



SPECIAL FOCUS 1.2

Currency Depreciations, Inflation,
and Central Bank Independence

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Financial market turbulence in 2018 illustrated, once again, that emerging market and developing economies (EMDEs) continue to face the risk of destabilizing exchange rate movements. These stress episodes often compel central banks to tighten policy to lessen currency pressures and fend off inflationary pressures despite slowing growth. To design appropriate policies, it is important to quantify the exchange rate pass-through to inflation associated with different domestic and global shocks and with different country characteristics. The pass-through to inflation tends to be largest when currency movements are triggered or amplified by monetary policy action. In contrast, the pass-through is significantly smaller when central banks pursue a credible inflation target, operate in a flexible exchange rate regime, and are independent from fiscal authorities. This highlights a self-reinforcing feedback loop between central bank credibility, exchange rate and price stability. Increased participation in global value chains and a lower share of imports invoiced in foreign currencies can also be associated with lower exchange rate pass-through, underscoring the need for complementary policies.

Introduction

Many emerging market and developing economies (EMDEs) confronted significant currency depreciations last year, reflecting a rise in advanced-economy yields, a strengthening in the U.S. dollar, and an increase in investor risk aversion amid financial stress in some countries. Currency pressures were most pronounced in Turkey and Argentina, due to acute concerns about monetary policy frameworks and debt sustainability. However, other EMDEs also suffered from sharp exchange rate depreciations, particularly countries with large external financing needs and those unable to maintain misaligned currency pegs or other forms of currency arrangements. In response, central banks were compelled to tighten monetary policy in order to restore market confidence: in the last quarter of 2018, the number of EMDEs hiking policy interest rates was four times larger than the number of EMDEs cutting them (Figure SF1.2.1.A). Currency pressures were accompanied by accelerating inflation, with a higher pass-through to consumer prices in countries with the largest depreciations and rising concerns about an erosion of central bank credibility (Figure SF1.2.1.B).

Despite easing global financing conditions since the start of 2019, the possibility of new episodes of financial market stress, broad-based capital outflows, and sharp exchange rate depreciations remain among the most prominent risks to EMDE prospects (Chapter 1). While flexible exchange rates can serve as a shock absorber and keep growth on a balanced and sustainable path over the medium term, sudden sharp currency depreciations can jeopardize price stability, especially when inflation expectations are poorly anchored as they tend to be in many EMDEs (Kose et al. 2019). In the presence of foreign-currency-denominated debt, currency depreciations can also raise debt burdens and financial stability concerns. These considerations help explain the greater propensity of central banks to respond to currency movements in EMDEs than in advanced economies, sometimes to a greater extent than is strictly needed to stabilize output growth and maintain low inflation (Calvo and Reinhart 2002; Ball and Reyes 2008).

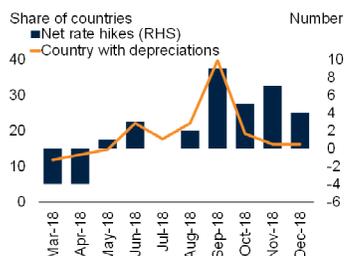
Since large exchange rate movements are more frequent in EMDEs than in advanced economies, a rigorous assessment of the exchange rate pass-through to inflation in EMDEs is a critical input into policymaking in those countries. This Special Focus provides an empirical analysis of the exchange rate pass-through ratio (ERPTR) to inflation, defined here as the percentage increase in consumer prices associated with a 1-percent depreciation of the effective exchange rate one

Note: This Special Focus was prepared by Marc Stocker, Jongrim Ha, and Hakan Yilmazkuday. Research assistance was provided by Julia Norfleet and Heqing Zhao.

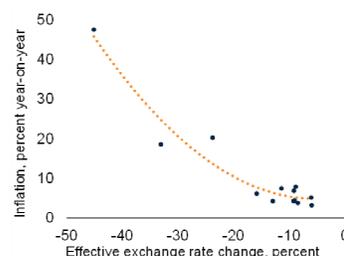
FIGURE SF1.2.1 EMDE exchange rates, monetary policy rates, and inflation in 2018

Central banks have responded to episodes of currency depreciations in 2018 by hiking policy interest rates. Inflation rose sharply in countries where currency pressures were most pronounced.

A. Frequency of currency depreciations and policy interest rate changes in EMDEs



B. Currency depreciations and inflation in EMDEs in 2018



Source: Haver Analytics, World Bank.

Note: EMDEs = emerging market and developing economies.

A. Depreciations are monthly declines in the nominal effective exchange rate of more than 5 percent on an annualized basis. Net interest rate hikes are the number of policy interest rate hikes minus the number of interest rate cuts in each month. Sample includes 68 EMDEs.

B. The horizontal axis shows cumulative change in the nominal effective exchange rate (NEER) of more than 5 percent over the period January to December 2018. Vertical axis shows consumer price inflation in December 2018. Dotted line shows second order polynomial trend. Sample includes 28 EMDEs.

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year earlier. This pass-through ratio is expected to be positive, on average, as a depreciation would tend to be accompanied by rising inflation. Specifically, this Special Focus examines the following questions:

- How does the exchange rate pass-through vary across countries and over time?
- Does the exchange rate pass-through depend on the nature of the shock?
- What country characteristics are associated with smaller pass-throughs?

The main conclusions are as follows. First, large depreciation episodes—defined as nominal effective depreciations of more than 10 percent in a quarter—continue to be associated, on average, with more significant increases in consumer price inflation in EMDEs than in advanced economies. In both country groups, larger depreciations tend to be followed by larger pass-through ratios. Second, the relationship between inflation and currency movements depends on the nature of the initial shock. Monetary policy shocks, such as an unexpectedly loose policy stance contributing to

currency depreciation and accelerating inflation and activity, are more closely associated with larger exchange rate pass-throughs than any other shocks. Third, pass-throughs are generally smaller in countries with greater global value chain integration and lower share of foreign-currency invoicing. They are also smaller 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 maintaining low inflation and makes exchange rate movements a more effective buffer against external shocks.

This Special Focus complements the existing literature by documenting nonlinearities in exchange rate pass-through depending on the magnitude and direction of the exchange rate movement. It also extends, on the basis of a larger and more EMDE-oriented sample than used in previous studies, a recent literature that emphasizes the importance of the nature of the initial shock and of structural country features for the transmission of exchange rate movements to inflation.

The Special Focus highlights that central banks need to consider not only the source of exchange rate movements but also the crucial role that their subsequent policy responses play in anchoring inflation expectations and lowering the eventual pass-through to domestic prices. There is a risk that a central bank that underestimates the exchange rate channel in the transmission of its policy actions might maintain an excessively tight (or loose) monetary policy stance relative to what is needed to maintain low inflation and stabilize output growth. This could lead to excessive fluctuations in activity and make the anchoring of inflation expectations more difficult.

Pass-through across countries and over time

Channels of transmission from exchange rate to inflation. The pass-through of currency depreciations to inflation is typically incomplete, with the effect dissipating through the supply chain. The pass-through to consumer prices goes through various channels, from direct effects through commodity and other import prices, to

indirect effects through wage formation and profit markups (Bacchetta and van Wincoop 2003; Burstein and Gopinath 2014; Ito and Sato 2008; McCarthy 2007). Distribution costs, firms' internal pricing, and inventory management can also drive a wedge between producer and consumer prices and impact the size and speed of the exchange rate pass-through (Alessandria, Kaboski, and Midrigan 2010; Berger et al. 2012; Copeland and Kahn 2012).

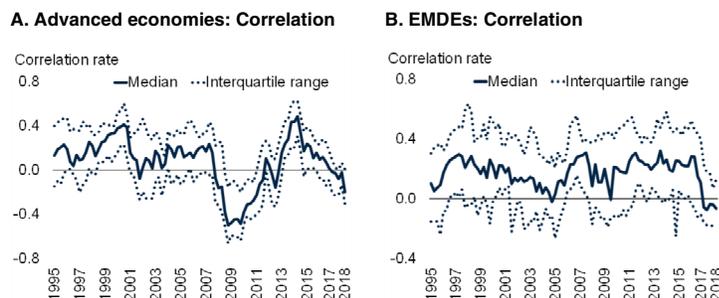
The size and speed of the impact of exchange rate movements on domestic inflation depend on several factors. These include competition among importing and exporting firms (Amiti, Itskhoki, and Konings 2016), the frequency of price adjustments (Devereux and Yetman 2003; Corsetti, Dedola, and Leduc 2008; Gopinath and Itskhoki 2010), wage bargaining structures (Aron, Macdonald, and Muellbauer 2014), the composition of trade (Campa and Goldberg 2010), and the share of trade invoiced in foreign currencies (Casas et al. 2017; Gopinath 2015).

Credible monetary policy frameworks that support well-anchored inflation expectations have also been associated with less pass-through to consumer prices (Carrière-Swallow et al. 2016; Gagnon and Ihrig 2004; Reyes 2004; Schmidt-Hebbel and Tapia 2002; Taylor 2000). A recent strand of the literature has emphasized the importance of identifying the underlying cause of currency movements when assessing pass-through ratios (Comunale and Kunovac 2017; Forbes, Hjortsoe, and Nenova 2017, 2018; Shambaugh 2008).

Correlation between exchange rate movements and inflation over time. Co-movement between exchange rate and consumer price developments has varied considerably over time. For advanced economies, the median correlation became 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)—periods marked by unusually large monetary policy shocks or heightened uncertainty over policy actions (Figure SF1.2.2.A). In contrast, correlation rates were close to zero during the recovery in the early 2000s and 2017-18, and significantly negative during the global financial crisis (-0.5 in 2008-09)

FIGURE SF1.2.2 Correlation between inflation and effective exchange rate changes

Correlations between inflation and exchange rate movements vary considerably over time.



Source: World Bank.

Note: EMDEs = emerging market and developing economies.

A,B. Correlation over a three-year rolling window between inflation and nominal effective exchange rate depreciations in the same quarter. The sample includes 51 economies. The median and interquartile range are for three-year window correlation during 1998-2018.

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—periods marked by shifts in domestic or global demand conditions.

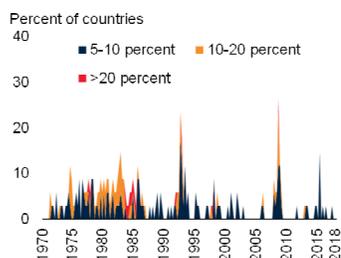
Among EMDEs, the median correlation also moved close to zero during the economic recovery in the early 2000s and during the global financial crisis, but it became increasingly positive after 2010 amid deteriorating supply-side conditions in many countries, including commodity exporters facing the end of the commodity supercycle (Baffés et al. 2015; Figure SF1.2.2.B). Shifts in the correlation between exchange rate and consumer price movements is consistent with the notion that different shocks as well as country-specific characteristics can modify the response of inflation to currency movements.

Events of large exchange rate movements. The event study presented in this section explores episodes of large exchange rate fluctuations, defined as quarterly movements in (trade-weighted) nominal effective exchange rates in excess of 5 percent across 34 advanced economies and 138 EMDEs during 1970-2018. By focusing on large exchange rate swings, the study is more likely to be successful in detecting related changes in prices throughout the entire production chain and in identifying potential nonlinearities that would cause larger ERPTRs in the event of sudden marked depreciations. By allowing for both

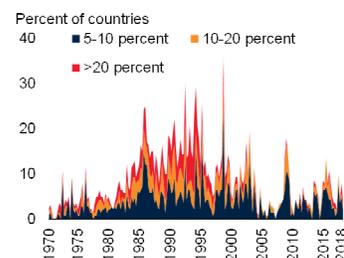
FIGURE SF1.2.3 Pass-through during significant currency depreciations

The frequency and severity of depreciation episodes have declined over recent decades. The median pass-through associated with large currency depreciations has dropped as well in EMDEs but remains higher than in advanced economies.

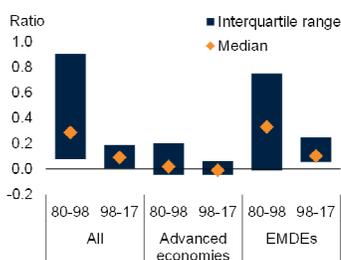
A. Frequency of significant exchange rate depreciations: Advanced economies



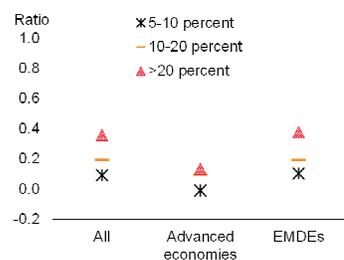
B. Frequency of significant exchange rate depreciations: EMDEs



C. Pass-through from depreciations of 5 to 10 percent



D. Pass-through from different depreciation episodes, 1998-2017



Source: World Bank.

Note: Depreciations are defined as negative quarterly changes in the nominal effective exchange rate. The sample comprises 34 advanced economies and 138 EMDEs. C.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.

C. The bars show the interquartile range of pass-throughs.

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depreciations and appreciation events, pass-throughs can be estimated conditional on the size and direction of the exchange rate movement.

This study identifies 2,323 depreciation events and 5,514 appreciation events in EMDEs and 242 depreciation events and 706 appreciation events in advanced economies (Figure SF1.2.3.A). The median depreciation across all events amounted to -10 percent in EMDEs and -8 percent for advanced economies, while the median appreciation amounted to 6 percent across the two groups.

The frequency and severity of large currency depreciations have declined over the past two

decades, particularly in EMDEs (Figure SF1.2.3.B). Prior to 1998, such episodes clustered around periods of broad-based 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 and Eastern Europe during the second half of the 1990s. The incidence of currency crises has diminished since the early 2000s, with depreciations in excess of 20 percent affecting less than 1 percent of EMDEs, on average.

ERPTRs during large depreciations. The event study suggests a broad-based decline in pass-through among EMDEs over the past two decades (Figure SF1.2.3.C). Median estimates of the same-quarter pass-through of currency depreciations of 5-10 percent per quarter dropped from +0.4 in the period 1980-98 to around +0.1 since 1998 (meaning that a 10 percent depreciation in the median EMDE triggered a 1 percent increase in consumer prices in the same quarter). In advanced economies, the median pass-through for similar depreciations is close to zero for both periods. Depreciations of 10-20 percent in a given quarter continue to be accompanied by a larger pass-throughs, with median values of +0.1 for advanced economies and +0.2 for EMDEs since 1998 (Figure SF1.2.3.D). Depreciations in excess of 20 percent were associated with pass-throughs of around +0.4 in both groups of countries.

The reduced frequency of large depreciations and smaller 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, and better external debt management (Frankel, Parsley, and Wei 2005). Pass-throughs remained larger 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.

ERPTRs during large appreciations. Appreciation episodes were generally associated with positive, but smaller, pass-throughs compared to

depreciations of the same magnitude, with median values of +0.02 for advanced economies and EMDEs for appreciations of 5-10 percent, and only slightly larger for appreciations of 10-20 percent. These results may indicate that currency appreciations induce a weaker response from import and consumer prices than similarly sized depreciations (Brun-Aguerre, Fuertes, and Greenwood-Nimmo 2017). However, large currency appreciations are also rare events, making rigorous conclusions about such asymmetric effects difficult to establish in this context. Overall, the results appear to point to the presence of possible nonlinearities in the relationship between exchange rate movements and inflation, including in EMDEs (Caselli and Roitman 2016).

Pass-through to inflation and underlying shocks

The event study documents wide cross-country and time variation in the relationship between exchange rate movements and inflation. This section explores this variation further by estimating ERPTRs conditional on the underlying shocks as well as country-specific characteristics.

Empirical approach. Exchange rate pass-through ratios are estimated for 29 advanced economies and 26 EMDEs over the periods 1971Q1 to 1997Q4 and 1998Q1 to 2017Q4 in country-specific Bayesian factor-augmented vector autoregression (FAVAR) models (see Annex 1 for details).¹ The models include a global block (featuring global inflation, global output growth, and oil price changes) and a domestic block (featuring inflation, output growth, changes in nominal effective exchange rates, and monetary policy rates or equivalent short-term nominal interest rates). The identification strategy is based on the following sign and timing assumptions:

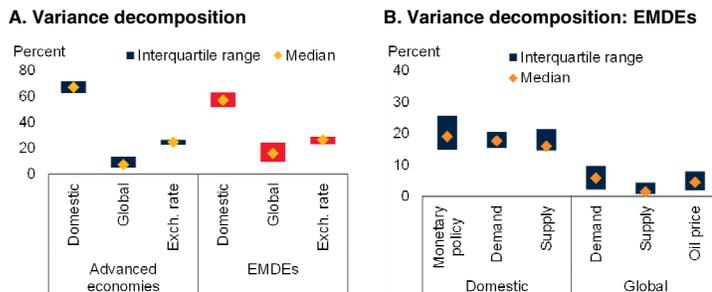
- A positive *monetary policy* shock (corresponding to an unexpected tightening of monetary policy) initially increases the domestic interest rate and appreciates the domestic currency, while it decreases domestic output growth and inflation.
- A positive country-specific *supply* or *demand* shock increases country-specific output growth. A country-specific supply shock reduces domestic inflation, whereas a country-specific demand shock increases it.
- A positive *exchange rate* shock (corresponding to an appreciation) only assumes a change in the exchange rate, while its impact on other domestic variables is left unrestricted.
- 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.
- A positive *oil price* shock induces an increase in oil prices and global inflation but a drop in global output growth.
- Global shocks can have contemporaneous effects on domestic variables, but domestic shocks can only influence global variables with a lag.

A two-step procedure is applied to measure shock-specific exchange rate and inflation responses to these shocks, and are mapped separately from impulse response functions. Second, the pass-through is defined as the cumulative impulse response of consumer price inflation relative to the impulse response of the effective exchange rate over one year. A positive pass-through ratio indicates that a shock triggering a currency depreciation is followed by an increase in consumer prices, as is generally expected. A negative value means that a shock triggering a currency depreciation is followed by a decline in consumer prices.

¹ The model framework used here—a FAVAR with sign restrictions to identify structural shocks—accounts for the endogenous nature of exchange rate movements by identifying truly structural shocks that are, by construction, orthogonal to each other. This reduces potential estimation bias due to simultaneous interactions between variables.

FIGURE SF1.2.4 Variance decompositions of exchange rate movements, 1998-2017

Domestic shocks account for about two-thirds of the variation in exchange rates in the median advanced economy and more than half in the median EMDE after one year. Monetary policy shocks have contributed most to exchange rate variations.



Source: World Bank.

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.

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Estimated exchange rate responses to shocks. Empirical studies have shown that certain macroeconomic 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). 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 tends to lead to currency depreciations, with a change in interest rate differentials unfavorable to the domestic currency putting downward pressure on its value (Chinn and Meredith 2005; Engel 2016). Rising risk premiums and heightened sovereign default risks tend to trigger depreciation pressures (Feroni, Ravazzolo, and Sadaba 2018). Finally, nominal exchange rates can respond to terms of trade shocks, particularly in commodity-exporting countries with flexible currency regimes (Aizenman, Edwards, Riera-Crichton 2012; Schmitt-Grohé and Uribe 2018).

Focusing on the period 1998-2017, the response of nominal effective exchange rates one year after different shocks are as follows:

- **Domestic shocks.** Monetary policy tightening is followed by currency appreciations in all advanced economies and, to an even greater extent, in EMDEs, particularly those with inflation-targeting central banks and some commodity exporters (Brazil, Colombia, and South Africa). Stronger domestic demand is accompanied by currency appreciations as well, but the impact is statistically insignificant after one year in most cases. Changes in domestic supply conditions have mixed effects, consistent with the literature on productivity shocks (Alfaro et al. 2018; Corsetti, Dedola, and Leduc 2008).
- **Global shocks.²** In EMDEs, domestic currency appreciations are more likely in the wake of a positive global demand shock, possibly reflecting the U.S. dollar depreciation that typically accompanies global upturns and capital inflows to EMDEs, particularly those with current account deficits (Avdjiev et al. 2018). A positive global supply 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 to exchange rate movements. Domestic factors are the main drivers of exchange rate movements, accounting for about two-thirds of currency movements in advanced economies and more than one-half in EMDEs over the past two decades (Figure SF1.2.4.A). Changes in monetary policy play a particularly prominent role (Figure SF1.2.4.B). Although the direction and magnitude of the impact of global shocks vary substantially across countries, global shocks explain around 7 percent of the variance of currency movements in

² The median impact of global shocks on exchange rates is close to zero across countries, since one country's currency depreciation is, by definition, another's appreciation.

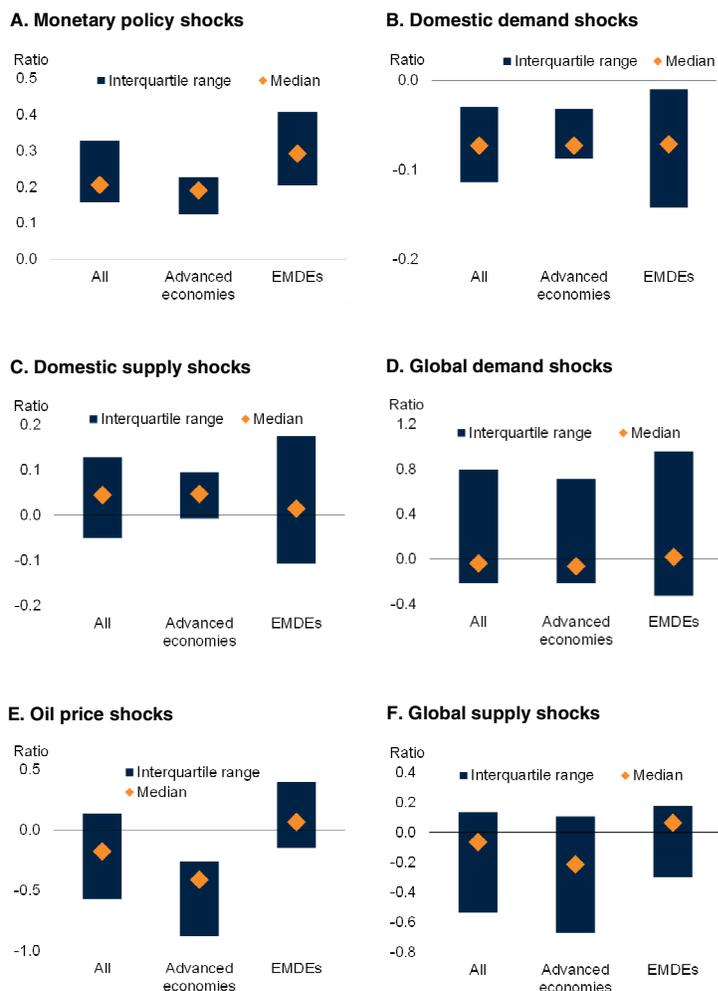
the median advanced economy and up to 16 percent in the median EMDE. About one-quarter of currency movements are accounted for by changes in other (unmeasured) factors, such as sovereign and private sector risk premiums. This is consistent with a significant impact of expectations about sovereign default risks on exchange rate dynamics (Alvarez, Atkeson, and Kehoe 2009; Foroni, Ravazzolo, and Sadaba 2018).

Estimated ERPTRs. Empirically, the following pattern of shock-specific one-year exchange rate pass-through ratios emerge:

- 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. *Monetary policy* shocks are generally associated with large, positive ERPTRs that are statistically significant in nearly all advanced economies and EMDEs. This means that currency appreciations triggered by monetary policy tightening tend to be followed by significantly slower inflation after one year, as the dampening impact of declining import prices is compounded by the effect of decelerating demand and activity. Median values since 1998 are estimated to be +0.2 for advanced economies and +0.3 for EMDEs (Figure SF1.2.5.A). *Domestic demand* shocks are associated with small, negative ERPTRs that are statistically insignificant for most advanced economies and EMDEs (Figure SF1.2.5.B). In other words, the buildup of domestic inflationary pressures when domestic demand strengthens unexpectedly could more than offset the disinflationary impact of the accompanying currency appreciation. Median values of the ERPTRs are at around -0.07 for both advanced economies and EMDEs. *Domestic supply* shocks are associated with positive ERPTRs with lower median values than monetary policy shocks (less than +0.1 for advanced economies and EMDEs; Figure SF1.2.5.C). However, most of these estimates are insignificant, with wide variations across country groups, largely reflecting the

FIGURE SF1.2.5 Shock-specific pass-throughs, 1998-2017

The exchange rate pass-through is large and positive when currency movements result from monetary policy shocks. It is smaller when currency movements are associated with changes in domestic supply conditions and negative when they are associated with changes in domestic demand conditions. Exchange rate pass-throughs vary widely when driven by global shocks.



Source: World Bank.
 Note: Pass-throughs are defined as the ratio of the one-year cumulative impulse response of consumer price inflation to 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.

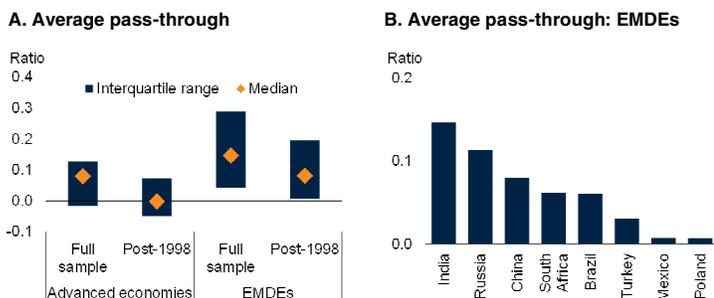
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heterogenous exchange rate response to these types of shocks.

- Global shocks.** Global shocks account for a smaller proportion of the variance of exchange rate movements and are associated with significant variations in estimated ERPTRs,

FIGURE SF1.2.6 Average pass-through

Over the past two decades, the average pass-through dropped close to zero in advanced economies and somewhat below +0.1 in EMDEs, albeit with considerable differences across countries.



Source: World Bank.

Note: Pass-throughs are defined as the ratio of the one-year cumulative impulse response of consumer price inflation to 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.

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reflecting the fact that these shocks have, by definition, diverging effects on individual country exchange rates (i.e., one country's currency depreciation is another's appreciation). Estimated ERPTRs associated with *global demand* shocks are statistically insignificant in over one-fifth of advanced economies and one-third of EMDEs, but are mostly positive across both groups (Figure SF1.2.5.D). *Oil price* shocks tend to be associated with positive ERPTR for the median energy exporters and a negative one for the median advanced economy, though not for the United States (partly due to the negative correlation between the U.S. dollar and oil prices; Figure SF1.2.5.E). However, estimates are insignificant in over one-half of advanced economies and almost two-thirds of EMDEs. *Global supply* shocks tend to be associated with largely insignificant ERPTRs (for nearly three-quarters of advanced economies and about two-thirds of EMDEs; Figure SF1.2.5.F).

- **Heterogenous consequences.** Collectively, these results suggest that the estimated exchange rate pass-through is highly

heterogeneous across underlying shocks that trigger exchange rate fluctuations. This heterogeneity in part reflects the endogenous nature of exchange rates (Rincón-Castro and Rodríguez-Niño 2018). In general, nominal shocks (such as commodity price shocks) are more likely to change relative prices, whereas real shocks (such as supply shocks) are more likely to be associated with lower pass-throughs but a higher impact on real exchange rates that facilitates expenditure switching.

Average ERPTRs. The average ERPTR has declined in both advanced economies and EMDEs since the late 1990s (Figure SF1.2.6.A). The average ERPTR is defined here as the weighted-average of shock-specific pass-through ratios, where weights are the estimated shares of currency movements accounted for by each type of shock. The median estimate over the period 1998-2017 was close to zero for advanced economies and +0.08 in EMDEs, significantly down from the prior two decades, but with wide country variations (Figure SF1.2.6.B).³

Pass-through and country characteristics

The previous section illustrates the fact that ERPTRs can vary considerably depending on the nature of the shock driving exchange rate movements. However, country characteristics matter as well. In particular, previous empirical studies have emphasized that differences in monetary policy frameworks and in the degree of international integration can account for some of

³Among 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 Russia (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-Ledesma 2009). For South Africa, the ERPTR is estimated at +0.07, broadly in line with the evidence presented in Kabundi and Mbelu (2018). For Turkey, the average ERPTR is somewhat lower than found in earlier studies, partly reflecting the shorter sample focusing on a period marked by significant de-dollarization and disinflation.

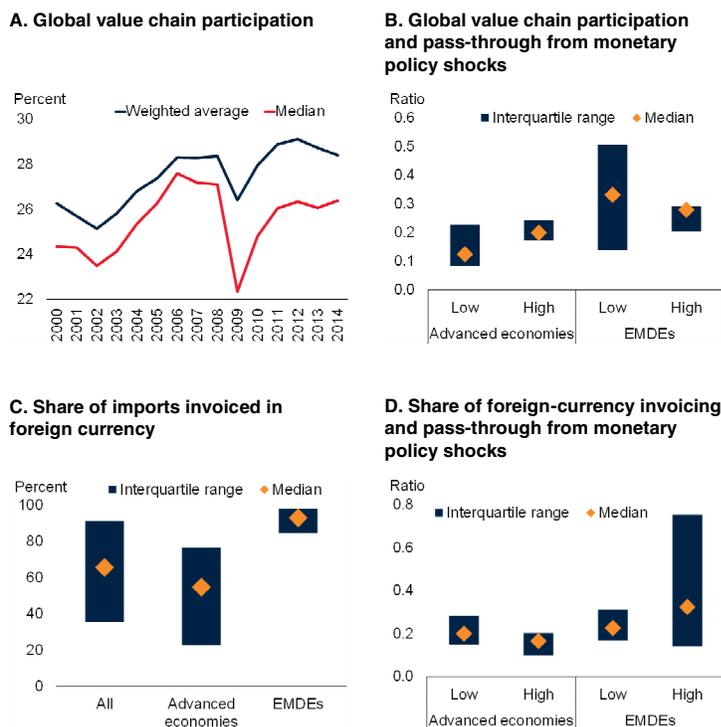
the heterogeneity in estimated ERPTRs (Campa and Goldberg 2010; Carrière-Swallow et al. 2016; Caselli and Roitman 2016; Coulibaly and Kempf 2010; Gagnon and Ihrig 2004; Mishkin and Schmidt-Hebbel 2007). These country characteristics are further investigated by comparing shock-specific ERPTRs for different subset of countries.

Global value chain integration. A priori, the impact of greater trade openness and international economic integration on estimated ERPTRs is difficult to ascertain. On the one hand, a larger share of imported products implies a potentially larger role for exchange rate movements in driving domestic inflation (Benigno and Faia 2016; Soto and Selaive 2003). On the other hand, increased foreign competition in domestic markets and greater integration in global value chains (GVCs) may reduce the ERPTR (Auer 2015; Berman, Martin, and Mayer 2012; Gust, Leduc, and Vigfusson 2010; Amiti, Itkhoki, and Konings 2016; de Soyres et al. 2018; Georgiadis, Gräß, and Khalil 2017; Figure SF1.2.7.A). Consistent with the literature, some economies in East Asia and the Pacific and in Eastern Europe and Central Asia are highly integrated into GVCs and also have low average pass-throughs (Chinn 2014). However, for other EMDEs, the association between GVC participation and ERPTRs is not as clear cut (Figure SF1.2.7.B).

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 tend 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). Domestic prices in highly dollarized economies also 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). The selection of the pricing currency could itself depend on the exchange rate pass-through (Gopinath, Itkhoki, and Rigobon 2010). Among EMDEs, a higher share of imports

FIGURE SF1.2.7 Global economic integration and pass-through

Higher global value chain participation is associated with lower pass-throughs in some EMDEs. A higher share of foreign-currency invoicing is associated with higher pass-throughs in some EMDEs, but does not seem to account for cross-country variations in EMDEs.



Source: Organisation for Economic Co-operation and Development, World Bank, World Trade Organization.

Note: Global value chain data are from the OECD-WTO TIVA (Trade in Value Added) 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.

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

C. Share of imports invoiced in foreign currency based on data for 50 countries calculated by Gopinath (2015).

D. Low and high share of foreign-currency invoicing are defined as below or above the sample average.

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invoiced in foreign currencies tends to be associated with higher pass-through ratios, but with significant heterogeneity across countries (Figures SF1.2.7.C and SF1.2.7.D).

Monetary policy framework and credibility. The increased adoption of credible monetary policy frameworks that support well-anchored inflation expectations has helped reduce the exchange rate pass-through to consumer prices in EMDEs by

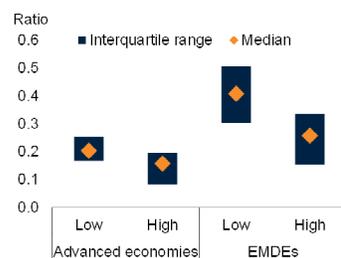
FIGURE SF1.2.8 Monetary policy frameworks and pass-through

A growing number of countries have adopted explicit inflation targets, and central bank independence has increased since 2000. Greater central bank independence has tended to dampen the pass-through to inflation of exchange rate movements stemming from monetary policy shocks and is also associated with lower average ERPTRs. Among EMDEs, the pass-through is generally lower among countries with more flexible exchange rate regimes and inflation-targeting central banks.

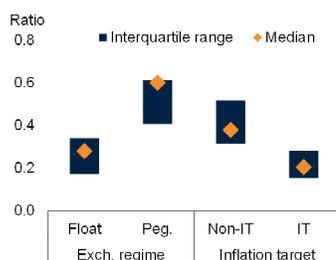
A. Central bank independence and inflation-targeting frameworks



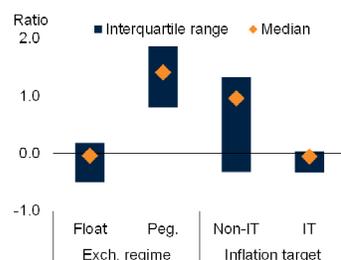
B. Central bank independence and ERPTRs from monetary policy shocks



C. ERPTRs associated with monetary policy shocks in EMDEs



D. ERPTRs associated with global demand shocks in EMDEs



Source: World Bank.

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. 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. Exchange rate and IT regimes are based on IMF classifications.

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minimizing domestic wage and mark-up adjustments (Figure SF1.2.8.A). In fact, ERPTRs associated with *domestic monetary policy* shocks are estimated to be significantly smaller in EMDEs with more independent central banks and higher

in EMDEs that do not have inflation-targeting central banks and have less flexible exchange rate regimes (for example, Azerbaijan, Botswana, Jordan, and North Macedonia; Figures SF1.2.8.B and SF1.2.8.C).⁴ The growing number of EMDEs adopting explicit inflation targets and reinforcing central bank transparency and independence has helped to dampen estimated ERPTRs over the last two decades. Thus an improvement of the central bank independence index from one standard deviation below the sample mean to one standard deviation above it is estimated to reduce the pass-through ratio associated with monetary policy shocks by half.

In countries with more independent central banks, inflation targets, and more flexible exchange rate regimes, inflation also responds less to exchange rate movements triggered by *global demand* and *oil price* shocks (Figure SF1.2.8.D). This implies that countries with such characteristics can better absorb external shocks through currency adjustments without threatening price stability. In countries with less flexible or pegged exchange rate regimes, global shocks could generate higher pass-through, making adjustments to devaluations more disruptive.

Conclusion

As recent financial market turbulences illustrate, large depreciations remain a threat to both price and financial stability in more vulnerable EMDEs. To formulate the appropriate monetary policy response to exchange rate pressures, central banks need to be able to anticipate the direction and magnitude of their impact on domestic inflation. But pass-through ratios—the percentage increase in consumer prices associated with a 1-percent depreciation of the nominal effective exchange rate—vary considerably across countries and over time, making inference from average values unreliable and potentially misleading for policy evaluation and forecasting purposes. Two fundamental factors help to account for the wide range of pass-through estimates: the nature of the shock triggering the currency movement and country characteristics.

An event study of past depreciation episodes suggests that the pass-through can more than

⁴This is in line with the empirical literature that has generally found ERPTRs to be smaller among advanced economies and in EMDEs with inflation targeting or more credible central banks (Carrière-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).

double when the effective exchange rate drops by more than 20 percent in a given quarter, illustrating the presence of non-linear effects. The exchange rate pass-through also depends on the nature of the shock. The pass-through associated with domestic monetary policy shocks, such as an unexpectedly loose policy stance contributing to currency depreciation and accelerating inflation and activity, is generally the strongest, especially in EMDEs without inflation-targeting central banks. In contrast, domestic demand shocks are typically accompanied by mostly insignificant pass-throughs, reflecting the offsetting effects of growth and exchange rate channels—that is, weakening domestic demand giving rise to currency depreciation but only a small effect on inflation. Greater central bank independence, increased global value chain integration, and a lower share of imports invoiced in foreign currencies are also associated with smaller pass-through ratios. A downward trend in average exchange rate pass-through ratios over the past two decades is consistent with improving central bank policies and increasing participation in global value chains in some countries.

These findings have important policy implications. First, structural policies can reduce the exchange rate pass-through to inflation. Policies that reinforce market competition, value chain integration, and local-currency invoicing can accelerate relative price adjustments in the event of shocks and hence help effective expenditure switching. Second, central bank credibility and transparency have significant impacts on macroeconomic stability. A credible commitment to maintaining low and stable inflation remains the most powerful way for central banks to limit the pass-through. A number of central banks have been able to achieve such outcome under inflation-targeting regimes. For countries with pegged or managed exchange rate regimes, allowing for a greater role of currency market discovery and avoiding sharp devaluations from prolonged periods of currency overvaluation is an important step toward lowering the pass-through. In any case, a clear delineation between monetary and fiscal policies helps reinforce the credibility of the central bank and keep pass-through to a minimum.

ANNEX SF1.2.1 Methodology

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 (Ha, Stocker, and Yilmazkuday 2019). 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.

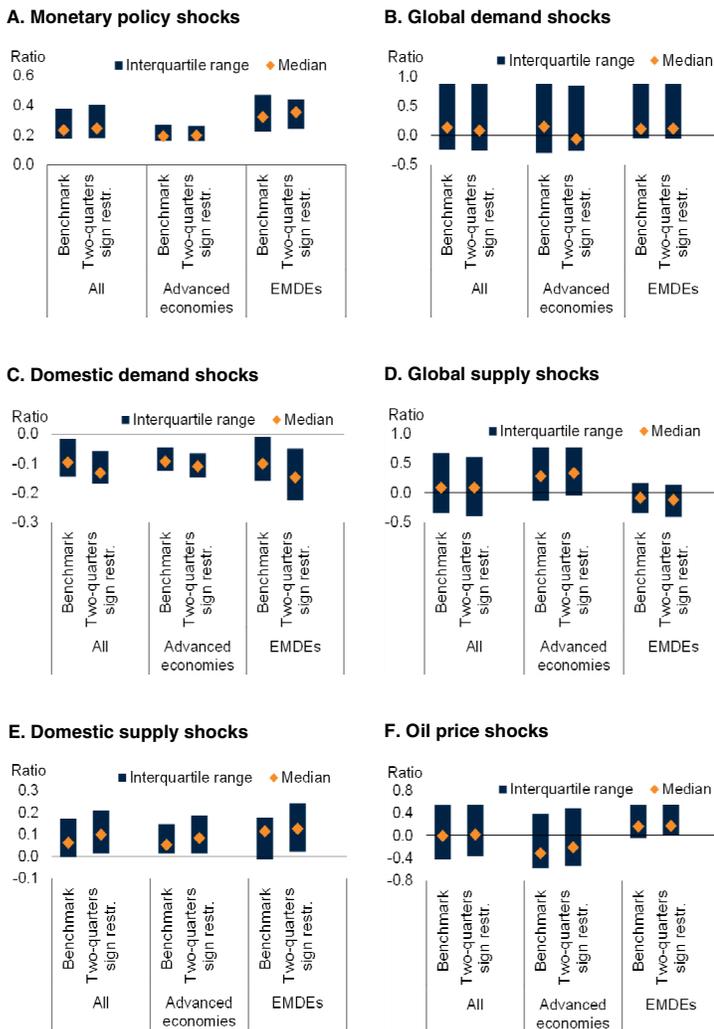
In its structural form, the FAVAR model is represented by

$$B_0 Y_t = \alpha + \sum_{j=1}^L B_j Y_{t-j} + \varepsilon_t$$

where ε_t is a vector of orthogonal structural innovations; Y_t consists of global inflation ($f_t^{\pi, \text{global}}$), global output growth ($f_t^{y, \text{global}}$), oil price growth (OP_t), country-specific inflation (π_t), country-specific output growth (Y_t), country-specific changes in nominal effective exchange rates (ER_t), and country-specific monetary policy (or equivalent short-term) nominal interest rates (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:

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

ANNEX FIGURE SF1.2.1.1 Robustness of pass-through estimates: One- versus two-quarter sign restrictions



Source: World Bank.

Note: Pass-throughs are defined as the ratio of the one-year cumulative impulse response of consumer price inflation to 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.

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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.¹ 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 (Annex Figure SF1.2.1.1). An alternative specification assumes that positive domestic demand shocks lead to a contemporaneous increase in domestic interest rates (Annex Figure SF1.2.1.2).

The structural FAVAR model framework has several advantages over the reduced-form approach in estimating the exchange rate pass-through (Rincón-Castro and Rodríguez-Niño 2018, Forbes, Hjortsoe, and Nenova 2017, Shambaugh

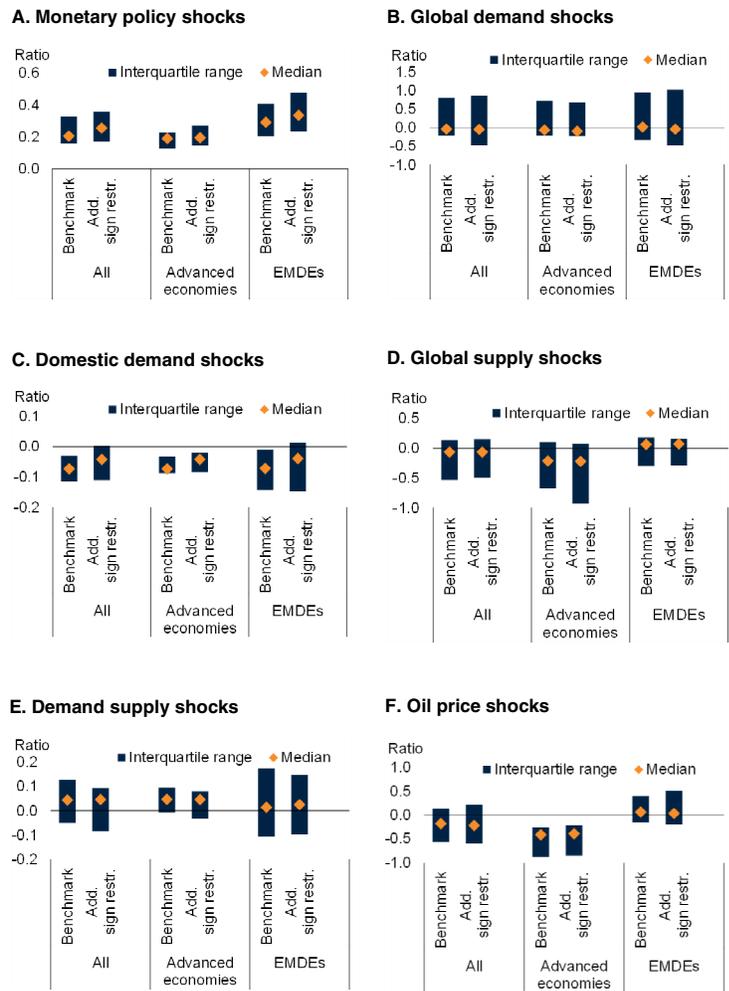
¹ Global shocks are derived from a separate tri-dimensional vector autoregression model that incorporates global output growth, global inflation, and oil price changes, following the approach of Charnavoki and Dolado (2014) and Uhlig (2005).

2008). First, it seeks to account for the endogenous nature of exchange rate movements, whereas reduced-form models assume that exchange rates are exogenously determined. In practice, exchange rates are often a function of macroeconomic fundamentals and thus the pass-through will depend on the type of shock the economy is facing. Second, the FAVAR model allows for the estimation of exchange rate pass-throughs are conditional on a variety of global and domestic shocks in a unified framework. Finally, the identification using sign and zero restrictions employed in this Special Focus seeks to identify truly structural shocks, orthogonal to each other, and reduce potential estimation bias due to simultaneous interactions between the variables.

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 this Special Focus 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).

ANNEX FIGURE SF1.2.1.2 Robustness of pass-through estimates: Additional sign restriction to identify domestic demand shocks



Source: World Bank.

Note: Pass-throughs are defined as the ratio of the one-year cumulative impulse response of consumer price inflation to 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.

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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. Since the exchange rate is defined such that an increase denotes appreciation, 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).

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 (Table SF1.2.1). 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 1971:1-2017:4.²
- 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.³

- 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:

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

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

where π_t^i and y_t^i are inflation and output growth in country i in quarter t , respectively, while $(f_t^{\pi,\text{global}})$ and $(f_t^{Y,\text{global}})$ are the global common factors for inflation and output growth in quarter t , respectively. $e_t^{Y,i}$ and $e_t^{\pi,i}$ are residual terms in output growth and inflation in country i in quarter t , respectively.

²The 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.

³The number of countries in the estimation of the global output and inflation factors is based on data availability. Estimates of global inflation and output factors are not found to change much when the same group of countries is employed.

TABLE SF1.2.1 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	Malta	1999:3 - 2017:4
Chile	1986:3 - 2017:4	Malaysia	2004:4 - 2017:4
China	1984:4 - 2017:4	Morocco	1995:4 - 2017:4
Colombia	1994:4 - 2017:4	Netherlands	1982:3 - 2017:4
Costa Rica	1997:3 - 2017:4	North Macedonia	2008:1 - 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 - 2017:3
Dominican Republic	2004:3 - 2017:3	Poland	1992:1 - 2017:4
Egypt	2002:4 - 2017:2	Portugal	1986:2 - 2017:4
Spain	1977:3 - 2017:4	Russia	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		

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