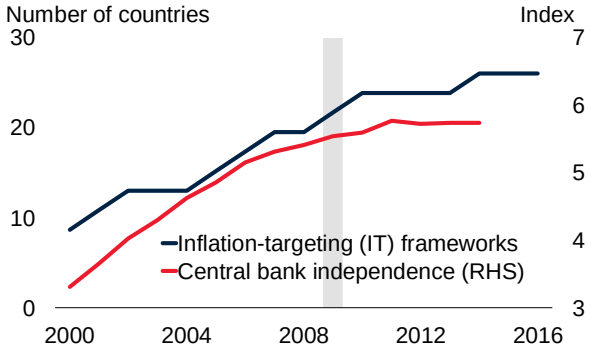
FIGURE 10 Average pass-through



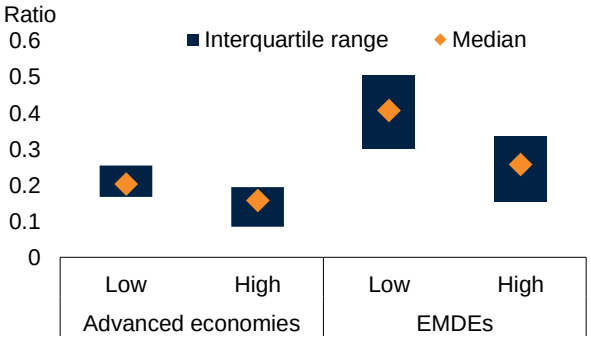
Note: Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse response of the exchange rate change estimated from factor-augmented vector autoregression models for 29 advanced economies and 26 EMDEs over 1998-2017. 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 11 Central bank credibility and pass-through

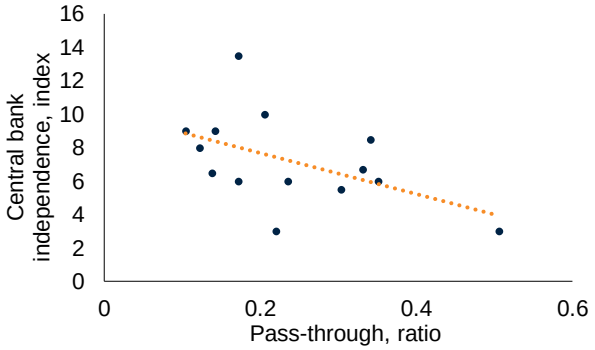
A. Central bank independence and inflation targeting frameworks



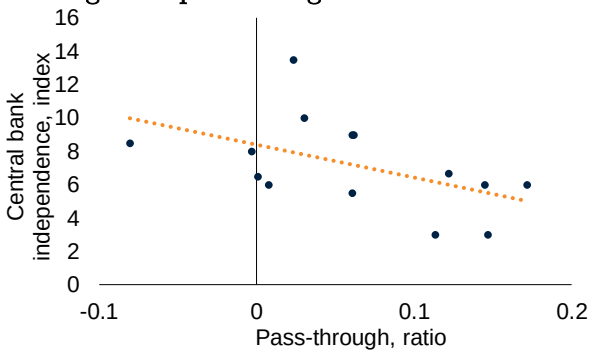
B. Central bank independence and exchange rate pass-through from monetary policy shocks



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



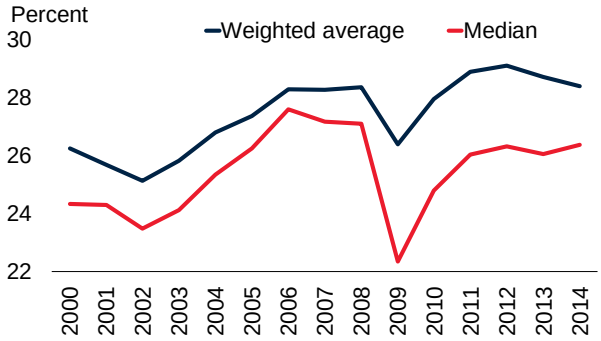
D. Central bank independence and average exchange rate pass-through in EMDEs



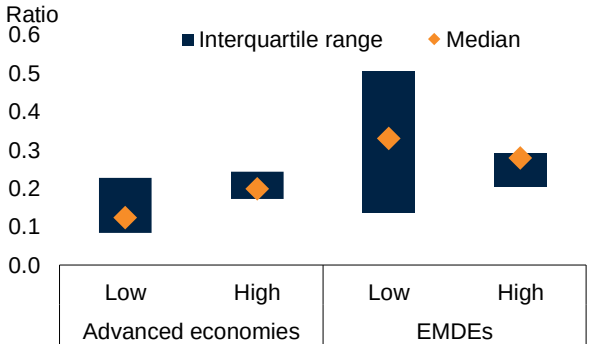
Note: The central bank independence index is computed by Dincer and Eichengreen (2014). An increase in the index means greater central bank independence. Pass-throughs are defined as the ratio between the one-year cumulative impulse response of consumer price inflation and the one-year cumulative impulse 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 12 Global value chain participation and pass-through

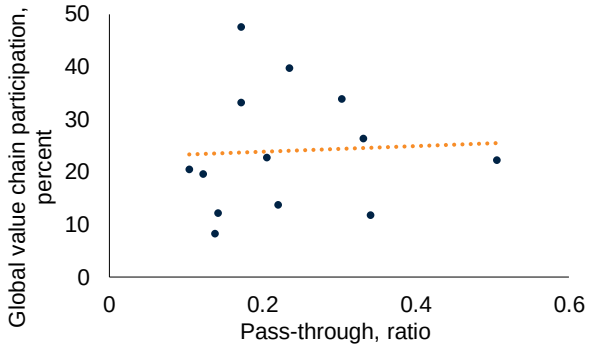
A. Global value chain participation



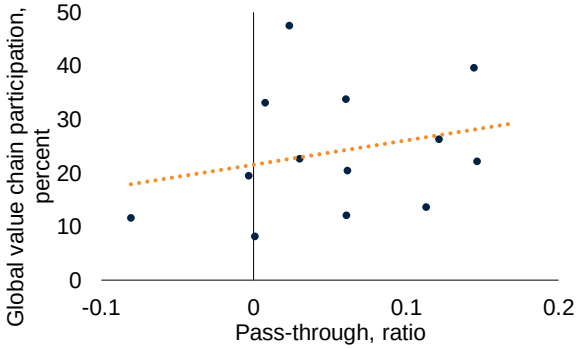
B. Global value chain participation and pass-through from monetary policy shocks



C. Global value chain participation and pass-through from monetary policy shocks in EMDEs



D. Global value chain participation and average exchange rate pass-through in EMDEs



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.

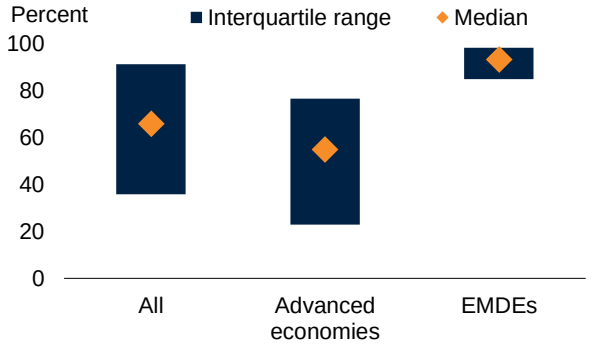
B. Low and high value chain participation are defined as below or above the sample average.

C.D. The sample only includes EMDEs with floating exchange rate regimes according to the IMF classification.

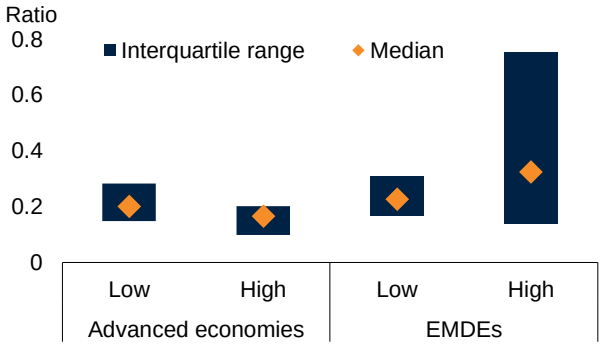
D. Shock-specific pass-throughs are aggregated using shares of currency movements accounted for by each type of shock as weights.

FIGURE 13 Foreign-currency import invoicing and pass-through

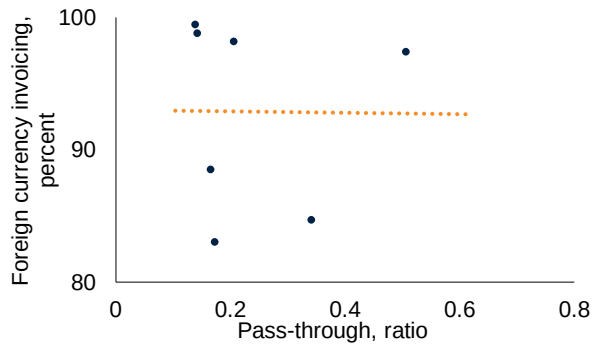
A. Share of imports invoiced in foreign currency



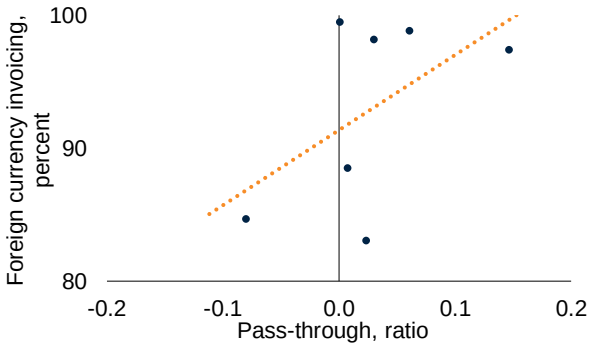
B. Share of foreign-currency invoicing and pass-through from monetary policy shocks



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: Share of imports invoiced in foreign currency based on data for 50 countries calculated by Gopinath (2015). 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 1: literature review on exchange-rate pass through

Properly measuring the exchange rate pass-through is important for forecasting inflation and setting monetary policy. Earlier studies generally estimated the exchange rate pass-through ratio (ERPTR) in a reduced-form framework, 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 ERPTRs. These studies usually identify underlying shocks in structural vector autoregression (SVAR) models, highlighting heterogeneity in the direction and magnitude of ERPTRs, depending on the nature of the shocks and country characteristics (Shambaugh 2008; Forbes, Hjortsoe, and Nenova 2017).

Explanatory factors include the monetary policy regime, level of central bank credibility, trade and financial market openness, degree of participation in global value chains, and structural features of product and labor markets.

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

An incomplete adjustment of prices to exchange rate movements can arise in the presence of international market segmentation for traded goods, 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 ERPTR 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 ERPTRs. In particular, the pricing-to-market literature (originally developed by Krugman 1987 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 1989; 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 ERPTRs (Goldberg and Hellerstein 2008; Hellerstein 2008; Goldberg and Verboven 2001; Nakamura and Zerom 2010).

Endogenous firm selection. International trade models of cross-border production networks have provided further rationale for partial ERPTRs. In these models, macroeconomic shocks produce a new, endogenously determined distribution of firms, impacting pricing strategies and aggregate ERPTRs (Bernard et al. 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; de Soyres et al. 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 ERPTRs. 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 et al. 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.

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

Although structural features play an important role in determining ERPTRs, the nature of the macroeconomic shocks behind exchange rate movements has been increasingly emphasized as a determining factor (Forbes, Hjortsoe, and Nenova 2017). Shocks can act concurrently on inflation and exchange rates, with varying implications for ERPTRs. 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.

Shambaugh (2008) takes this argument a step further by systematically categorizing exchange rate pass-throughs by 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. ERPTRs 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, 2018) apply a five-variable SVAR 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 ERPTRs in responses to domestic monetary policy shocks but modest ones in response to domestic demand shocks. Their estimates of ERPTRs following global shocks (permanent and transitory) are quite heterogeneous across countries. Borensztein and Queijo (2016) follow a broadly similar approach for a group of South American countries; Comunale and Kunovac (2017) for Euro Area countries; Cunningham et al. (2017) for a sample of advanced economies; and Ca'Zorzi, Hahn, and Sanchez (2007) for 12 emerging market and developing economies (EMDEs).

Although ERPTRs were historically larger in EMDEs, with currency depreciations often associated with inflation crises and subsequent sharp recessions (Frankel and Rose 1996; Reinhart and Rogoff 2008), they have recently declined in many countries, reflecting the shifting nature of shocks and institutional change (Carriere-Swallow et al. 2016; Forbes, Hjortsoe, and Nenova 2017; Tunç 2017).

What are the key country characteristics affecting pass-throughs?

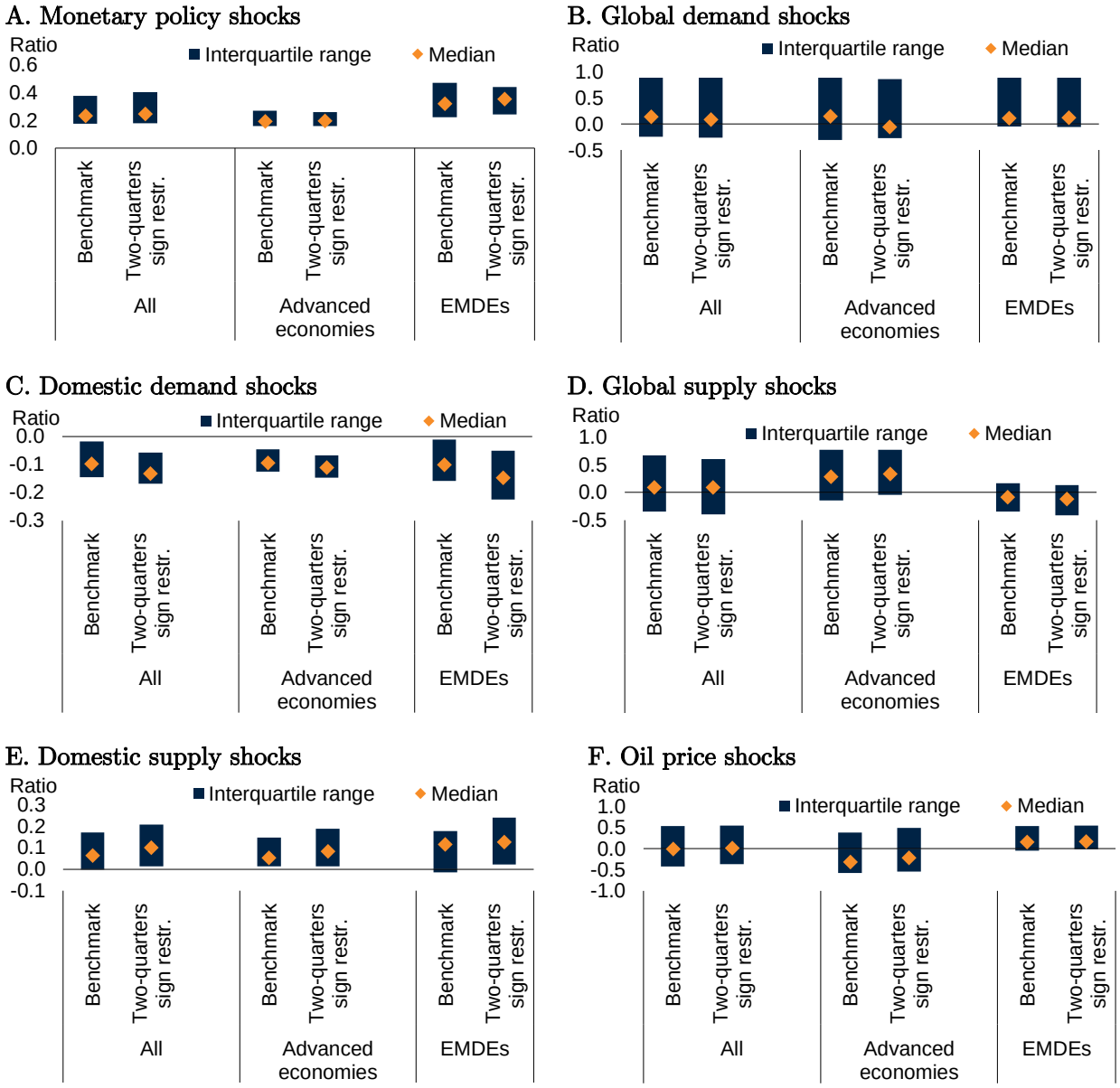
Many empirical studies focus on the relationship between estimated ERPTRs and country characteristics. In general, greater openness to trade and financial transactions, less credible central banks, more volatile inflation and exchange rates, and lower levels of market competition are associated with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

Various studies emphasize trade openness and the composition of imported goods (Campa and Goldberg 2005, 2010), central bank credibility (Taylor 2000; Gagnon and Ihrig 2004; Choudri and Hakura 2006; Mishkin and Schmidt-Hebbel 2007; Coulibaly and Kempf 2010; Caselli and Roitman 2016; Carriere-Swallow et al. 2016), the degree of competition in product markets (Devereux, Tomlin, and Dong 2015; Amiti, Itskhoki, and Konings 2016), inflation volatility (Ca'Zorzi, Hahn, and Sanchez 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 2003; 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). Korhonen and Wachtel (2006) find that high degrees of dollarization and import penetration accelerated the speed of pass-through in Commonwealth of Independent States countries relative to other emerging markets.

Empirical results in this paper indicates that exchange rate pass-through varies over time and may be subject to regime switching and structural breaks (Ozkan and Erden 2015; Campa and Goldberg 2005; Cunningham et al. 2017; Donayre and Panovska 2016; Khalaf and Kichian 2005). Some studies link this time-varying exchange rate pass-through to the role of domestic factors, such as the changing composition of imports and shifts in monetary policy frameworks, or to external factors, such as the increasing role of China in the global economy (Marazzi et al. 2005; Gust, Leduc, and Vigfusson 2010).

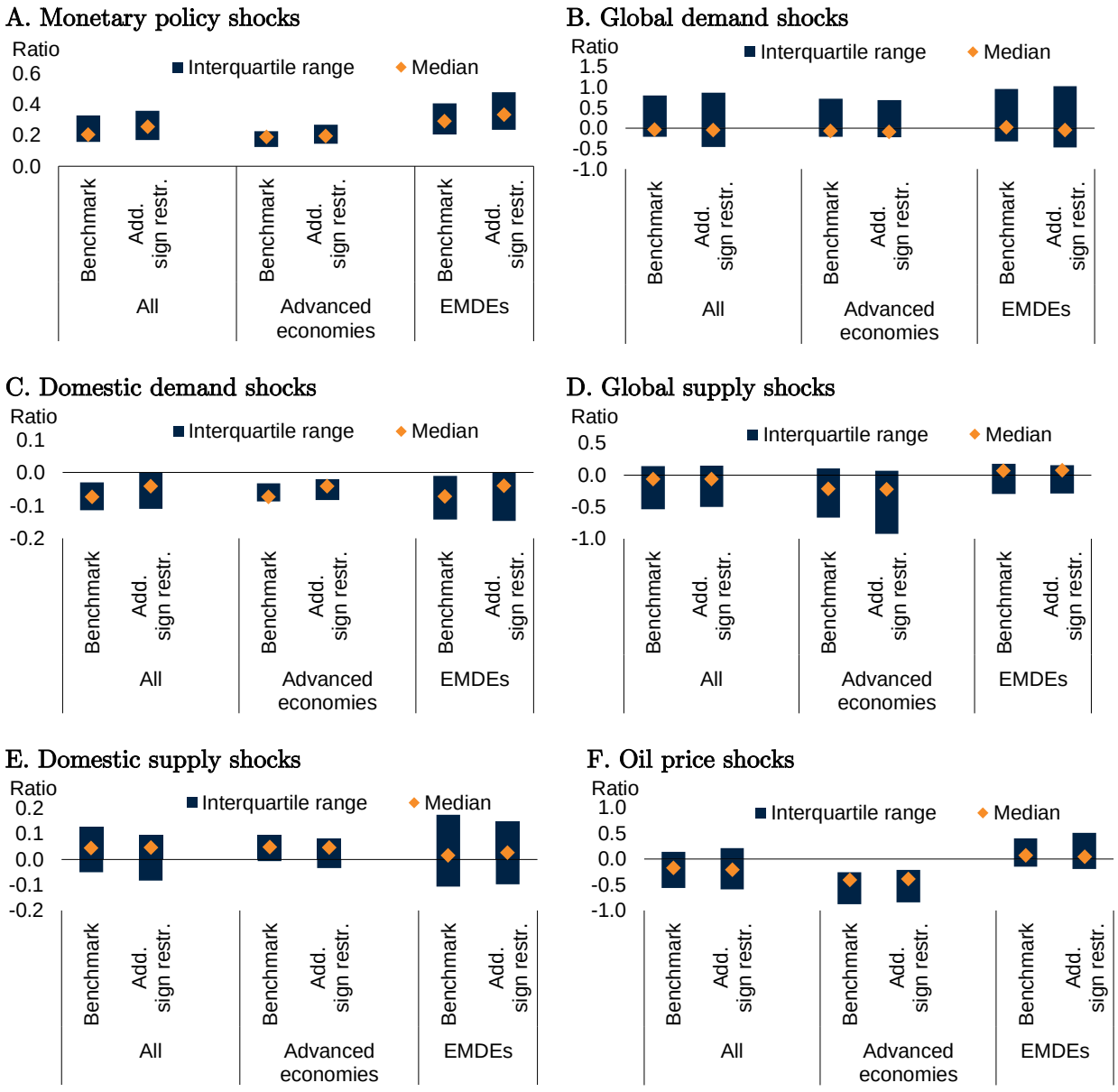
Appendix 2: Results with robustness checks

FIGURE A.1 Pass-through: 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 51 economies (29 advanced economies and 22 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.

FIGURE A.2 Pass-through: 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 51 economies (29 advanced economies and 22 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.