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Núm. 1011
2017

BANCO DE LA REPÚBLICA COLOMBIA

Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá - Colombia - Bogotá

Volatility Spillovers and the Global Financial Cycle Across Economies: Evidence from a Global Semi-Structural Model

Javier G. Gómez-Pineda*†

Abstract

The paper provides some evidence on the relevance of global uncertainty and risk aversion and the lesser importance of US interest rates for the global financial and business cycles. As framework, we use a global semi-structural model augmented with financial and trade interlinkages. Financial interlinkages are modelled with proposed global uncertainty, global risk aversion and global financial cycle channels. Trade interlinkages are modelled with proposed value-chain trade equations. We find that global uncertainty and global risk aversion are, by far, the main volatility factors in all economies. Other volatility factors such as US interest rates, foreign interest rates and trade-related factors rarely explain shares of forecast error variance above one percent.

JEL classification: E58; E37; E43; Q43

Keywords: Global financial cycle; Uncertainty; Risk aversion; Global risk; Global value chains; Value-chain trade equations; Global semi-structural model

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*This version: February 14, 2020. The author is Senior Economist at Banco de la República (the central bank of Colombia). The author thanks Mauro Napoletano and an anonymous referee for comments and Julián Roa, Liliana Muñoz, Jorge Guevara, Sergio Nocua and Sofía Salamanca for excellent research assistance. The paper was written under the cooperation aggreement between the Swiss Secreatriat for Economic Affairs (SECO) and Banco de la República.

†The findings, recommendations, interpretations and conclusions expressed in this paper are those of the author and do not necessarily reflect the view of the Central Bank of Colombia.

1 Introduction

Spillovers are a topic of increasing relevance, but spillovers from US interest rates, as the global financial cycle literature has emphasized (Miranda-Agrippino and Rey, 2019, Jorda et al., 2019) do not seem to be the most influential in the results of this article. By focusing on US interest rates, analysts and authorities seem to be leaving aside the major source of financial and real variability.

The global financial cycle involves several financial markets and countries. It typically comprises movements in credit, residential property prices, stock prices and leverage. It has important consequences worldwide (Jorda et al., 2019); nonetheless, it is largely absent in existing macroeconomic models (Akerlof and Schiller, 2009).

In the results of this article, shocks to global uncertainty and global risk aversion have important spillovers. By contrast, US interest rate and trade shocks have repercussions of second order relevance. In the policy implications, global uncertainty and global risk aversion are by far the key variables to monitor. Apparently, these variables should be included in macroeconomic models in policy institutions.

Global uncertainty is measured here as a common factor of country uncertainty. Likewise, global risk aversion is a common factor of country risk aversion while the global financial cycle is a common factor of the country financial cycle. In addition, in light of the decompositions of the VIX in Bekaert et al. (2013), country uncertainty is measured as the historical volatility of stock returns at the same time that country risk aversion is the difference between implicit volatility and country uncertainty.[1]

In sum, the model in this paper incorporates three global financial channels: a global uncertainty channel, a global risk aversion channel and a global financial cycle channel. We also augment the model with a trade channel using value-chain trade equations. Following the insights of the world-input-output literature (see for instance Johnson 2014), we derive value-chain trade equations that account for interlinkages among intermediate goods, final goods, sectors and economies. In the trade equations, exports and imports are both demand-determined, with demand being explained by absorption in the economies in the model. Inasmuch as the trade equations depend on absorption in the economies in the model, the paper follows Bems, Johnson and Yi (2010). In addition, the value-chain trade equations are augmented in this paper with the real exchange rate, accounting for substitution effects between home and foreign goods.

[1] Country uncertainty is measured here as the historical volatility of stock returns. It is a single uniform measure available to any country in which there is a stock market. Ideally we would incorporate not only the stock market but also the bond and credit derivatives markets. But there are limits to the information that can be made available for a large number of economies and for a sufficiently large time span.

We use as theoretical framework a Global Semi-Structural Model (GSSM) enhanced with the said global financial and value-chain trade interlinkages. The GSSM enables us to study the global uncertainty channel (global uncertainty, country uncertainty, aggregate demand, inflation), the global risk aversion channel (global risk aversion, country risk aversion, aggregated demand, inflation), the global financial cycle channel (global financial cycle, country financial cycle, aggregate demand, inflation) and the value-chain trade channels (from absorption abroad and at home to gross exports, from absorption at home and abroad to gross imports and from trade to the output gap and inflation).

A semi structural model, like the one dealt with here, pertains in essence to the New Neoclassical Synthesis (NNS). The main equations in the model can be derived from optimization; however, explicit optimization is left for further research.[2] Typically, semi structural models consist of a Phillips curve, an aggregate demand equation, a policy rule and an uncovered interest parity condition. Importantly, in the NNS, monetary policy has real effects in the short term but is neutral in the long term. The semi structural models that preceded those used for policy analysis were originated in McCallum and Nelson (2001) and Svensson (2000) and incorporated into actual policy formulation with the implementation of inflation targeting.

Turning to the definition of spillovers, they are a transmission of volatility to another economy. They can be defined as the share of forecast error variance explained by a shock originated abroad.[3] The forecast error variance can be broken-down into different shocks or volatility factors.

As regards to the choice of countries in the study, we include a group of countries or groups of countries that regard as core economies, or that are relevant system-wide (the United States, Europe, Japan, China, the United Kingdom) and a group of economies that we denominate non-core (we include in this paper the largest Latin American economies: Brazil, Mexico, Colombia, Chile and Peru). In addition, a block for the rest of the world, given its size and financial and trade interlinkages interlinkages, acts as an artificial core economy.

In the conclusions, global uncertainty and global risk aversion are the most critical volatility factors, a result that is in line with the views in Arkelof and Shiller (2009) as well as with the findings in Georgiadis and Jancokova (2017), who argue that, absent financial spillovers, global macroeconomic models may be misspecified.

The paper is related to Bekaert et al. (2013) who propose a monetary-financial transmission mechanism (US interest rates, risk aversion, uncertainty, the business cycle). They split implicit volatility into uncertainty and risk aversion. We borrow their decomposition as well as the terms

[2] Blanchard (2016, p. 3) notes that "[semi structural models] can be useful upstring, before DSGE modelling, as a first cut to think about the effect of a particular distortion or a particular policy."

[3] This definition borrows from the concept of directional spillovers in Diebold and Yilmaz (2012, p. 58−59).

uncertainty and risk aversion. They conclude that US monetary policy is an important driver of both uncertainty and risk aversion. We attempt to complement their work by embedding their empirical findings into a global semi structural model. We find that uncertainty and risk aversion do seem to correlate with monetary policy and in particular with US monetary policy. But from the focus of this paper, the relationship between US monetary policy with uncertainty and risk aversion appears to be a reduced form because in the semi structural model a relationship arises by virtue of two equations. The first one is the augmented aggregate demand equation, where risk aversion and uncertainty have an impact on aggregate demand. The second one is the monetary policy rule, where the interest rate responds to aggregate demand.

The paper is related to Miranda-Agrippino and Rey (2019), although we deal with different concepts and transmission channels. They measure the global financial cycle as a factor model of a large number of risky asset returns and commodity prices. In evaluating the relevance of the monetary-financial transmission mechanism (US interest rates, risk aversion, the business cycle), they conclude that US monetary policy is an important driver of risk aversion and the global financial cycle. The policy implication is that the monetary policy of the United States is imported along with the global financial cycle (see Rey 2015). This paper is similar in spirit to that of Miranda-Agrippino and Rey (2019) since it also studies the global financial cycle and its effects on the business cycle and the current account. However, this paper attempts to build on an earlier definition of the financial cycle used in Borio (2012) and Drehmann et al. (2012). In said papers, the (country) financial cycle can be parsimoniously approximated with the cycle in credit and residential property prices. We propose to extend their work by defining the global financial cycle as a common factor of the country financial cycle, particularly of the cycle in credit and property prices in the advanced economies. We evaluate the consequences of global uncertainty and global risk aversion on the global and country financial cycles, the business cycle and the current account.

Although Rey (2018) points at an important monetary-financial channel (US interest rates, risk aversion, stock returns and commodity prices), we do not evaluate the relevance of US interest rates in this monetary-financial channel that ultimately affects stock returns and commodity prices. Rather, our interest is in the relevance of global uncertainty and global risk aversion according to the global uncertainty and global risk aversion channels that ultimately affect aggregate demand and inflation (global uncertainty, global risk aversion, country uncertainty, country risk aversion, aggregate demand, inflation). In addition, we find that US interest rates are not the most important driver of the country financial cycle or the current account.

The model in the paper is related to the IMF Global Projection Model (Caravenciob et al.

2013, Andrle et al. 2015) and the quantitative models for projection and policy analysis.[4] The GPM features a linkage from financial to real variables in the form of a risk variable, included in the output gap equation.[5] We attempt to build on their work by using as risk variables global and country uncertainty and risk aversion.

Another strand of the literature also underlines the effect of US interest rates on foreign output. Examples are Ammer et al. (2016), Georgiadis (2015) and Fukuda et al. (2013). For example, Ammer et al. (2016), considers spillovers from US interest rates on foreign output. The authors use the SIGMA model of the Federal Reserve, with the United States and one foreign country. They conclude that spillovers are positive, meaning that monetary policy actions that tend to stimulate output in the United States also tend to stimulate output abroad.

The paper is organized as follows: after this introduction, in the second section we present some of the features of the economies dealt with in the paper. In the third section we explain the GSSM. Section four presents an overview of the data. Section five explains the computation, calibration and estimation of the model. The sixth section presents the results. Section seven offers some conclusions and an Appendix presents the derivation of the value-chain trade equations.

2 The core and non core economies

The core economies are those that are significant in financial markets, world output and trade. The output of the five largest core economies amounts to slightly more than half of world output (Table 1). The United Kingdom has the lowest weight in world output, about 2.6 percent, it is included as a core economy owing to its size as well as its relevance in financial markets. Japan is still a rather large economy and it used to be among the largest three, but however, currently the group of the largest three economies comprises the United States, Europe and China, amounting to 46.3 percent of world output.

Turning to financial integration, we look at three measures. First the correlation of country uncertainty (historical stock volatility) with the available measures of implicit volatility (the VIX, the VUK, the VDAX and the VUK). Second, the correlation of country uncertainty with global uncertainty. Third the effect of the global financial cycle on the country financial cycle (or the loading factor of the country financial cycle in the global financial cycle equation). By these measures, the United States, Europe and the United Kingdom can be regarded as highly integrated while China, Colombia and Peru can be considered less integrated.[6]

[4] The term quantitative means that it is useful for numerical analysis and projections, as in Goodfriend and King (1997).

[5] They use as risk variable the Fed senior loan officer opinion survey on bank lending practices.

[6] The level of financial integration in Colombia and Peru, as reported in Table 1, may be influenced by move-

As to trade openness, China and Europe are relatively opened while the United States is relatively closed (Table 1). Europe is quite opened, with shares of exports and imports of about 33 percent. Among the non core economies, Mexico is relatively opened while Brazil is relatively closed.

Regarding the weight of the economies as trade partners, the three largest economies are the main trade partners for each and every core economy (Table 2). From the standpoint of the Latin American non core economies, the United States and China are the main trade partners. In contrast, for Mexico, the United States alone is almost the sole trade partner.

Overall, we include the United States, Europe and China as core economies because they account for large shares of world output and trade and also owing to the relevance of the United States as a financial center. In addition, we include Japan and the United Kingdom due to their size and relevance in financial markets.

3 The model

The set up of the country models in the GSSM require some decision about the monetary policy trilemma. The trilemma establishes that monetary policy can obtain two out of three policy objectives: international capital mobility, monetary policy autonomy and a fixed exchange rate. Five economies in the model are considered to cope with the trilemma with capital mobility, monetary policy autonomy and floating exchange rates (the United States, Europe, Japan, the United Kingdom and the group for the rest of the world). One economy is considered to confront the trilemma with capital controls, monetary policy autonomy and a fixed, or at least rigid, exchange rate (China).

In the economies with international capital mobility, the UIP condition holds. In these economies, the UIP condition (plus the UIP residual) dictates the evolution of the floating exchange rate. In contrast, in economies with capital controls, the UIP condition does not need to hold. Particularly for the exchange rate of China, a special equation is proposed.

In all the economies in the model there is monetary policy autonomy. With monetary policy autonomy, the policy interest rate is characterized by a Taylor rule.

Implicit volatility, uncertainty and risk aversion. We follow Bekaert et al. (2013) in decomposing implicit volatility into expected uncertainty and risk aversion

$$v_t = \rho_t + \alpha_t, \tag{1}$$

ments in stock prices related to particular commodity-related stocks.

where variable v_t denotes implicit volatility, ρ_t denotes country uncertainty and α_t denotes country risk aversion.[7] [8]

Country uncertainty is the historical volatility of the stock market at every quarter t, denoted as h_t and calculated as the standard deviation of daily volatility over the previous 30 days

$$h_t = \text{std}(\boldsymbol{\sigma}_i^D)/\sqrt{12}, \tag{2}$$

where daily volatility σ_i^D is the the log daily return of the stock index X_i (from day $i-1$ to day i), in percent and at an annual rate[9]

$$\boldsymbol{\sigma}_i^D = 100 \times 360(\log X_i - \log X_{i-1}). \tag{3}$$

Historical stock volatility or country uncertainty enters the model in normalized form. Quarterly data for historical stock volatility h_t was divided by the standard deviation of historical stock volatility. We used as standard deviation a simple average of the standard deviation of historical stock volatility for the five core economies $\bar{\sigma}_{h,core}$. Our measure of country uncertainty is then

$$\rho_t = \frac{h_t}{\bar{\sigma}_{h,core}}. \tag{4}$$

The normalization is completed when the mean is subtracted. This step is performed when historical stock volatility enters the model in deviation form as

$$\hat{\rho}_t = \frac{h_t - \bar{h}_t}{\bar{\sigma}_{h,core}}, \tag{5}$$

where $\bar{h}_t$ is latent country uncertainty or historical stock volatility in each economy.[10]

Country uncertainty is denoted as ρ_t, while global uncertainty, as ρ_t^G. Global uncertainty is a common factor of country uncertainty as follows:[11]

$$\hat{\rho}_t^G = \eta_1 \hat{\rho}_{t-1}^G + \varepsilon_t^{\hat{\rho}^G}. \tag{6}$$

$$\hat{\rho}_t = \eta_g \hat{\rho}_t^G + \varepsilon_t^{\hat{\rho}}, \tag{7}$$

There is one equation of the form (7) for each economy. In equations (7) and (6), $\varepsilon_t^{\hat{\rho}}$ is a country-specific uncertainty shock, $\varepsilon_t^{\hat{\rho}^G}$ is a global uncertainty shock, ω_ρ are the loading factors of country uncertainty for each country and a hat denotes deviation from latent values.

[7] We use the specification in equation (1), instead of $v_t = \rho_{t|t-1} + \alpha_t$ owing to the quarterly frequency of our data.

[8] Miranda-Agripinno and Rey (2019) obtain risk aversion as the residual of a regression of the VIX on country unceretainty. Their procedure and ours are identical for a unit coefficient in the regressor.

[9] Daily stock returns were calculated for the seven days of the week. Weekends and holidays were obtained by interpolation.

[10] Note that $\bar{\rho}_t = \bar{h}_t/\bar{\sigma}_{Sys}$.

[11] All coefficients are nonnegative.

Likewise, global risk aversion is a common factor of country risk aversion

$$\hat{\alpha}_t^G = \tau_1 \hat{\alpha}_{t-1}^G + \varepsilon_t^{\hat{\alpha}^G}, \tag{8}$$

$$\hat{\alpha}_t = \tau_g \hat{\alpha}_t^G + \varepsilon_t^{\hat{\alpha}}, \tag{9}$$

also with one equation of the form (9) for each economy. In equations (8) and (9) global risk aversion $\hat{\alpha}_t^G$ is the common factor of country risk aversion $\hat{\alpha}_t$ with one loading factor ω_α, for each economy.

Turning to the latent variables, latent country uncertainty is given by

$$\bar{\rho}_t = \eta_3 \bar{\rho}_{t-1} + (1 - \eta_3)\bar{\rho}^{ss} + \varepsilon_t^{\bar{\rho}}. \tag{10}$$

while latent global uncertainty is given by a weighted average of country uncertainty with weights given by PPP-adjusted shares in world output as follows:

$$\bar{\rho}_t^G = \Sigma_i \lambda_i \bar{\rho}_t. \tag{11}$$

Latent country risk aversion and latent implicit volatility follow stochastic process similar to those given by equations (10) and (11) for latent country uncertainty.

The global and country financial cycles. We designate the global financial cycle as global, although it is more properly the cycle in credit and property prices in the advanced economies. Moreover, in the arrangement of countries in our model, the advanced economies with a common financial cycle are the United States, Europe and the United Kingdom, or in other words, the transatlantic economies.[12] The country financial cycle in the remaining economies core and non core economies in the model has, in general, idiosyncratic features.

The global financial cycle is given by the equation

$$\hat{w}_t^G = \varkappa_w \hat{w}_{t-1}^G - \varkappa_r \hat{r}_{AE,t} - \varkappa_v \hat{v}_{AE,t} + \varkappa_y \varepsilon_{AE,t}^{\hat{y}} + \varepsilon_t^{\hat{w}^G}, \tag{12}$$

where $\hat{w}_t^G$ is the global financial cycle, AE denotes the advanced economies, the term $\hat{v}_{AE,t}$ denotes implicit volatility in the advanced economies, the term $\hat{r}_{AE,t}$ denotes the real interest rate in the advanced economies, and the term $\varepsilon_{AE,t}^{\hat{y}}$ is the output gap shock, to be explained below.[13]

[12] In other advanced economies, such as Japan, the country financial cycle does not correlate with that of the transatlantic economies. Still other advanced economies are averaged out in the group for the rest of the world. The classification of countries in the model follows the core and non core rationalle explained above. A classification based on the country financial cycle is a matter of future research.

[13] The three explanatory variables at the right hand side of equation (12) are weighted by the share of these economies in the output of the advanced economies at PPP exchange rates.

Turning to the country financial cycle, it is given by

$$\hat{w}_t = \beta_w \hat{w}_{t-1} + \beta_g \hat{w}_t^G - \beta_r \hat{r}_t - \beta_v \hat{v}_t + \beta_y \varepsilon_t^{\hat{y}} + \epsilon_t^{\hat{w}}, \tag{13}$$

with one equation of the form (13) for each economy. In equations (12) and (13), the global financial cycle $\hat{w}_t^G$ is a common factor of the country financial cycle $\hat{w}_t$, with loading factors β_g. In the economies that are integrated to the global financial cycle, the effect of implicit volatility, the real interest rate, the output gap and the country financial cycle persistence are given at the global level, that is β_v, β_r, β_y, and β_w are all equal to zero. In contrast, in the economies that are not integrated to the global financial cycle, the effect of implicit volatility, the real interest rate and the output gap on the country financial cycle, as well as the country financial cycle persistence are given at the country level, that is β_v, β_r, β_y, and β_w are different from zero.

In equation (13), the error term $\epsilon_t^{\hat{w}}$ is the country financial cycle shock which will be made part of the aggregate demand equation below.

In the countries that are integrated to the global financial cycle, the country financial cycle responds to global and country financial shocks. In contrast, in the countries that are not integrated to the global financial cycle, the country financial cycle responds only to country financial cycle shocks. Algebraically, the error term $\epsilon_t^{\hat{w}}$ in equation (13) is given by

$$\epsilon_t^{\hat{w}} = \xi \varepsilon_t^{\hat{w}^G} + \varepsilon_t^{\hat{w}}, \tag{14}$$

where $\xi \neq 0$ in the countries that are integrated to the global financial cycle and $\xi = 0$ in the countries that are not.

The residual in the aggregate demand block $\varepsilon_t^{\hat{y}}$ is defined as

$$\varepsilon_t^{\hat{y}} = \bar{c}\varepsilon_t^{\hat{c}} + \bar{x}\varepsilon_t^{\hat{x}} - \bar{m}\varepsilon_t^{\hat{m}}, \tag{15}$$

where $\varepsilon_t^{\hat{c}}$, $\varepsilon_t^{\hat{x}}$ and $\varepsilon_t^{\hat{m}}$ are the residuals in the absorption, exports and imports equations, respectively, and $\bar{c}$, $\bar{x}$, $\bar{m}$ are the share of absorption, exports and imports in output in the steady state.

In both, advanced and emerging economies, the unobserved country financial cycle is estimated as a common factor of the cycle in credit $\hat{\mu}_t$ and property prices $\hat{\delta}_t$ as follows

$$\hat{\mu}_t = \omega_\mu \hat{w}_t + \varepsilon_t^{\hat{\mu}}, \tag{16}$$

$$\hat{\delta}_t = \varpi_\delta \hat{w}_t + \varepsilon_t^{\hat{\delta}}, \tag{17}$$

with loading factors ω_μ and ω_δ.

Turning to the latent variables, latent country and global credit follow

$$\bar{\mu}_t = \bar{\mu}_{t-1} + \frac{1}{4}\gamma_t^{\bar{\mu}} + \varepsilon_t^{\bar{\mu}} \tag{18}$$

$$\gamma_t^{\bar{\mu}} = \alpha_{13}\gamma_{t-1} + (1-\alpha_{13})\gamma^{\bar{\mu},ss} + \varepsilon_t^{\gamma^{\bar{\mu}}}, \tag{19}$$

and

$$\bar{\mu}_t^G = \Sigma_i \lambda_i \bar{\mu}_t, \tag{20}$$

where $\gamma_t^{\bar{\mu}}$ is the rate of growth of latent credit at an annual rate and the fraction $\frac{1}{4}$ transforms the annualized rate of growth $\gamma_t^{\bar{\mu}}$ into quarterly growth.

Latent property prices $\bar{\delta}_t$ follow stochastic processes similar to those in equations (18) and (19).

Aggregate demand block and the trade equations. The output gap is obtained from the basic macroeconomic equation,[14] that in deviation form can be written as

$$\hat{y}_t = \bar{c}\hat{c}_t + \bar{x}\hat{x}_t - \bar{m}\hat{m}_t, \tag{21}$$

where y_t is output, c_t is absorption, x_t is exports and m_t is imports, a hat denotes deviation from the latent variables and a bar denotes share in output in the steady state.

A standard approach in dealing with equation (21) is to plug behavioral equations for absorption, exports and imports to derive a behavioral equation for the output gap as a function of variables such as interest rates, exchange rates and the foreign output gap. This construct is called the aggregate demand equation.

Following the "minimalistic" approach of Rotemberg and Woodford (1997) and McCallum and Nelson (2000), we breakdown aggregate demand into absorption, exports and imports with not separate treatment of investment or government expenditure. Hence, absorption, denoted as c_t, accounts for consumption, investment, change in inventories and government expenditure.

As pointed out by Johnson (2014: 132), the trade balance is equivalent in gross and net terms. Thus, in equation (21), the output and absorption gaps are measured in units of value added while the trade balance $\bar{x}\hat{x}_t - \bar{m}\hat{m}_t$ is measured equivalently in gross or value added terms.

The task at this point is to propose behavioral equations for the terms at the right side of equation (21). Absorption is to follow the augmented Euler equation.

$$\hat{c}_t = \sigma_1\hat{c}_{t+1|t} + \sigma_2\hat{c}_{t-1} - \sigma_r\hat{r}_t - \sigma_v\hat{v}_t + \sigma_w\epsilon_t^{\hat{w}} + \varepsilon_t^{\hat{c}}, \tag{22}$$

where $\hat{r}_t$ is the real interest rate, $\hat{v}_t$ is country implicit volatility or the sum of country uncertainty and country risk aversion, our proxy for country risk, and $\epsilon_t^{\hat{w}}$ is the residual in the country financial-cycle-equation shock defined in equation (14) above.

[14] In the basic macroeconomic equation output is the sum of consumption, investment, government expenditure and net exports.

Intuitively, the interest rate r_t accounts for the risk free, short term interest rate while implicit volatility $v_t = \rho_t + \alpha_t$ helps explain risk in long term interest rates. In addition, the financial cycle surprise $\epsilon_t^{\hat{w}}$ allows aggregate demand to be driven by the country financial cycle (credit and residential property prices), after controlling for the effect on this cycle of implicit volatility, the real interest rate and the output gap, as in equations (12) and (13).

We then turn to the exports and imports aggregates in equation (21). These aggregates are modelled taking into account global value chains, following the insights of the world-input-output literature (see for instance Johnson 2014a). The value-chain export and import equations are derived in the Appendix.

In the trade equations, (gross) exports and imports are both demand-determined, with (final) demand given by absorption in the number of economies in the model. Exports and imports are also driven by a form of real multilateral (or effective) exchange rate. For expositional purposes we present the trade equations for the United States. The export and import equations are

$$\hat{x}_{US,t} = \varepsilon_{US}\hat{x}_{US,t-1} + \hat{c}^x_{US,t} + \sigma\hat{q}^x_{US,t} + \varepsilon^{\hat{x}}_{US,t} \tag{23}$$

and

$$\hat{m}_{US,t} = \xi_{US}\hat{m}_{US,t-1} + \hat{c}^m_{US,t} - \sigma\hat{q}^m_{US,t} + \varepsilon^{\hat{m}}_{US,t}, \tag{24}$$

where ε_{US} and ξ_{US} are persistence coefficients, $\hat{c}^x_{US,t}$ is aggregate demand for gross exports, $\hat{c}^m_{US,t}$ is aggregate demand for gross imports, $\hat{q}^x_{US|US,t}$ is the exchange rate for gross exports and $\hat{q}^m_{US|US,t}$ is the exchange for gross imports.

The measures of aggregate demand for gross exports and imports are

$$\hat{c}^x_{US,t} = \varepsilon^c_{US,US}\hat{c}_{US,t} + \varepsilon^c_{US,EU}\hat{c}_{EU,t} + ... + \varepsilon^c_{US,PE}\hat{c}_{PE,t} \tag{25}$$

and

$$\hat{c}^m_{US,t} = \xi^c_{US,US}\hat{c}_{US,t} + \xi^c_{US,EU}\hat{c}_{EU,t} + ... + \xi^c_{US,PE}\hat{c}_{PE,t}. \tag{26}$$

These measures are a sum of country absorption (aggregate demand) in the economies of the model, multiplied by elasticities $\varepsilon^c_{i,j}$ and $\xi^c_{i,j}$, respectively. Elasticities $\varepsilon^c_{i,j}$ denote the response of country i exports to absorption in country j. Likewise, elasticities $\varepsilon^c_{i,j}$ denote the response of country i imports to a shock to absorption in country j. These elasticities are not trade weights but a function of trade weights and coefficients from the Leontieff inverse of the world input output matrix.

In equations (23) and (25), gross exports depend on absorption in the list of economies in the model, including the local economy, the own effect on exports. The own effect on exports is explained by the fact that local absorption can elicit intermediate exports to destinations where, after processing, are shipped back to the local economy for final absorption. Likewise, in equations (24) and (26), gross imports depend on aggregate demand in economies different from the local economy, the foreign effect on imports. The foreign effect in imports is explained by the fact that gross imports can include intermediate inputs that, after processing, are shipped to foreign economies to be used as final absorption or for further processing.

The absorption elasticities $\varepsilon^c_{i,j}$ and $\xi^c_{i,j}$ depend on the distribution of aggregate demand shocks across sectors and countries. When shocks are homogeneous across sectors, the elasticity of world trade to world aggregate demand is one. In contrast, when shocks are larger in sectors that are highly interconnected, for instance, in the manufacturing sector, the elasticity of world trade to world aggregate demand increases.

The exchange rates for exports and imports are

$$\hat{q}^x_{US,t} = \varepsilon^q_{US,US}\hat{q}_{US|US,t} + \varepsilon^q_{US,EU}\hat{q}_{US|EU,t} + ... + \varepsilon^q_{US,PE}\hat{q}_{US|PE,t} \tag{27}$$

and

$$\hat{q}^m_{US,t} = \xi^q_{US,US}\hat{q}_{US|US,t} + \xi^q_{US,EU}\hat{q}_{US|EU,t} + ... + \xi^q_{US,PE}\hat{q}_{US|PE,t}. \tag{28}$$

They are sums of real bilateral exchange rates vis a vis the economies in the model, multiplied by elasticities $\varepsilon^q_{i,j}$ and $\xi^q_{i,j}$. For a given elasticity of substitution between local and foreign goods, the stream of elasticities $\varepsilon^q_{i,j}$ denote the response of country i exports to a depreciation in the real bilateral exchange rate of country i vis a vis country j. Likewise, the stream of elasticities $\xi^q_{i,j}$ denote the response of country i imports to the real bilateral exchange rate of country i vis a vis country j. As before, these elasticities are not trade weights but the product of trade weights and input requirements form the Leontieff inverse of the world input output table. We scale elasticities $\varepsilon^q_{i,j}$ and $\xi^q_{i,j}$ to add up to one so as to make the exchange rates for exports and imports comparable to the conventional real multilateral exchange rates.

Turning to the latent variables in the basic macroeconomic equation, latent absorption is given by the stochastic processes

$$\bar{c}_t = \bar{c}_{t-1} + \frac{1}{4}\gamma^{\bar{c}}_t + \varepsilon^{\bar{c}}_t \tag{29}$$

and

$$\gamma^{\bar{c}}_t = \alpha_{13}\gamma_{t-1} + (1-\alpha_{13})\gamma^{\bar{c},ss} + \varepsilon^{\gamma^{\bar{c}}}_t, \tag{30}$$

while latent exports and imports follow similar processes.

In turn, potential output is obtained as

$$\bar{y}_t = \bar{y}_{t-1} + \frac{1}{4}\gamma^{\bar{y}}_t, \tag{31}$$

where potential growth is obtained as

$$\gamma^{\bar{y}}_t = \bar{c}\gamma^{\bar{c}}_t + \bar{x}\gamma^{\bar{x}}_t - \bar{m}\gamma^{\bar{m}}_t, \tag{32}$$

and output itself as

$$y_t = \hat{y}_t + \bar{y}_t. \tag{33}$$

Finally, net exports may be used as an approximation to the current account

$$\bar{z}\hat{z}_t = \bar{x}\hat{x}_t - \bar{m}\hat{m}_t \tag{34}$$

By multiplying $\hat{x}_t$ and $\hat{m}_t$ by the shares of exports and imports in GDP in the steady state, $\bar{x}$ and $\bar{m}$, the deviation terms are translated into approximate percent of GDP. Then, the measure of the trade balance $\bar{z}\hat{z}_t$ is also measured in approximate percent of GDP.

Core inflation. Core inflation is represented here as inflation in the CPI excluding food and energy. The movements in core inflation are useful for the estimation of potential output. However, there is an important share of the variability in core inflation that is not related to movements in the output gap; particularly, a large part of the variation in the short term is noise. We then split core inflation, denoted as $\pi^{NS}_{C,t}$, into noise, $\pi^{N}_{C,t}$, and signal, $\pi_{C,t}$ components.[15] The later is the component that is related to the output and exchange rate gaps. Thus, core inflation becomes

$$\pi^{NS}_{C,t} = \pi_{C,t} + \pi^{N}_{C,t}, \tag{35}$$

where the behavioral equation explaining the signal component of core inflation is given by

$$\pi_{C,t} = (1-\kappa_1)\pi^{e}_{C,t} + \kappa_1\pi^{4}_{C,t-1} + \kappa_y\hat{y}_t + \kappa_q\hat{q}_{RER,t} + \varepsilon^{\pi_C}_t, \tag{36}$$

where $\hat{q}_{RER,t}$ is the gap of the conventional real multilateral exchange rate.

Likewise, the behavioral equation for non core inflation is[16]

$$\pi_{NC,t} = (1-\kappa_2)\pi^{e}_{NC,t} + \kappa_2\pi^{4}_{NC,t-1} + \kappa_{y,nc}\hat{y}_t + \kappa_{q,nc}\hat{q}_{RER,t} + \varepsilon^{\pi_{NC}}_t. \tag{37}$$

Total inflation is the weighted average of the core and non core components as follows:

$$\pi_t = \zeta_C\pi_{C,t} + (1-\zeta_C)\pi_{NC,t} + \varepsilon^{\pi}_t, \tag{38}$$

where the inflation accounting residual ε^{π}_t enables equality in equation (38) with changes in the share of core inflation in total inflation, ζ_C, given by changes in the CPI basket.

As regards to inflation expectations, they are a linear combination of the rational-expectation inflation forecast and past inflation expectations as follows:

$$\pi^{e}_{C,t} = \theta_C\pi^{e}_{C,t+4} + (1-\theta_C)\pi^{e}_{C,t-1} + \varepsilon^{\pi^e_C}_t, \tag{39}$$

[15] Notation $\pi^{c}_{NS,t}$ stands for noise and signal.

[16] We did not use the noise-signal decomposition for non core inflation for simplicity.

$$\pi^e_{NC,t} = \theta_{NC}\pi^e_{NC,t+4} + (1-\theta_{NC})\pi^e_{NC,t-1} + \varepsilon_t^{\pi^e_{NC}}, \quad (40)$$

$$\pi^e_t = \zeta_C \pi^e_{C,t} + (1-\zeta_C)\pi^e_{NC,t}. \quad (41)$$

Implicit inflation targets for core inflation are estimated by the stochastic process

$$\bar{\pi}_t = \bar{\pi}_t^{Det} + \bar{\pi}_t^{Trend}, \quad (42)$$

where $\bar{\pi}_t^{Det}$ and $\bar{\pi}_t^{Trend}$ are the trend and detrended components given by

$$\bar{\pi}_t^{Det} = \kappa_3 \bar{\pi}_{t-1}^{Det} + (1-\kappa_3)\pi_t^{Det,ss} + \varepsilon_t^{\bar{\pi}^{Det}}, \quad (43)$$

$$\bar{\pi}_t^{Trend} = \bar{\pi}_{t-1}^{Trend} + \frac{1}{4}\gamma_t^{\bar{\pi}^{Trend}} + \varepsilon_t^{\bar{\pi}^{Trend}} \quad (44)$$

and

$$\gamma_t^{\bar{\pi}^{Trend}} = \gamma_{t-1}^{\bar{\pi}^{Trend}} + \varepsilon_t^{\gamma^{\bar{\pi}^{Trend}}}. \quad (45)$$

The policy rule. The policy interest rate is given by a variant of the Taylor (1993) rule,[17] $i_t = \bar{\imath}_t + 1.5\hat{\pi}_t^4 + 0.5\hat{y}_t + \varepsilon_t^i$. In order to keep supply shocks aside from monetary policy, the Taylor rule is defined here on the basis of core inflation as follows:

$$i_t = \bar{\imath}_t + 1.5\hat{\pi}_{C,t} + 0.5\hat{y}_t + \varepsilon_t^i, \quad (46)$$

where variable $\hat{\pi}_{C,t}$ is the gap of quarterly inflation, the latent interest rate is $\bar{\imath}_t \equiv \bar{r}_t + \bar{\pi}_t^c$, and the real interest rate is defined as

$$r_t \equiv i_t - \pi_t^e. \quad (47)$$

In turn, following Laubach and Williams (2003), the natural interest rate is defined as the sum of detrended and trend components

$$\bar{r}_t = \bar{r}_t^{Det} + \bar{r}_t^{Trend}, \quad (48)$$

where the detrended component is equal to the growth of potential output plus an error term

$$\bar{r}_t^{Det} = \gamma_t + \varepsilon_t^{\bar{r}^{Det}}, \quad (49)$$

the trend component follows a random walk

$$\bar{r}_t^{Trend} = \bar{r}_{t-1}^{Trend} + \varepsilon_t^{\bar{r}^{Trend}} \quad (50)$$

and the bars denote latent values.

[17] This version is proposed by Svensson (1999), p. 614. In our notation, $\hat{\pi}_t^4$ is CPI inflation over four quarters.

The exchange rate. In economies with international capital mobility, the exchange rate is given by a risk-augmented uncovered interest rate parity condition (UIP), as follows[18]

$$\begin{aligned} q_{EU|US,t} &= q_{EU|US,t+1|t} \\ &-\frac{1}{4}\left[\left(r^{Det}_{EU,t} - r^{Det}_{US,t}\right) - \alpha_{12}\left(v_{EU,t} - v_{US,t}\right)\right] + \chi_{EU|US,t} \end{aligned} \tag{51}$$

$$r^{Det}_{US,t} = r_{US,t} - \bar{r}^{Trend}_{US,t},$$

where, for expositional convenience, we use the (log of the real) euro dollar bilateral real exchange rate, $q_{EU|US}$, $r^{Det}_{US,t}$ is the detrended real interest rate, $v_{EU,t}$ is the country uncertainty premium and $\chi_{EU|US,t}$ is a UIP shock.

The UIP residual may be broken down into latent and deviation components

$$\chi_{EU|US,t} = \hat{\chi}_{EU|US,t} + \bar{\chi}_{EU|US,t}, \tag{52}$$

where the latter is defined as the residual of the UIP equation in latent form

$$\begin{aligned} \bar{\chi}_{EU|US,t} &\equiv \bar{q}_{EU|US,t} - \bar{q}_{EU|US,t+1|t} \\ &+\frac{1}{4}[\left(\bar{r}^{Det}_{EU,t} - \bar{r}^{Det}_{US,t}\right) - \alpha_{12}(\bar{v}_{EU,t} - \bar{v}_{US,t})] \end{aligned} \tag{53}$$

and the former is obtained as a residual. Plugging equations (52) and (53) into equation (51), the UIP condition in deviation form obtains. This result helps estimate the latent real bilateral exchange rates, given the strong trends in the natural interest rates.

The latent bilateral real exchange rate, $\bar{q}_{EU|US}$, follows the stochastic process

$$\bar{q}_{EU|US,t} = \gamma^{\bar{q}_{EU|US}}_{t} + \bar{q}_{EU|US,t-1} + \varepsilon^{\bar{q}_{EU|US}}_{t}, \tag{54}$$

$$\gamma^{\bar{q}_{EU|US}}_{t} = \zeta\gamma^{\bar{q}_{EU|US}}_{t-1} + (1-\zeta)\gamma^{\bar{q}^{SS}_{EU|US}} + \varepsilon^{\gamma^{\bar{q}_{EU|US}}}_{t}, \tag{55}$$

In China, with capital controls, the exchange rate is given by

$$q_{CN|US,t} = \bar{q}_{CN|US,t} + \hat{\chi}_{CN|US,t}, \tag{56}$$

thus, the exchange rate follows a long term component $\bar{q}_{CN|US,t}$ and a short term component $\hat{\chi}_{CN|US,t}$. The long term component is given by equations (54) and (55). The short term component is exogenous and attributed to tacit or explicit exchange rate policy.

Another modelling strategy for the Chinese exchange rate is to model the nominal exchange rate explicitly. Although the complication would make the model more realistic, the simpler set up proposed in equation (56) captures the behavior of the real exchange rate well because

[18] Note that unlike other equations in the model, the variables at the left hand side of equation (51) are not in deviation form. Hence, the UIP residual $\chi^{j|US}_{t}$ involves both deviation and latent components.

the correlation between the short term component of the real multilateral exchange rates of the United States against China is 89.4. For comparison, the correlation of the short term component of the multilateral real exchange rate of the United States vis a vis the economies in the model that have floating exchange rate is in all cases smaller than 25.5 and in some cases negative.

4 The data

Data are quarterly for the period 1996Q1−2017Q4. Table 3 presents the data sources for each variable and country, as well as the seasonal adjustment and splicing, if any.

Data are for the core economies, non core economies and for the block for the rest of the world. In order to construct the time series for the block of the rest of the world we used a second group of non core economies. The group of economies in the second group consists of economies whose share in world output is larger than one percent an do not include the Latin American non core economies in the model. The six economies in this group are India, Korea, Canada, Indonesia, Turkey and Australia, with a share in world GDP of 14.1 percent and in the model they account for the 39.8 percent of world output not accounted for by the core or non core economies.[19]

First we deal with implicit volatility data. We use the VIX, VDAX, VNKY and VFTSE as the indexes for the United Sates, Europe, Japan and the United Kingdom, respectively, from source Bloomberg Finance L.P.[20] Data for implicit volatility are not available for every country because there are not markets for implied volatility options across the board. However, since available implied volatility data is highly correlated, we approximated unavailable implicit volatility data with the US VIX.

Second, we deal with country uncertainty or historical stock volatility data, built with stock market prices from source Bloomberg Finance L.P. For Europe, historical stock volatility was built on a stock index calculated as a weighted average of Germany, France, Italy, Spain, Hungary and Poland, with weights given by the share in PPP-adjusted GDP. For Colombia, Indonesia and Italy, the overall-economy stock market indexes were spliced with older stock market indexes that would include the largest number of stocks in each country, namely, the stock indexes for Bogota, Jakarta and Milan.

Third, we turn to the credit data. This data is from source BIS and in the particular case

[19] The share in world output of each of the economies in the second group is 6.5, 2.0, 1.6, 1.6, 1.3 and 1.1, respectively. Russia was excluded owing to the episode of high inflation at the begining of the sample.

[20] For Europe we used the VDAX instead of the VSTOXX because the later was available for a larger sample period.

of Peru from source the country central bank.

Fourth we have the residential property prices data from source BIS. These data is generally not available for the entire sample for all economies.[21] The unavailable data was estimated as unobserved in a satellite model including credit, property prices, the country financial cycle, the global financial cycle, and the output gap, equations (16) to (19).[22]

Fifth, we discuss the National Income and Product Accounts (NIPA) data. The macroeconomic variables extracted from the NIPA data were GDP and gross exports and imports in real terms. Absorption was obtained as the residual between output and net exports. All data was quarterly in the source except for Indonesia.[23]

Sixth, we consider the interest rate data. Most data comes from the IMF International Financial Statistics (IFS). Owing to changes in monetary policy regimes, in some cases the central bank policy rate was spliced with data for comparable interest rates (see Table 3).

Seventh, we present the inflation and core inflation data. The core price index is the CPI excluding food and energy, available for a large number of countries from the country statistics departments and central banks (see Table 3). Nonetheless, in China, Russia, Indonesia and India, the core CPI was approximated using the coefficients of a regression of core inflation on CPI inflation in a group of comparable countries, namely, Mexico, Colombia, Chile and Peru. The CPI data is from the same sources as for the core CPI data.

Eighth, we consider the trade data necessary for the calibration of the model. First, the global input output table is from source OECD. The world input output table was also used to compute the share of the trade partners in exports and imports. Second, the shares of exports and imports in output were calculated from the NIPA at current prices, from sources already mentioned for the NIPA.

Ninth, we have the exchange rate data. The source is Bloomberg Finance L.P.

Finally, we turn to the aggregation method. Aggregates for the world, the rest of the world and for Latin America were calculated as PPP-weighted averages. These shares are for the year 2015,[24] from source World Economic Outlook database, October 2016.

[21] The data starts in 2000Q1, 2011Q1, 2005Q1, 2001Q1, 2005Q1 and 2002Q1 in Europe, China, United Kinddom, Brazil, Mexico and Chile, respectively.

[22] Residential property prices for Japan are available on a half-yearly frequency. The unavailable data was obtained by interpolation.

[23] For Indonesia, yearly data was transformed into quarterly frequency with the Boot et al. (1967) method.

[24] On the use of fixed or variable shares in the calculation of GDP aggregates see Gulde and Schulze-Ghattas (1993 p. 109).

5 Computation, calibration and estimation

The computation of the value-chain trade equations required an assumption about the sectoral composition of demand changes. The elasticity of world trade to world demand depends on the sectoral composition of demand shocks. A derivation of value-chain trade equations with shocks that are homogeneous across sectors gives a unit elasticity of world trade to demand shocks. The elasticity of world trade to world demand increases as demand changes are more concentrated in goods rather than services, particularly in manufacturing goods compared to perishable goods (see Bems, Johnson and Yi, 2010: 33). Although the model can incorporate heterogeneous changes across the 36 sectors, for tractability we split the demand changes into those for manufacturing and nonmanufacturing. We worked with the assumption that demand changes for manufacturing were a tenth of shocks to manufacturing. With this assumption the elasticity of world trade to world output is 2.1.

Turning to the remaining model coefficients, some were calibrated and other obtained by Bayesian maximum likelihood estimation. Values for the calibrated parameters as well as priors for the estimated parameters were set so as to obtain reasonable impulse responses and historical error decompositions.

The parameters that were estimated were those deemed most relevant for the global channels in the model. Table 5 reports the results of the estimation. The obtained posterior estimates were different from the prior means, reflecting the contribution of the data to the estimated parameters.[25]

Stochastic processes for the unobserved latent values were estimated jointly with the estimated coefficients, the usual practice with the multivariate Kalman filter. However, as the calibration of the 375 variances in the model was time intensive, some latent variables were imported from three satellite models. First, a satellite model for the country financial cycle as well as for the cycle in credit and property cycles helped in the estimation of the latent country financial cycle, latent credit and latent property prices.

Second, a series of satellite two-country models helped in the estimation of the natural real interest rate and inflation expectations. These models are presented in Gómez (2019) for the Latin American economies and similar two-country models were used to estimate the natural interest rate in the core economies and for the block for the remaining countries.

Third, we also set up a satellite model for the estimation of the cycle in output, absorption, exports and imports. This model consisted of local-linear-trend filters for each one of these

[25] The prior standard deviations were schrunk in each estimation run until convergence of the regularized likelihood to the maximum was achieved. The estimation process took about five estimation runs. For more detail on the estimation process see Gómez and Julio (2016).

variables. A pair of constraints per country helped impose consistency in the aggregation of the gaps and the latent or potential growth rates of these macroeconomic aggregates within each country. Other two constraints helped ensure that the world output gap was equal to the world absorption gap and that the gap of world exports was equal to the gap of world imports. The constraints helped estimate reasonable gaps for most macroeconomic aggregates. In addition, to enhance the estimation of the latent processes, absorption was intervened with a priori tunes.[26]

The remaining latent variables, namely, latent global uncertainty, latent global risk aversion, the latent global financial cycle, latent country uncertainty, latent country risk aversion and latent exchange rates were estimated jointly with the transmission mechanisms in the GSSM model.

The error terms in equations (22), (23), (24), (36), (46), and in the deviation part of equation (52) were assumed to be autocorrelated so as to improve the fit of the model and its forecasting performance. The correlation coefficient was set at 0.5 to maintain reasonable impulse responses and historical decompositions.

6 Results

The global-reach of the global uncertainty and global risk aversion channels. The global uncertainty channel is the transmission mechanism from global uncertainty shocks to country uncertainty, aggregate demand and inflation. Global uncertainty shocks are transmitted to country uncertainty across both advanced and emerging economies (Figures 2 and Figure 7, Panel A).[27] The increase in country uncertainty involves expenditure-reducing and expenditure-switching effects. The expenditure-reducing effect is the drop in absorption (of domestically produced and imported goods) as a result of higher country uncertainty (Figure 7, Panel B and Table 7). The expenditure-switching effect is the rise in net exports as a result of exchange rate depreciation. These expenditure reducing and switching effects enable the model to reproduce sudden stops with output drops in a relatively simple set up.[28] [29] Two features of the model that are key in obtaining sudden stops with output drops are; first, the expenditure-reducing effect of country uncertainty and country risk aversion on the aggregate demand in equation (22); and second, the expenditure-switching effect of country uncertainty and country risk aversion on net

[26] Finally, for better results in the fit of the policy rule, the implicit inflation target was estimated outside the model with the Hodrick-Prescott filter.

[27] In the graphs, shocks are of 1-standard deviation. Exports, imports and the trade balance are in percent of GDP.

[28] Chari, Kehoe and McGrattan (2005) argue that standard equilibrium theory reproduce sudden stops with output increases, not with output drops.

[29] In the model, net capital flows are approximated by the inverse of the trade balance.

exports via exchange rate depreciation, equations (23), (24) and (51). [30] [31]

The result of the estimated unobserved global uncertainty, presented in Figure 1, is that it has high correlation with global implicit volatility. A regression of global implicit volatility on global uncertainty (in deviation form) yields a unit coefficient and a coefficient of determination $R^2 = 0.74$.[32] Because global risk aversion is the difference between global implicit volatility and global uncertainty, the residual of the regression is global risk aversion (also in Figure 1).[33]

Turning to the global risk aversion channel, it is similar to the global uncertainty channel. It is the transmission from global risk aversion to country risk aversion, and thereby to aggregate demand and inflation (Figure 3. Also note that Figure 7 is similar for a shock to global risk aversion). Shocks to global risk aversion involve expenditure reducing and switching effects like those of the global uncertainty channel.

Bekaert et al. (2013) showed that the picks and troughs in uncertainty and risk aversion highlight important financial events. He illustrated these indicators using uncertainty and risk aversion in the United States. Figure 1 shows that also using uncertainty and risk aversion at the global level, the peaks and troughs highlight these salient financial events.

The transmission of global uncertainty and global risk aversion shocks across economies is pervasive. These shocks are not only transmitted across economies but they also explain most of the variability in country uncertainty and country risk aversion (Figures 16 to 18).

One of the results of the paper is that global uncertainty and global risk aversion shocks are the main volatility factors explaining the output gap in core as well as non core economies (Table 7 and Figure 21[34]). These shocks explain most of the variability in the output gap, including the expansion during the great moderation and the contraction that ensued. In the Latin American economies, they also help explain both the run up to the end-of-the-century crisis and its aftermath. In contrast, other shocks, such as to policy interest rates and to the global financial cycle, explain some–albeit only a small–part of the variability of the output gap (Figure 21).

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[30] The output drop can be emphasized if the monetary authority raises interest rates to stabilize the exchange rate, owing to either the financial channel of the exchange rate (exchange rate, wealth of agents with foreign currency exposures, output gap and inflation) or the passtrough of the exchange rate to inflation. With a tamed depreciation, the external adjustment or transfer problem is more difficult.

[31] The model can also reproduce sudden stops with output drops in a single given economy by means of a shock to country uncertainty, holding global uncertainty unchanged.

[32] In addition, for the period 1996Q1−2016Q2, the correlation of global uncertainty with the observed measures of implicit volatility, the VIX, VDAX, VXJ and VUK is 88.3, 77.3, 87.2 and 84.4, respectively.

[33] The results for the estimated unobserved risk aversion are similar to those presented in Miranda-Agrripino and Rey (2019: p. 8).

[34] In Figure 21, the sum of global uncertainty and global risk aversion shocks is labelled “implicit volatility shocks.”

Although global uncertainty and global risk aversion shocks have important effects on output gaps, their influence on the country financial cycle is strikingly small (Table 13 and Figure 20). The country financial cycle is explained, in the advanced, transatlantic economies, mostly by financial cycle shocks at the global level (Figure 20) and in the emerging economies by financial cycle shocks at the country level (Figure 20).

It is interesting to consider the relationship between the shocks and transmission channels in the model with capital flows. We have made a loose, although macroeconomic, approximation of net capital flows with the trade balance. The trade balance gap is explained mainly by global uncertainty and global risk aversion shocks (Table 14). The result in Table 14 that global uncertainty and risk aversion shocks are important drivers of the trade balance is in line with the finding that the VIX acts as an important push factor of capital flows (see for instance Forbes and Warnok, 2012).

Some of the findings in Bekaert et al. (2013) deal with the relationship between uncertainty, risk aversion and real interest rates. They find, on one hand, a negative effect of uncertainty and risk aversion shocks on real US interest rates; and, on the other hand, a positive effect of real US interest rate shocks on uncertainty and risk aversion. In contrast with the results of their empirical model, using our semi-structural set up we find a negative effect of global uncertainty and global risk aversion shocks on real world interest rates. The reason is that monetary policy responds to the effect of global uncertainty and global risk aversion shocks on aggregate demand (Figure 7). We could not replicate a negative effect of real interest rates on uncertainty and risk aversion, perhaps due to the simple set up we choose for equations (6) and (8), where global uncertainty and global risk aversion are taken in the model as exogenous, explained only by the own shocks, plus some persistence. This is also shown in Figures 14 and 15, where only global uncertainty and global risk aversion shocks explain (the gaps in) global uncertainty and risk aversion.

The narrower effect of the global financial cycle channel. With our definitions, the global financial cycle is the common factor in the country financial cycle (Figure 4) while the country financial cycle is the common factor in credit and residential property prices (Figure 6).

The global financial cycle channel is the transmission from global financial cycle shocks to the country financial cycle, credit, residential property prices, aggregate demand and inflation (Figure 8, Panels A to C).

The pervasive effect of the global uncertainty and global risk aversion channels contrasts with the narrower effect of the global financial cycle channel. Global financial cycle shocks are transmitted to the country financial cycle of the advanced, transatlantic economies (Figure 5);

nonetheless, these shocks are not transmitted to the country financial cycle of the emerging economies (Figures 5 and 20).

Although global financial cycle shocks do not reach the country financial cycle of the emerging economies, they do appear to lead to a mild export of capital from the emerging to the advanced economies. The transmission involves both expenditure-reducing and expenditure-switching effects. The bulk of the explanation relies on the fact that in advanced economies the shock has an expenditure enhancing effect on imports while in emerging economies the trade channel leads to an increase in output. Consequently, in the emerging economies interest rates rise, causing an expenditure reducing effect on imports (Figure 8, Panel D). Net exports rise; or in other words, the emerging economies export capital to the advanced world. The effect on the trade balance is, nonetheless, small, because the estimated effect of the global financial cycle on absorption in the advanced economies is small.

The global financial cycle is explained mostly by global financial cycle shocks (Table 10, Figure 19). Global uncertainty shocks explain a smaller share of forecast error variance of the global financial cycle, but larger than the share explained by US monetary policy shocks (Table 10). European monetary policy shocks also play a role, at about half the forecast error variance explained by US monetary policy shocks (Table 10).

As regards to the country financial cycle (Table 13, Figure 20), it is explained in the advanced economies mostly by global financial cycle shocks and in the emerging economies by country financial cycle shocks. Interest rate shocks explain smaller portions of the country financial cycle, particularly in Latin America (Figure 20, Table 13).

In light of these results, given the set up of the model in this paper, not only US monetary policy plays a role in explaining the global financial cycle, European monetary policy shocks also do. But besides the own shocks, it is the shocks to global uncertainty that are important in explaining the global financial cycle. The evidence in support of an effect of monetary policy on the global financial cycle does not seem to be special compared with the effect of global uncertainty shocks, nor the influence appear special of the monetary of the United States (Table 10).

As we have set up the model, interest rate shocks from the United States and Europe do not affect the output gap *via* the financial cycle. The reason is that the financial cycle affects absorption after controlling for interest rates; or in other words, it is the error term of the country financial cycle in equation (14) that enters the absorption equation, not the country financial cycle itself. From the point of view of the transmission mechanisms of monetary policy, interest rates affect aggregate demand directly through the absorption equation, not indirectly *via* the global or country financial cycles.

The trade channel. In a narrow sense, the trade channel is the transmission from exports and imports shocks to the output gap and inflation. In a broader sense, the trade channel is a segment of other channels that affect trade but begin upstream in shocks that involve the global uncertainty, risk aversion and foreign interest rate channels (see for instance the response of trade in Figures 7 and 10). For instance, a trade war could be incorporated in the model as a shock to the export and import equations; the narrow sense of the trade channel. Nonetheless, a trade war can also activate the global uncertainty and risk aversion channels, with effects on aggregate demand in all economies, exchange rates and trade; this is the broader sense of the trade channel.

Movements in absorption and exchange rates affect gross exports and imports according to the absorption and trade elasticities of the value-chain trade equations (Tables 4 and 5). The upper panel of Table 4 shows the elasticity of gross exports to absorption shocks. Along the first row, the coefficients indicate the effect of a unit shock to absorption in the United States, Europe, Japan, etc, on the exports of the United States. A shock to absorption in each of the economies has unit size, on average, but is heterogeneous across sectors. Although we deal with 36 sectors,[35] for simplicity we have made the size of the shock to the non manufacturing sectors equal to a tenth of the shock to the manufacturing sectors. The shocks are weighted by the share of the non manufacturing and manufacturing sectors in final aggregate demand in each country. Using the value-chain trade equations in Tables 4 and 5, with homogeneous shocks the elasticity of world trade to world aggregate demand is close to one. In contrast, with shocks that are heterogeneous across the non manufacturing and manufacturing sectors, the elasticity raises to 2.1.[36]

According to the elasticities presented in Table 4, absorption shocks in the larger, core economies (the United States, Europe, China and the rest of the world) have important effects on exports in all economies. The off-diagonal elements in Table 4 belong to the conventional-type of export equations; in contrast, the diagonal, own effect on exports explained above belongs to the value-chain export equations.

The lower panel of Table 4 presents the absorption elasticities of the import equations. Along the first row, each coefficient represents the effect of a unit shock to absorption in the United States, Europe, Japan, etc., on the imports of the United States. Along the diagonal, the own elasticity is characteristic of the standard or conventional import equations. In the value-chain equations, in contrast, the elasticities are larger than one, particularly as the shocks lean more heavily to the manufacturing sector, with stronger trade interconnections. The off-diagonal

[35] These are the sectors in the data from source OECD.

[36] A matlab code to reproduce this result is available.

elements represent the foreign effect on imports, explained previously.

Table 5 shows the exchange rate elasticities or the response of exports and imports to a unit shock to the bilateral real exchange rates.[37] Along the first row of the upper panel, the coefficients indicate the effect of the bilateral real exchange rate of the United States *vis a vis* Europe, Japan, etc on the exports (and imports in the lower panel) of the United States. The exchange rates *vis a vis* the larger core economies play the most important role in the substitution effects across economies.

Are financial channels or trade channels more relevant explaining business cycle synchronization across economies? In the context of the model, the question may be posed as: are global-financial or foreign-trade–related shocks more relevant in explaining business cycle synchronization?

The transmission of financial shocks such as global uncertainty and risk aversion shocks to output gaps is in part financial- and in part trade-related. The financial part refers to the effect on output gaps of the global uncertainty and risk aversion channels; the transmission is from global uncertainty and risk aversion shocks to country uncertainty and risk aversion, absorption gaps and output gaps. The trade-related part is the effect of foreign absorption on trade and thereby on output gaps; the transmission is from foreign absorption to exports and output gaps. Importantly, foreign absorption also reacts to global uncertainty and risk aversion shocks; in other words, the global uncertainty and global risk aversion channels have a foreign absorption *cum* trade stream.

The balance between the financial and trade strands can be gauged with a look at the historical error and forecast error variance decompositions of the export, import and output gaps. The effect of global uncertainty and global risk aversion shocks on exports and imports gaps is large (Figures 23 and 24 and Table 14). In contrast, the effect of absorption and trade shocks on the export and import gaps is small (in Figures 23 and 24 the blue bars are smaller than the orange bars[38]). The effect of implicit volatility shocks on output gaps is also large (Figure 21, Table 11). In contrast, the effect of foreign absorption and trade shocks on output gaps is small (in Figure 21 the orange bars are more relevant than the white bars[39]).

The result is that the synchronization of trade and output gaps is largely due to the effect of global uncertainty and risk aversion shocks. Shocks to foreign absorption and to the foreign trade

[37] Here the elasticities have been rescaled to add up to one across economies. In addition, the elasticities take into account an estimated elasticity of substitution between local and foreign goods of 0.25 (Table 6).

[38] In Figures 23 and 24 absorption shocks include shocks to absorption in all economies. In Table 14 foreign absorption shocks are included in the group of other shocks in the spillover section.

[39] In Figure 21 the white bars include shocks to foreign absorption and the foreign trade equations. In Table 11 the group of other shocks in the spillover section includes shocks to foreign absorption and trade.

equations do not explain relevant portions of the historical or forecast error decompositions, even accounting for global-value chains.

The foreign interest rate channel. The foreign interest rate channel is the transmission mechanism from interest rate shocks in core economies, with effects on local aggregate demand and exchange rates, and also with spillovers on foreign economies, i.e. on trade, exchange rates, aggregate demand and inflation. The feature of the spillover that stands out is its size. At the outset, the response of the multilateral real exchange rate of, say, Colombia, is one order of magnitude smaller than the shock to US interest rate (Figure 10, Table 8). Thereafter, the response of the output gap and inflation in Colombia is about two orders of magnitude smaller than the shock to the US interest rate (Figure 10). The result is that spillovers from interest rate shocks in the United States or any core economy, for the matter, are negligible.

In response to a one-standard-deviation shock to the policy interest rate in the United States, that is, a 0.98 percentage-point shock, the real multilateral exchange rate of Colombia depreciates by 0.125 percent because the interest rate enters the UIP condition (51) in quarterly terms (0.25×0.98) and because the change in the multilateral exchange rate of Colombia against the United States is about one third (36.87 in Table 2 and 32.5 in Table 5). Since the interest rate shock is meant to last one quarter, starting the second quarter the second phase of the shock takes place, including a quick drop in the interest rate of the United States. By means of the expenditure-reducing and expenditure-switching effects, the main effect in Colombia is a quantitatively unimportant drop in exports. Along with the drop in exports, in Colombia the trade balance gap and the output gap both follow.

More generally, a look at the effect of interest rate shocks from different sources (Table 8) reveals that the response of output and inflation to an interest rate shock abroad is one order of magnitude smaller than the response to a shock at home. Spillovers are larger for shocks originated in the core economies as well as in the block for the rest of the world.[40] The heterogeneity in the response to shocks to foreign interest rates depends on the relative strength of the expenditure-reducing and expenditure-substitution effects, computed in the value-chain trade equations (Tables 4 and 5).

As said above, our measure of spillovers is the fraction of the forecast error variance explained by a given shock. By this measure, spillovers from foreign interest rates are not relevant, particularly when compared with the effect of shocks to global uncertainty and global risk aversion. Nonetheless, as special cases, interest rate spillovers from the United States appear

[40] Although spillovers from interest rates in the block for the rest of the world appear large, they do not correspond to the monetary policy of a real economy. They are merely the residual of the policy rule of a synthetic economy, a weighted average of the economies in that group.

important for Mexico and to a lesser extent for China (Tables 11 to 14) owing to the relevance of the United States in the trade equations of these economies (Tables 4 and 5).

The interest-rate financial channel. According to the dilemma hypothesis (Rey 2018), interest rate shocks in the United States affect a global financial cycle defined as the cycle in stock returns and commodity prices. Furthermore, this global financial cycle have effects across countries that inhibit monetary policy autonomy, particularly in economies without sufficient prudential regulation or eventually without capital controls.

In contrast, with the dilemma hypothesis, given the set up of the model in this paper, the interest-rate financial channel cannot undermine monetary policy autonomy abroad. Monetary autonomy is represented in the model by a Taylor rule that defines an autonomous path of the interest rate in a way that is independent of the state of the global financial channel.

Furthermore, as discussed above, the country financial cycle does not affect the output gap or inflation; only the surprise or error term in equation (14) does. Hence, the effect of interest rate shocks on aggregate demand abroad through the global financial cycle is, by the construction of the model, zero.

Spillovers from interest rate shocks are not transmitted to the output gap and inflation through the interest-rate financial channel but through the expenditure-reducing and expenditure-switching effects of the foreign interest rate channel explained above.

The effect of a shock to the policy interest rate in the United States on the global and country financial cycles, real interest rates and inflation is shown in Figure 11. The effect is transmitted to the country financial cycle in the advanced, transatlantic economies. The effect of the shock on the output gap and inflation in the emerging economies is the result of the foreign interest rate channel not of the interest-rate financial channel.

Figures 12 and 13 show the effect of a one standard deviation shock to the policy interest rates of Europe and the United Kingdom. Policy interest rate shocks in these economies affect the global financial cycle although the effect of shocks from the United States is found to be larger. The effect is also confirmed by looking at the forecast error variance decomposition (Table 10).

Turning to the trade balance, Table 14 shows that global uncertainty shocks are more relevant as a volatility factor than US interest rate spillovers. Although interest rate spillovers from the United States gain relevance, they do not reach, in general, the relevance of global uncertainty shocks.

A contrast between global uncertainty shocks and US interest rate spillovers. Global uncertainty shocks are the most important factor explaining the variability of the output gap and core inflation (Tables 11 and 12). In contrast, interest-rate spillovers explain smaller fractions of forecast error variance (Tables 11 and 12). Among the sources of interest rate spillovers, those from the United States are larger, particularly in the cases of China and Mexico, but even in these cases the forecast error variance explained by interest rate spillovers from the United States is only a tenth of that explained by global uncertainty shocks (Tables 11 and 12).

US monetary policy is not completely irrelevant, nonetheless. A look at the country financial cycle of the advanced economies reveals that the importance of US interest rate shocks is comparable to that of global uncertainty shocks (Table 13). Nonetheless, according to the set up in the model, the country financial cycle in the advanced economies does not affect the output gap or core inflation, only country financial cycle shocks do.

The channels that are important at explaining the output gap and core inflation are the global uncertainty and global risk aversion channels. The transmission channels that are less important are the foreign interest rate and trade channels. Global uncertainty and global risk aversion shocks were the main volatility factors explaining the impulse responses, historical decompositions and forecast error variance decompositions of the output gap and core inflation. US interest rate spillovers, in contrast, were not the most relevant volatility factor explaining the output gap and core inflation in foreign economies.

7 Conclusions

The literature has emphasized the effect of interest rate spillovers from the United States on a particular definition of the global financial cycle. We do find important interest rate spillovers from the United States on the global and advanced-economy financial cycles, defined here as the cycle in credit and residential property prices. However, we do not find important interest rate spillovers from the United States on the country financial cycle of the emerging economies. Furthermore, the relevance of interest rate spillovers from the United Sates on global or country financial cycles, do not reach beyond the financial cycle itself; that is, these shocks are not transmitted to aggregate demand and inflation. With the set up of the model in this paper, interest rates affect aggregate demand because interest rates belong to the aggregate demand equation, not because the financial cycle enters this equation, only the shock to the financial cycle does.

As framework, we used a Global Semi-Structural Model (GSSM) augmented with common factors for country uncertainty, country risk aversion, the country financial cycle as well as value-chain trade equations.

In the policy implications, it appears that global uncertainty, risk aversion and implicit volatility are critical variables for the monetary authorities to follow. In contrast, foreign (US) interest rates do not seem as critical, in contrast with the dilemma hypothesis about an effect of US interest rates on a global financial cycle that undermines monetary policy autonomy elsewhere (Rey 2018).

Regarding the relevance of the global uncertainty and risk aversion channels, and to the extent that current policy analysis in policy institutions is informed by model forecasts and scenarios, failure to include global financial transmission channels in policy models can bias the analysis and can give undue emphasis to variables with otherwise smaller influence, particularly US interest rates and trade.

The paper has a number of limitations. For instance, global uncertainty and risk aversion are measured using stock market and implicit-volatility derivatives data. However, risk measures would ideally combine data from different financial markets, including bonds and credit derivatives. In the same vein, country uncertainty and risk aversion were incorporated in the model as autoregressive and independent processes. This set up reflects, plainly, our lack of knowledge about how to incorporate uncertainty and risk aversion into a structural set up.

Another limitation of the paper is that the UIP equation was enhanced with a country risk differential; however, future work may improve this set up dealing separately with the effects that global and country uncertainty and risk aversion may have on the exchange rate of each of the economies.

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Appendix 1: Derivation of the value-chain trade equations

Gross output in terms of final demand. In a world with N countries and S sectors, the world input output system can be written as

$$\mathbf{Y} = \mathbf{Z}\boldsymbol{\iota} + \mathbf{F}\boldsymbol{\iota}, \tag{57}$$

where $\mathbf{Y}$ is an $NS \times 1$ vector of gross output, $\mathbf{Z}$ is an $NS \times NS$ matrix of intermediate inputs, $\mathbf{F}$ is an $NS \times NS$ matrix of final demand and $\boldsymbol{\iota}$ is a $NS \times 1$ (or conformable) vector of ones.[41]

The model in the text runs with $N = 11$ and $S = 36$; however, for expositional convenience, consider a 2-country, 2-sector example. The matrices in the world input output system (57) are

$$\mathbf{Y}= \begin{bmatrix} \begin{bmatrix} Y_{US}(1) \\ Y_{US}(2) \end{bmatrix} \\ \begin{bmatrix} Y_{RC}(1) \\ Y_{RC}(2) \end{bmatrix} \end{bmatrix},$$

$$\mathbf{Z} = \begin{bmatrix} \begin{bmatrix} Z_{US,US}(1,1) & Z_{US,US}(1,2) \\ Z_{US,US}(2,1) & Z_{US,US}(2,2) \end{bmatrix} & \begin{bmatrix} Z_{US,RC}(1,1) & Z_{US,RC}(1,2) \\ Z_{US,RC}(2,1) & Z_{US,RC}(2,2) \end{bmatrix} \\ \begin{bmatrix} Z_{RC,US}(1,1) & Z_{RC,US}(1,2) \\ Z_{RC,US}(2,1) & Z_{RC,US}(2,2) \end{bmatrix} & \begin{bmatrix} Z_{RC,RC}(1,1) & Z_{RC,RC}(1,2) \\ Z_{RC,RC}(2,1) & Z_{RC,RC}(2,2) \end{bmatrix} \end{bmatrix},$$

$$\mathbf{F}= \begin{bmatrix} \begin{bmatrix} F_{US,US}(1) & 0 \\ 0 & F_{US,US}(2) \end{bmatrix} & \begin{bmatrix} F_{US,RC}(1) & 0 \\ 0 & F_{US,RC}(2) \end{bmatrix} \\ \begin{bmatrix} F_{RC,US}(1) & 0 \\ 0 & F_{RC,US}(2) \end{bmatrix} & \begin{bmatrix} F_{RC,RC}(1) & 0 \\ 0 & F_{RC,RC}(2) \end{bmatrix} \end{bmatrix},$$

[41] For a review of different aspects of global value chains see Johmson (2017) and for context about the data involved see Timmer (2012).

where US and RC denote the United States and the remaining countries, and 1 and 2 denote the sectors. In system (57), term $Z_{i,j}(s,t)$ denotes the intermediate goods from sector s, country i , used in the production of the intermediate good produced by sector t of country j. Likewise, $F_{i,j}(s)$ denotes the final good produced in sector s, country i, consumed in country j.

Dividing each row in system (57) by gross output of sector s in country i, $Y_i(s)$, system (57) becomes

$$\boldsymbol{\iota} = \mathbf{A}\boldsymbol{\iota} + \mathbf{D}\boldsymbol{\iota}, \tag{58}$$

where matrices $\mathbf{A}$ and $\mathbf{D}$ are arrangements of the weights of intermediate and final consumption in gross output as follows: $a_{ij}(s,t) \equiv \frac{Z_{ij(s,t)}}{Y_i(s)}$ and $d_{ij}(1) \equiv \frac{F_{ij}(s)}{Y_i(s)}$, respectively.

Using system (58), gross output in deviation form may be written as

$$\hat{\mathbf{Y}} = \tilde{\mathbf{Z}}\boldsymbol{\iota} + \tilde{\mathbf{D}}\boldsymbol{\iota}, \tag{59}$$

where $\hat{\mathbf{Y}}$ is a sector-level, $NS \times 1$ vector of gross output in deviation form, with elements $\hat{Y}_i(s)$ denoting the deviation of gross output in sector s of country i; $\tilde{\mathbf{Z}}$ is an $NS \times NS$ matrix with elements $a_{i,j}(1,1)\hat{Z}_{i,j}(s,t)$; and $\tilde{\mathbf{D}}$ is an $NS \times NS$ matrix with elements $d_{i,j}(s)\hat{F}_{i,j}(s)$.

We now turn to write the elements $\hat{Z}_{i,j}(s,t)$ and $\hat{F}_{i,j}(s)$ in matrices $\tilde{\mathbf{Z}}$ and $\tilde{\mathbf{D}}$ in terms of aggregate demand (absorption) and the real exchange rate. We obtain these elements from optimization.

The optimization of the first column of intermediate goods at the right hand side of equation (59) involves minimizing the budget constraint

$$I = P_{Z_{US}(1)} S_{US|US} Z_{US,US}(1,1) + P_{Z_{US}(2)} S_{US|US} Z_{US,US}(2,1) \tag{60}$$
$$+ P_{Z_{RC}(1)} S_{US|RC} Z_{RC,US}(1,1) + P_{Z_{RC}(2)} S_{US|RC} Z_{RC,US}(2,1),$$

subject to the composite input

$$[Z_{US}(1)]^{\frac{\sigma-1}{\sigma}} = \left[\omega^{z}_{US,US}(1,1)\right]^{\frac{1}{\sigma}} [Z_{US,US}(1,1)]^{\frac{\sigma-1}{\sigma}} + \left[\omega^{z}_{US,US}(2,1)\right]^{\frac{1}{\sigma}} [Z_{US,US}(2,1)]^{\frac{\sigma-1}{\sigma}} \tag{61}$$
$$+ \left[\omega^{z}_{RC,US}(1,1)\right]^{\frac{1}{\sigma}} [Z_{RC,US}(1,1)]^{\frac{\sigma-1}{\sigma}} + \left[\omega^{z}_{RC,US}(2,1)\right]^{\frac{1}{\sigma}} [Z_{RC,US}(2,1)]^{\frac{\sigma-1}{\sigma}}.$$

In budget constraint (60), prices are deaminated in the currency of the country where the good is produced. In addition, the budget constraint (60) is written in terms of the currency where cost minimization takes place, in the case being explained, in US dollars. Also note that $S_{US|RC}$ is the indirect nominal exchange rate of the rest of the world against the United States, which is the inverse of the direct nominal exchange rate, $S_{RC|US}$, or the number of RC units of currency exchange for one unit of US currency.[42]

[42] Also note that $S_{US|US} \equiv 1$ is made explicit to facilitate the derivations.

The solution for this problem gives demand functions that, in linear form, may be written as

$$\hat{Z}_{US,US}(1,1) = -\sigma\hat{Q}_{US|US} + \hat{Z}_{US}(1), \tag{62}$$

$$\hat{Z}_{US,US}(2,1) = -\sigma\hat{Q}_{US|US} + \hat{Z}_{US}(1), \tag{63}$$

$$\hat{Z}_{RC,US}(1,1) = -\sigma\hat{Q}_{US|RC} + \hat{Z}_{US}(1) \tag{64}$$

and

$$\hat{Z}_{RC,US}(2,1) = -\sigma\hat{Q}_{US|RC} + \hat{Z}_{US}(1). \tag{65}$$

These functions reveal that the demand for intermediate goods from all sources depends on aggregate demand in the destination country and on the real bilateral exchange rate of the destination country vis a vis each of the source countries. For simplicity, the derivation of equations (62) to (65) abstracts from relative goods prices.[43]

Similar optimization problems give demand functions for the remaining intermediate goods.

Turning to the first column of final goods at the right hand side of equation (59), the optimization consists of minimizing budget constraint

$$I = P_{F_{US}(1)}S_{US|US}F_{US,US}(1) + P_{F_{RC}(1)}S_{US|RC}F_{RC,US}(1), \tag{66}$$

subject to the consumption aggregate

$$F_{US}(1) = \left[\left[\omega^f_{US,US}(1)\right]^{\frac{1}{\sigma}}\left[F_{US,US}(1)\right]^{\frac{\sigma-1}{\sigma}} + \left[\omega^f_{RC,US}(1)\right]^{\frac{1}{\sigma}}\left[F_{RC,US}(1)\right]^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{67}$$

where goods prices have been set in the country where the goods are produced and the budget constraint is written in the currency of the country where the optimization takes place; again, in this example, in US dollars.

The solution for this problem gives demand functions

$$\hat{F}_{US,US}(1) = -\sigma\hat{Q}_{US|US} + \hat{F}_{US}(1) \tag{68}$$

and

$$\hat{F}_{RC,US}(1) = -\sigma\hat{Q}_{US|RC} + \hat{F}_{US}(1). \tag{69}$$

In these functions the demand for final goods from each sector and country depends on absorption of the sectoral good in the destination country and on the real bilateral exchange rate vis a vis the source country.[44]

Similar optimization problems give demand functions for the remaining final goods.

[43] The assumption amounts to setting $P_{Z_{US}(1)} = P_{Z_{US}(2)}$, $P_{Z_{RC}(1)} = P_{Z_{RC}(2)}$.

[44] Also in the derivation of the demand for final goods we have ignored the goods relative prices.

Staking the linearized first order conditions for intermediate and final goods, system (59) can be written as

$$\hat{\mathbf{Y}} = \mathbf{A}\hat{\mathbf{Z}} + \mathbf{D}\hat{\mathbf{F}} - \sigma\mathbf{A} \circ \hat{\mathbf{Q}}\boldsymbol{\iota} - \sigma\mathbf{D} \circ \hat{\mathbf{Q}}\boldsymbol{\iota}$$

where

$$\hat{\mathbf{Z}} = \begin{bmatrix} \begin{bmatrix} \hat{Z}_{US}(1) \\ \hat{Z}_{US}(2) \end{bmatrix} \\ \begin{bmatrix} \hat{Z}_{RC}(1) \\ \hat{Z}_{RC}(2) \end{bmatrix} \end{bmatrix}, \quad \hat{\mathbf{F}} = \begin{bmatrix} \begin{bmatrix} \hat{F}_{US}(1) \\ \hat{F}_{US}(2) \end{bmatrix} \\ \begin{bmatrix} \hat{F}_{RC}(1) \\ \hat{F}_{RC}(2) \end{bmatrix} \end{bmatrix},$$

$$\hat{\mathbf{Q}} = \begin{bmatrix} \hat{Q}_{US|US} & \hat{Q}_{RC|US} \\ \hat{Q}_{US|RC} & \hat{Q}_{US|RC} \end{bmatrix} \otimes \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix},$$

the operator $\otimes$ indicates the tensorial product and the operator $\circ$ indicates the element by element product.

Assuming $\hat{\mathbf{Z}} = \hat{\mathbf{Y}}$ and rearranging gives

$$\hat{\mathbf{Y}} = \mathbf{S}^F\hat{\mathbf{F}} - \boldsymbol{\sigma}\mathbf{S}^Q \circ \hat{\mathbf{Q}}\boldsymbol{\iota}, \tag{70}$$

where

$$\mathbf{S}^F = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{D}, \tag{71}$$

$$\mathbf{S}^Q = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{A} + \mathbf{D}) \tag{72}$$

and

$$\hat{\mathbf{Q}} = \tilde{\mathbf{Q}} \otimes \mathbf{J}_S, \tag{73}$$

where $\tilde{\mathbf{Q}} = \begin{bmatrix} \hat{Q}_{US|US} & \hat{Q}_{RC|US} \end{bmatrix}'$ and $\mathbf{J}_S$ is an $S \times S$ matrix of ones.

Gross exports in terms final demand and exchange rates. A similar derivation applies to gross exports. Taking again the case of the United States, gross exports $\mathbf{X}_{US}$ can be written as

$$\mathbf{X}_{US} = \mathbf{Z}^X_{US}\boldsymbol{\iota} + \mathbf{F}^X_{US}\boldsymbol{\iota}, \tag{74}$$

where $\mathbf{X}_{US}$ is a sector-level, $NS \times 1$ vector of gross exports, $\mathbf{Z}^x_{US}$ is an $NS \times NS$ matrix of intermediate inputs, $\mathbf{F}^x_{US}$ is an $NS \times NS$ matrix of final demand and $\boldsymbol{\iota}$ is a conformable vector of ones.

In the 2-sector 2-country example, the matrices in equation (74) are

$$\mathbf{X}_{US} = \begin{bmatrix} \begin{bmatrix} X_{US}(1) \\ X_{US}(2) \end{bmatrix} \\ \begin{bmatrix} 0 \\ 0 \end{bmatrix} \end{bmatrix},$$

$$\mathbf{Z}_{US}^{X} = \begin{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} Z_{US,RC}(1,1) & Z_{US,RC}(1,2) \\ Z_{US,RC}(2,1) & Z_{US,RC}(2,2) \end{bmatrix} \\ \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix},$$

and

$$\mathbf{F}_{US}^{X} = \begin{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} F_{US,RC}(1) & 0 \\ 0 & F_{US,RC}(2) \end{bmatrix} \\ \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix}.$$

Dividing each row in system (74) by $X_{US}(s)$ gives

$$\boldsymbol{\iota}_{US}^{X} = \mathbf{A}_{US}^{X}\boldsymbol{\iota} + \mathbf{D}_{US}^{X}\boldsymbol{\iota}, \tag{75}$$

where matrices $\mathbf{A}_{US}^{X}$ and $\mathbf{D}_{US}^{X}$ are arrangements of the weights of intermediate and final exports in total exports as follows: $a_{i,j}^{X}(s,t) \equiv \frac{z_{ij(s,t)}^{X}}{X_{i(s)}}$ and $d_{ii}^{X}(1) \equiv \frac{F_{ii}^{X}(s)}{X_{i(s)}}$, respectively. These weights add up to 1 horizontally, that is, across exports of intermediate and final goods for every sector s and country i.

Let $\hat{\mathbf{X}}_{US}$ be an $S \times 1$ sector-level vector of gross exports in deviation form. Using the weights obtained in equation (75), the sector-level vector of gross exports in deviation form may be written as

$$\hat{\mathbf{X}}_{US} = \tilde{\mathbf{A}}_{US}^{X}\boldsymbol{\iota} + \tilde{\mathbf{D}}_{US}^{X}\boldsymbol{\iota}, \tag{76}$$

where element a_{US}^{X} of matrix $\tilde{\mathbf{A}}_{US}^{X}$ is given by $a_{US,i}^{X}(s,t)\hat{Z}_{US,i}(s,t)$ and element d_{US}^{X} of matrix $\tilde{\mathbf{D}}_{US}^{X}$ is given by $d_{US,i}^{X}(s)\hat{F}_{US,i}(s)$.

Using the appropriate demand functions, system (76) becomes

$$\hat{\mathbf{X}}_{US} = \mathbf{A}_{US}^{X}\hat{\mathbf{Z}} + \mathbf{D}_{US}^{X}\hat{\mathbf{F}} - \boldsymbol{\sigma}\mathbf{A}_{US}^{X} \circ \hat{\mathbf{Q}}\boldsymbol{\iota} - \sigma\mathbf{D}_{US}^{X} \circ \hat{\mathbf{Q}}\boldsymbol{\iota}. \tag{77}$$

Letting $\hat{\mathbf{Z}} = \hat{\mathbf{Y}}$ and plugging equation (70), system (77) becomes

$$\hat{\mathbf{X}}_{US} = \left(\mathbf{A}_{US}^{X}\mathbf{S}^{F} + \mathbf{D}_{\mathbf{US}}^{\mathbf{X}}\right)\hat{\mathbf{F}} - \boldsymbol{\sigma}\left(\mathbf{A}_{US}^{X}\mathbf{S}^{Q} + \mathbf{A}_{US}^{X} + \mathbf{D}_{US}^{X}\right) \circ \hat{\mathbf{Q}}\boldsymbol{\iota}. \tag{78}$$

Recall that $\hat{\mathbf{X}}_{US}$ is a sector-level vector of exports in deviation form. We now turn to find country exports in deviation form. A vector of weights indicating the weight of each sector in the country exports can be calculated as $\boldsymbol{\omega}_{X_{US}} = \frac{1}{X_{US}}\mathbf{X}_{US}$; where, scalar X_{US} denotes total country exports, obtained as $X_{US} = \boldsymbol{\iota}\mathbf{X}_{US}$. Weights $\boldsymbol{\omega}_{X_{US}}$ up to 1 vertically.

Country exports in deviation form can be obtained as

$$\hat{X}_{US} = \boldsymbol{\omega}_{X_{US}}\hat{\mathbf{X}}_{US}. \tag{79}$$

The value-chain export equation for country US is the response of exports to a shock to the sector-level vector of final demand (absorption), $\hat{\mathbf{F}}$ and to the matrix of bilateral real exchange rates $\hat{\mathbf{Q}}$. The response of country US exports to absorption in each economy gives elasticities $\varepsilon^{c}_{US,j}$ in equation (25). Likewise, the response of exports to the bilateral real exchange rate against each of the economies in the model gives elasticities $\varepsilon^{q}_{US,j}$ in equation (27).

Gross imports in terms of final demands and exchange rates. Likewise, gross imports can be written as

$$\mathbf{M}_{US} = \mathbf{A}^{M}_{US}\boldsymbol{\iota} + \mathbf{D}^{M}_{US}\boldsymbol{\iota}, \tag{80}$$

where, in the 2-sector, 2-country example, the matrices in system (80) are

$$\mathbf{M}_{US} = \begin{bmatrix} \begin{bmatrix} 0 \\ 0 \end{bmatrix} \\ \begin{bmatrix} M_{RC,US}(1) \\ M_{RC,US}(2) \end{bmatrix} \end{bmatrix}, \tag{81}$$

$$\mathbf{A}^{M}_{US} = \begin{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ \begin{bmatrix} Z_{RC,US}(1,1) & Z_{RC,US}(1,2) \\ Z_{RC,US}(2,1) & Z_{RC,US}(2,2) \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix}, \tag{82}$$

and

$$\mathbf{D}^{M}_{US} = \begin{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ \begin{bmatrix} F_{RC,US}(1) & 0 \\ 0 & F_{RC,US}(2) \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix}. \tag{83}$$

Dividing each row in system (80) by $M_{US}(s)$ gives

$$\boldsymbol{\iota}^{M}_{US} = \mathbf{A}^{M}_{US}\boldsymbol{\iota} + \mathbf{D}^{M}_{US}\boldsymbol{\iota}. \tag{84}$$

Let $\hat{\mathbf{M}}_{US}$ be an $S \times 1$ sector-level vector of gross imports in deviation form. Using the weights obtained in equation (84), sector-level vector $\hat{\mathbf{M}}_{US}$ may be written as

$$\hat{\mathbf{M}}_{US} = \tilde{\mathbf{A}}^{M}_{US}\boldsymbol{\iota} + \tilde{\mathbf{D}}^{M}_{US}\boldsymbol{\iota}, \tag{85}$$

where element a^{M}_{US} of matrix $\tilde{\mathbf{A}}^{M}_{US}$ is given by $a^{M}_{i,US}(1,1)\hat{Z}_{i,US}(s,t)$ and element d^{M}_{US} of matrix $\tilde{\mathbf{D}}^{M}_{US}$ is given by $d^{M}_{i,US}(1)\hat{F}_{i,US}(s)$.

Plugging first order conditions (64), (65) and (69), and similar demand functions for the rest of the world, system (85) becomes

$$\hat{\mathbf{M}}_{US} = \mathbf{A}^{M}_{US}\hat{\mathbf{Z}}_{US} + \mathbf{D}^{M}_{US}\hat{\mathbf{F}}_{US} - \sigma\mathbf{A}^{M}_{US} \circ \mathbf{Q}\boldsymbol{\iota} - \sigma\mathbf{D}^{M}_{US} \circ \mathbf{Q}\boldsymbol{\iota}. \tag{86}$$

Letting $\hat{\mathbf{Z}}_{US}= \hat{\mathbf{Y}}_{US}$ and using $\hat{\mathbf{Y}}_{US}= \mathbf{S}^F_{US}\hat{\mathbf{F}} - \boldsymbol{\sigma}\mathbf{S}^Q_{US}\circ\hat{\mathbf{Q}}\boldsymbol{\iota}$ gives an equation for the sector-level vector of imports in deviation form as follows:

$$\hat{\mathbf{M}}_{US}= \mathbf{A}^M_{US}\mathbf{S}^F_{US}\hat{\mathbf{F}}+\mathbf{D}^M_{US}\hat{\mathbf{F}}_{US}-\boldsymbol{\sigma}\left(\mathbf{A}^M_{US}\left[\mathbf{S}^Q_{US}+\mathbf{I}\right]+\mathbf{D}^M_{US}\right)\circ\mathbf{Q}\boldsymbol{\iota}. \tag{87}$$

A vector of weights denoting the share in imports of each sector and country can be obtained as $\boldsymbol{\omega}_{M_{US}} = \frac{1}{M_{US}}\mathbf{M}_{US}$, where total imports can be computed as $M_{US} = \boldsymbol{\iota}\mathbf{M}_{US}$. These weights add up to 1 vertically. Finally, total imports can be obtained as the weighted average of the sector-level vector of imports as follows:

$$\hat{M}_{US} = \boldsymbol{\omega}_{M_{US}}\hat{\mathbf{M}}_{US}. \tag{88}$$

The value-chain import equations give the response of country imports to a shock to the sector-level vector of final demand (absorption), $\hat{\mathbf{F}}$, and to the matrix of bilateral real exchange rates $\hat{\mathbf{Q}}_t$. The response to absorption in each economy gives the elasticities $\xi^c_{i,j}$ in equation (26) while the response to the bilateral real exchange rate against each economy gives elasticities $\xi^q_{i,j}$ in equation (28).

Table 1. Some descriptive statistics

	The United States	Europe	Japan	China	The United Kingdom	The rest of the world[1]	Brazil	Mexico	Colombia	Chile	Peru
Share in world output[1]	17.9	11.1	5.1	17.3	2.6	39.8	2.9	2.0	0.6	0.4	0.4
Financial Integration[3]											
Correlation of country uncertainty with the VIX[2]	94.0	88.0	73.0	41.0	89.0	72.0	67.0	71.0	17.0	63.0	45.0
Correlation of country uncertainty with global uncertainty[2]	87.0	85.0	82.0	38.0	87.0	71.0	87.0	85.0	42.0	76.0	63.0
Loading factor for global financial cycle[4]	1.1	0.3	0	0	0.7	0	0	0	0	0	0
Trade openness[5]											
Exports	12.5	33.7	15.9	27.8	27.9	27.9	12.2	30.4	16.9	37.1	27.3
Imports	16.3	31.6	16.0	23.2	30.2	28.1	12.7	31.8	20.2	32.8	24.3

1. Source: WEO database, October 2016, evaluated at 2015 PPP exchange rates. Share in world output for the rest of the world is for all countries but the 10 countries in the model.
2. Correlations are for the period 1996Q1—2016Q2.
3. The loading factors are taken from the model in the paper.
4. Effect of the global financial cycle on the country financial cycle.
5. Shares in exports and imports for the rest of the world are PPP weighted average of India, Korea, Indonesia, Russia, Canada, Turkey and Australia. Source: World Bank. Average for 2006-2015.

Table 2. Trade shares

	Share in trade of country:										
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
						Share in exports					
Exports of country:											
The United States		16.48	5.46	11.74	4.31	47.59	2.68	9.63	0.99	0.64	0.48
Europe	15.18		2.87	8.49	12.05	56.99	2.08	1.46	0.32	0.36	0.20
Japan	18.67	7.83		22.10	1.88	46.11	0.72	2.06	0.17	0.28	0.17
China	22.25	10.66	7.86		3.01	49.13	1.75	3.63	0.56	0.74	0.41
The United Kingdom	15.73	38.58	2.47	4.63		36.77	1.06	0.42	0.14	0.12	0.07
The rest of the world[1]	21.70	38.27	7.33	23.74	4.83		1.64	1.53	0.31	0.40	0.25
Brazil	15.71	13.19	3.28	19.72	1.60	39.95		2.09	1.04	2.53	0.91
Mexico	71.24	3.93	1.19	3.48	0.50	16.57	1.09		1.00	0.54	0.45
Colombia	36.87	13.32	1.71	10.65	1.30	24.29	3.34	2.76		2.02	3.73
Chile	12.85	9.70	8.00	27.24	0.94	29.97	5.74	2.30	1.11		2.14
Peru	18.77	11.76	3.51	25.15	0.81	29.61	3.42	1.11	2.78	3.07	
						Share in imports					
Imports in country:											
The United States		16.45	5.41	19.33	4.25	41.06	1.41	10.82	0.62	0.36	0.29
Europe	11.98		2.06	8.42	9.48	65.82	1.08	0.54	0.20	0.25	0.16
Japan	14.75	10.51		23.04	2.25	46.81	0.99	0.61	0.10	0.75	0.97
China	12.56	12.31	8.57		1.67	60.05	2.37	0.71	0.24	1.01	0.52
The United Kingdom	11.84	44.92	1.88	8.98		31.42	0.49	0.26	0.08	0.09	0.04
The rest of the world[1]	21.92	35.59	7.70	24.58	5.72		2.07	1.45	0.24	0.48	0.26
Brazil	21.53	22.64	2.10	15.27	2.87	31.22		1.67	0.57	1.60	0.53
Mexico	47.05	9.70	3.65	19.29	0.70	17.68	1.15		0.28	0.39	0.10
Colombia	30.10	13.41	1.91	18.51	1.39	22.49	3.57	5.81		1.18	1.63
Chile	18.11	13.85	2.92	22.87	1.20	27.11	8.10	2.94	1.22		1.68
Peru	21.77	12.13	2.82	20.21	1.15	26.49	4.62	3.85	3.58	3.38	

Source: Author's calculations based on the OECD world input output tables.

Table 3. Data sources

Variable	Source	Country	End of period or average, seasoal djustment and splicing
Stock prices	Bloomberg Financial L.P.	All countries	Average for the quarter, not seasonally adjusted
Exchange rates	Bloomberg Financial L.P.	All countries	End of period, not seasonally adjusted
Share of exports and imports in output	As in the NIPA data and in current prices	All countries	The shares are for the year 2015
Share of trade partners in exports and imports	OECD World input output tables	All countries	The shares are for the year 2015
Credit to the private non-nonfinancial sector	BIS	All countries except for Peru	End of period, seasonally adjusted
	BIS and country central bank	Colombia	End of period, seasonally adjusted
	Country central bank	Peru	End of period, seasonally adjusted
Interest rates	Country central banks	Japan	Call Rate, Uncollateralized Overnight, end of period, not seasonally adjusted
		Mexico	28 days interbank rate, with source Banco de Mexico, spliced in 2008Q1 with the central bank policy rate with source Banco de Mexico. End of period, not seasonally adjusted
		Peru	Interbank rate, with source Reserve Bank of Peru, spliced in 2003Q3, with the central bank policy rate, with source Reserve Bank of Peru. End of period, not seasonally adjusted
	IMF International Financial Statistics	The United States	Central bank policy rate. End of period, not seasonally adjusted
		Europe	One-month money market rate, with source Eurostats, spliced in 1999Q3 with the central bank policy rate, with source IFS. End of period, not seasonally adjusted
		China	Lending rate. End of period, not seasonally adjusted
		United Kingdom	Central bank policy rate. End of period, not seasonally adjusted
		Brazil	Central bank base rate, with source Banco Central do Brazil, spliced in 1999Q3 with the central bank policy rate with source IFS. End of period, not seasonally adjusted
		Colombia	Central bank policy rate. End of period, not seasonally adjusted
		Chile	Central bank policy rate. End of period, not seasonally adjusted
		Canada	Central bank policy rate. End of period, not seasonally adjusted
		Indonesia	Central bank policy rate. End of period, not seasonally adjusted
		Australia	Central bank policy rate. End of period, not seasonally adjusted
		Korea	Interbank rate, with source OECD Statistics, spliced in 1999Q2 with ith the central bank policy rate, with source IFS. End of period, not seasonally adjusted
	OECD Statistics	Russia	Interbank rate. End of period, not seasonally adjusted
		India	Interbank rate. End of period, not seasonally adjusted
		Turkey	Interbank rate. End of period, not seasonally adjusted

Table 3. Data sources (continued)

Variable	Source	Country	End of period or average, seasoal djustment and splicing
NIPA data	Country statistics departments	The United States	Seasonally adjusted in the source
		Japan	Seasonally adjusted in the source
		United Kingdom	Seasonally adjusted in the source
		Brazil	Seasonally adjusted
		Colombia	Seasonally adjusted in the source
		India	Seasonally adjusted
		Korea	Seasonally adjusted in the source
		Canada	Seasonally adjusted in the source
		Turkey	Seasonally adjusted
		Autralia	Seasonally adjusted
	Country central banks	Mexico	Seasonally adjusted in the source
		Chile	Seasonally adjusted in the source
		Peru	Seasonally adjusted
	OECD statistics	Rusia	Put into quarterly frequency with the Boot et al (1967) method
		Indonesia	Put into quarterly frequency with the Boot et al (1967) method
	Eurostats (1)	Europe	Seasonally adjusted in the source
	IMF (direct information)	China	Seasonally adjusted in the source
CPI and core CPI	Country statistics departments	Japan	Seasonally adjusted, end of period
		United Kingdom	Seasonally adjusted, end of period
		Korea	Seasonally adjusted, end of period
		Brazil	Seasonally adjusted, end of period
	Country central banks	Chile	Seasonally adjusted, end of period
		Peru	Seasonally adjusted, end of period
		The United States	FRED, seasonally adjusted in the source, end of period
	Eurostats (1)	Europe	Seasonally adjusted, end of period
	OECD Statistics	Mexico	Seasonally adjusted, end of period
		Australia	Seasonally adjusted, end of period
		Canada	Seasonally adjusted, end of period
		Colombia	Seasonally adjusted, end of period
		Turkey	Seasonally adjusted, end of period
		China	Core inflation was calibrated with coefficients taken from an estimation of core inflation as a function of CPI inflation in Colombia, Chile, Peru and Mexico
		Russia	Core inflation was calibrated with coefficients taken from an estimation of core inflation as a function of CPI inflation in Colombia, Chile, Peru and Mexico
		Indonesia	Core inflation was calibrated with coefficients taken from an estimation of core inflation as a function of CPI inflation in Colombia, Chile, Peru and Mexico
		India	Excluding food and energy, Seasonally adjusted, end of period
Implicit volatility	Bloomberg Financial L.P.	United States	VIX index, SOURCE Chicago Board of Exchange (CBOE) spliced with the VXO index in 2004
		Germany	VDAX index, period average, not seasonally adjusted
		Japan	VXJ index, period average, not seasonally adjusted
		United Kingdom	IVUKX30 index, period average, not seasonally adjusted
Residential property prices	Bank for international Settlements (BIS) dataset on nominal residential property prices	Data was estimated with the model in the text for Europe (1996Q1—1999Q4), China (1996Q1—2010Q4), the United Kingdom (1996Q1—2004Q4), Brazil (1996Q1—2000Q4), Mexico (1996Q1—2004Q4), and Chile (1996Q1—2001Q4).	

1. Data for Europe from Eurostats is for the euro zone including the following countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain.

Table 4. Absorption elasticities

	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
Exports equations											
The United States	0.139	0.238	0.079	0.160	0.093	0.790	0.049	0.130	0.024	0.018	0.010
Europe	0.424	0.058	0.058	0.154	0.256	0.989	0.041	0.029	0.012	0.012	0.006
Japan	0.673	0.189	0.021	0.352	0.061	0.997	0.026	0.044	0.009	0.013	0.007
China	0.678	0.282	0.176	0.048	0.106	1.156	0.057	0.065	0.023	0.028	0.015
The United Kingdom	0.337	0.452	0.041	0.089	0.029	0.592	0.022	0.012	0.005	0.005	0.003
The rest of the world	0.531	0.471	0.115	0.264	0.117	0.173	0.041	0.032	0.012	0.013	0.007
Brazil	0.394	0.160	0.049	0.168	0.039	0.602	0.008	0.042	0.029	0.060	0.026
Mexico	1.991	0.094	0.027	0.070	0.026	0.449	0.036	0.015	0.035	0.019	0.016
Colombia	0.688	0.172	0.035	0.117	0.035	0.480	0.072	0.057	0.006	0.043	0.087
Chile	0.287	0.149	0.104	0.318	0.035	0.537	0.082	0.031	0.023	0.005	0.040
Peru	0.401	0.163	0.062	0.269	0.035	0.538	0.065	0.024	0.058	0.055	0.003
Import equations											
The United States	2.279	0.022	0.007	0.017	0.010	0.089	0.005	0.017	0.003	0.002	0.001
Europe	0.082	1.244	0.010	0.028	0.049	0.186	0.007	0.005	0.002	0.002	0.001
Japan	0.090	0.025	1.502	0.050	0.008	0.143	0.004	0.006	0.001	0.002	0.001
China	0.145	0.062	0.039	1.128	0.022	0.254	0.013	0.016	0.005	0.006	0.003
The United Kingdom	0.069	0.083	0.007	0.018	1.999	0.115	0.004	0.002	0.001	0.001	0.001
The rest of the world	0.094	0.074	0.017	0.048	0.020	1.752	0.007	0.007	0.002	0.002	0.001
Brazil	0.062	0.020	0.006	0.020	0.005	0.084	1.971	0.006	0.005	0.009	0.004
Mexico	0.718	0.027	0.008	0.024	0.009	0.154	0.013	1.384	0.013	0.007	0.006
Colombia	0.054	0.011	0.002	0.007	0.003	0.052	0.010	0.007	2.715	0.006	0.012
Chile	0.048	0.022	0.014	0.044	0.006	0.086	0.015	0.006	0.005	2.669	0.009
Peru	0.047	0.014	0.005	0.019	0.003	0.049	0.007	0.003	0.008	0.008	2.347

Table 5. Exchange rate elasticities

	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
Exports equations											
The United States		0.178	0.054	0.149	0.039	0.460	0.028	0.073	0.009	0.006	0.004
Europe	0.149		0.032	0.117	0.099	0.557	0.024	0.014	0.003	0.003	0.002
Japan	0.163	0.092		0.249	0.021	0.443	0.009	0.017	0.002	0.003	0.002
China	0.225	0.115	0.076		0.029	0.493	0.018	0.029	0.005	0.006	0.004
The United Kingdom	0.143	0.376	0.027	0.066		0.367	0.012	0.005	0.001	0.001	0.001
The rest of the world	0.205	0.317	0.084	0.305	0.046		0.019	0.015	0.003	0.004	0.002
Brazil	0.147	0.131	0.039	0.253	0.017	0.360		0.016	0.008	0.022	0.006
Mexico	0.632	0.057	0.017	0.061	0.008	0.195	0.012		0.009	0.005	0.004
Colombia	0.318	0.135	0.024	0.171	0.013	0.245	0.032	0.023		0.016	0.025
Chile	0.116	0.096	0.082	0.313	0.011	0.299	0.044	0.017	0.007		0.013
Peru	0.150	0.114	0.043	0.304	0.010	0.298	0.031	0.011	0.020	0.018	
Import equations											
The United States		0.156	0.049	0.195	0.042	0.424	0.016	0.103	0.008	0.004	0.003
Europe	0.129		0.022	0.080	0.108	0.634	0.013	0.006	0.003	0.003	0.002
Japan	0.128	0.091		0.199	0.021	0.529	0.012	0.006	0.001	0.010	0.002
China	0.108	0.105	0.076		0.014	0.640	0.027	0.007	0.004	0.013	0.006
The United Kingdom	0.114	0.439	0.020	0.085		0.331	0.006	0.002	0.001	0.001	0.000
The rest of the world	0.212	0.357	0.080	0.246	0.058		0.021	0.014	0.003	0.006	0.003
Brazil	0.206	0.236	0.020	0.134	0.027	0.332		0.015	0.007	0.017	0.006
Mexico	0.486	0.096	0.035	0.182	0.007	0.174	0.011		0.003	0.004	0.001
Colombia	0.325	0.125	0.020	0.168	0.013	0.224	0.037	0.055		0.013	0.020
Chile	0.182	0.132	0.026	0.211	0.011	0.279	0.101	0.028	0.014		0.016
Peru	0.222	0.121	0.029	0.191	0.012	0.273	0.045	0.034	0.038	0.035	

Table 6. Estimated and calibrated parameters

	World	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
η_1												
Calibration	0.55											
τ_1												
Calibration	0.55											
η_g												
Prior		1.00	1.00	1.00	1.00	1.00	1.00	1.30	1.00	1.00	1.00	1.00
Posterior		1.174	1.126	1.110	0.977	1.079	0.905	1.418	1.079	0.809	0.927	1.010
τ_g												
Prior		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.20	1.20
Posterior		0.827	0.887	0.869	0.928	0.871	1.049	1.175	1.104	1.284	1.224	1.276
$\varkappa_r$												
Prior	0.1											
Posterior	0.111											
$\varkappa_v$												
Prior	0.1											
Posterior	0.096											
$\varkappa_y$												
Prior	0.5											
Posterior	0.464											
β_g												
Calibration				0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
Prior		1.40	0.30			0.80						
Posterior		1.122	0.274			0.704						
β_v												
Calibration		0.00	0.00			0.00						
Prior				0.10	0.10		0.10	0.10	0.10	0.10	0.10	0.10
Posterior				0.069	0.100		0.100	0.081	0.124	0.114	0.089	0.0565
β_r												
Calibration		0.00	0.00			0.00						
Prior				0.10	0.05		0.05	0.05	0.05	0.05	0.05	0.05
Posterior				0.104	0.044		0.051	0.057	0.047	0.061	0.048	0.067
β_y												
Calibration		0.00	0.00			0.00						
Prior				0.3	0.3		0.3	0.3	0.3	0.3	0.3	0.3
Posterior				0.261	0.291		0.345	0.394	0.121	0.397	0.125	0.414
ω_μ												
Calibration										1.20	1.10	
Prior		0.40	0.80	0.60	0.70	1.00	1.30	1.20	0.90			1.10
Posterior		0.540	0.825	0.525	0.672	0.678	1.625	0.900	1.500			1.258
ϖ_δ												
Calibration				1.00	1.00		1.00	1.00	1.00	1.00	1.00	
Prior		1.60	1.10			1.60						0.90
Posterior		1.750	0.675			1.089						1.125
σ_1												
Calibration		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
σ_2												
Calibration		0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
σ_r												
Prior		0.10	0.20	0.20	0.07	0.10	0.10	0.15	0.10	0.10	0.15	0.15
Posterior		0.097	0.185	0.196	0.069	0.095	0.103	0.119	0.078	0.087	0.127	0.157
σ_v												
Prior		0.70	0.60	0.60	0.40	0.70	0.60	0.70	0.80	0.70	0.80	0.70
Posterior		0.577	0.464	0.477	0.348	0.627	0.543	0.706	0.976	0.728	0.905	0.721
σ_w												
Prior		0.10	0.20	0.10	0.07	0.10	0.10	0.20	0.10	0.10	0.20	0.10
Posterior		0.129	0.181	0.099	0.045	0.102	0.100	0.211	0.089	0.106	0.169	0.100
σ												
Prior	1.0											
Posterior	0.248											

Table 7. Peak response to global uncertainty, global risk aversion and global financial cycle shocks

	Response in:											
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru	Standard Deviation
						Peak response of output gap						
Shock to												
Global uncertainty	-0.707	-0.795	-0.767	-0.973	-0.618	-0.726	-1.033	-1.144	-0.657	-0.568	-0.646	0.71
Global risk aversion	-0.190	-0.224	-0.211	-0.311	-0.173	-0.200	-0.284	-0.301	-0.185	0.115	-0.200	0.23
Global financial cycle	0.107	0.159	0.023	0.037	0.084	0.049	0.014	0.063	0.028	0.030	0.029	1.18
						Peak response of core inflation						
Shock to												
Global uncertainty	-0.554	-0.657	-0.663	-0.788	-0.557	-0.625	-0.602	-0.736	-0.622	-0.522	-0.544	0.71
Global risk aversion	-0.162	-0.185	-0.184	-0.273	-0.154	-0.161	-0.163	-0.177	-0.118	-0.099	-0.145	0.23
Global financial cycle	0.033	0.047	0.025	-0.023	0.031	0.031	0.021	0.035	0.024	0.022	0.023	1.18

The table reports the response to a one-standard deviation shock. The standard deviation of the shock is 0.71, 0.23 and 1.18 for global uncertainty, global risk aversion and global financial

Table 8. Peak response to policy interest rate shocks

	Response in:											
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru	Standard Deviation
						Peak response of output gap						
Policy interest rate shock in												
The United States	-0.082	-0.012	-0.015	-0.044	-0.013	-0.019	-0.008	-0.049	-0.017	-0.013	-0.015	0.98
Europe	-0.009	-0.150	0.010	-0.020	-0.026	-0.027	0.006	-0.008	-0.009	-0.014	-0.012	0.36
Japan	-0.003	0.003	-0.151	-0.013	-0.003	-0.007	0.002	-0.002	-0.002	-0.008	-0.005	0.94
China	-0.002	-0.003	-0.005	-0.054	-0.002	-0.006	-0.002	-0.002	-0.002	-0.010	-0.007	1.04
The United Kingdom	-0.002	-0.006	-0.001	-0.004	-0.089	-0.004	-0.001	-0.001	-0.001	-0.002	-0.001	0.45
The rest of the world	-0.014	-0.026	-0.021	-0.043	-0.020	-0.099	-0.011	-0.014	-0.012	-0.023	-0.020	1.1
Brazil	-0.001	-0.001	0.001	-0.003	-0.001	-0.002	-0.100	-0.001	-0.002	-0.004	-0.003	3.29
Mexico	-0.002	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	-0.092	-0.001	-0.001	-0.001	2.51
Colombia	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	-0.001	-0.073	-0.001	-0.002	1.24
Chile	0.000	0.000	0.000	-0.001	0.000	0.000	-0.001	-0.001	-0.001	-0.073	-0.002	1.33
Peru	0.000	0.000	0.000	-0.001	0.000	0.000	-0.001	-0.001	-0.003	-0.002	-0.095	1.22
						Peak response of core inflation						
Policy interest rate shock in												
The United States	-0.048	-0.013	-0.014	-0.030	-0.011	-0.013	-0.011	-0.022	-0.013	-0.010	-0.012	0.98
Europe	-0.012	-0.075	-0.013	-0.019	-0.019	-0.018	-0.011	-0.011	-0.011	-0.012	-0.012	0.36
Japan	-0.003	-0.004	-0.070	-0.011	-0.003	-0.005	-0.003	-0.003	-0.003	-0.005	-0.004	0.94
China	-0.002	-0.003	-0.003	-0.038	-0.002	-0.003	-0.002	-0.002	-0.002	-0.005	-0.004	1.04
The United Kingdom	-0.001	-0.003	-0.002	-0.003	-0.048	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	0.45
The rest of the world	-0.010	-0.014	-0.013	-0.032	-0.011	-0.053	-0.009	-0.010	-0.009	-0.012	-0.012	1.1
Brazil	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001	-0.052	-0.001	-0.001	-0.002	-0.002	3.29
Mexico	0.002	-0.001	-0.001	0.001	-0.001	-0.001	-0.001	-0.048	-0.001	-0.001	-0.001	2.51
Colombia	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	-0.043	0.000	0.001	1.24
Chile	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	-0.040	0.001	1.33
Peru	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.045	1.22

The table reports the response to an unit shock. The standard deviation of the shock is 0.98, 0.36, 0.94, 1.04, 0.45, 1.1, 3.29, 2.51, 1.24, 1.33 and 1.22 for each country, respectively.

Table 9. Peak response to absorption shocks

	Response in:											
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru	Standard Deviation
						Peak response of output gap						
Absorption shock in												
The United States	0.646	0.085	0.099	0.114	0.094	0.140	0.053	0.359	0.124	0.105	0.110	0.69
Europe	0.035	0.664	-0.035	0.077	0.112	0.113	0.024	0.035	0.036	0.058	0.050	0.85
Japan	0.011	0.011	0.664	0.046	0.012	0.028	0.007	0.010	0.008	0.033	0.017	1.08
China	0.019	0.027	0.045	0.698	0.023	0.056	0.019	0.017	0.021	0.093	0.066	1.38
The United Kingdom	0.012	0.041	0.009	0.028	0.419	0.027	0.006	0.008	0.007	0.013	0.011	0.91
The rest of the world	0.093	0.164	0.131	0.294	0.136	0.527	0.070	0.098	0.081	0.165	0.136	0.77
Brazil	0.007	0.008	-0.004	0.015	0.007	0.011	0.686	0.008	0.012	0.027	0.017	1.2
Mexico	0.015	0.006	0.007	0.013	0.005	0.009	0.005	0.525	0.010	0.011	0.007	3.16
Colombia	0.003	0.002	0.001	0.006	0.002	0.003	0.003	0.006	0.465	0.006	0.013	1.46
Chile	0.002	0.002	0.002	0.007	0.001	0.003	0.006	0.003	0.006	-0.292	0.011	1.89
Peru	0.001	0.001	0.001	0.004	0.001	0.002	0.003	0.003	0.011	0.010	0.387	1.9
						Peak response of core inflation						
Absorption shock in												
The United States	0.153	0.088	0.096	-0.124	0.078	0.097	0.075	0.170	0.093	0.073	0.082	0.69
Europe	0.044	0.153	0.044	0.062	0.074	0.071	0.041	0.039	0.040	0.044	0.044	0.85
Japan	0.012	0.013	0.128	0.037	0.011	0.017	0.010	0.010	0.009	0.018	0.013	1.08
China	0.015	0.020	0.026	0.273	0.016	0.026	0.015	0.014	0.015	0.039	0.031	1.38
The United Kingdom	0.010	0.019	0.010	0.020	0.074	0.014	0.008	0.009	0.008	0.009	0.009	0.91
The rest of the world	0.063	0.091	0.081	0.198	0.076	0.114	0.058	0.066	0.058	0.081	0.076	0.77
Brazil	0.006	0.007	0.006	0.011	0.006	0.007	0.127	0.007	0.008	0.014	0.011	1.2
Mexico	0.010	0.007	0.007	-0.010	0.005	0.007	0.006	0.089	0.008	0.007	0.007	3.16
Colombia	0.002	0.002	0.001	0.003	0.001	0.002	0.002	0.003	0.078	0.003	0.005	1.46
Chile	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001	-0.064	0.002	1.89
Peru	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.003	0.003	0.066	1.9

The table reports the response to an unit shock. The standard deviation of the shock is 0.69, 0.85, 1.08, 1.38, 0.91, 0.77, 1.2, 3.16, 1.46, 1.89 and 1.9 for each country, respectively.

Table 10. Global uncertainty, global risk aversion and the global financial cycle: forecast error variance decomposition into global shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

	Forecast error variance of		
	Global uncertainty	Global risk aversion	Global financial cycle
Percent of forecast error variance explained by			
Global shocks	100.00	100.00	68.86
Global uncertainty shocks	100.00	0.00	11.61
Global risk aversion shocks	0.00	100.00	0.83
Global financial cycle shocks	0.00	0.00	56.42
Local shocks	0.00	0.00	31.14
Interest rate shocks	0.00	0.00	16.14
From the United States	0.00	0.00	9.30
From Europe	0.00	0.00	6.19
From Japan	0.00	0.00	0.00
From China	0.00	0.00	0.00
From the United Kingdom	0.00	0.00	0.29
From the rest of the world	0.00	0.00	0.35
Other shocks	0.00	0.00	15.00

Table 11. Output gap: forecast error variance decomposition into global shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

	Forecast error variance of output gap in:										
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
Percent of forecast error variance explained by											
Global shocks	55.36	36.75	60.66	61.25	37.75	42.00	62.52	59.24	53.14	34.75	42.18
Global uncertainty shocks	49.17	31.59	55.91	54.91	33.76	38.25	57.82	54.57	48.92	32.12	38.00
Global risk aversion shocks	3.80	2.64	4.50	5.96	2.75	3.09	4.63	3.99	3.88	2.34	3.88
Global financial cycle shocks	2.39	2.53	0.25	0.38	1.25	0.66	0.07	0.68	0.34	0.29	0.30
Local shocks	41.64	59.25	32.74	18.63	53.58	51.40	35.82	32.06	41.88	58.84	52.31
Interest rate shocks	29.82	47.69	13.87	7.26	25.89	28.02	26.93	14.90	23.36	30.44	32.37
Country financial cycle shocks	0.17	0.17	0.09	0.01	0.04	0.05	0.30	0.02	0.06	0.11	0.04
Other shocks	11.65	11.40	18.79	11.35	27.65	23.33	8.59	17.14	18.45	28.29	19.90
Spillovers	2.72	4.04	6.57	20.12	8.67	6.61	1.65	8.53	4.91	6.38	5.50
Inflation and inflation expectations shocks	0.51	1.06	1.66	5.61	1.75	1.38	0.49	1.96	1.22	1.12	1.01
Exchange rate shocks	0.27	0.26	0.29	0.62	0.89	0.37	0.10	0.15	0.20	0.47	0.28
Latent shocks	0.17	0.27	0.46	0.55	0.26	0.03	0.12	0.17	0.17	0.21	0.22
Interest rate shocks	1.64	2.18	3.86	12.71	5.35	4.57	0.87	5.76	3.06	4.20	3.70
Other Shocks	0.12	0.26	0.29	0.64	0.42	0.26	0.07	0.49	0.26	0.39	0.29
	Breakdown of interest rate spillovers										
From the United States		0.45	1.17	5.96	0.68	1.55	0.26	5.03	1.66	0.70	0.94
From Europe	0.51		0.56	1.59	3.01	2.80	0.19	0.23	0.53	0.87	0.80
From Japan	0.01	0.01		0.08	0.01	0.03	0.00	0.00	0.01	0.05	0.02
From China	0.03	0.03	0.12		0.03	0.13	0.02	0.01	0.03	0.38	0.22
From the United Kingdom	0.01	0.08	0.01	0.05		0.05	0.00	0.00	0.01	0.01	0.01
From the rest of the world	1.05	1.62	1.99	4.99	1.61		0.39	0.48	0.76	2.09	1.65
From Brazil	0.01	0.01	0.00	0.02	0.01	0.01		0.00	0.02	0.07	0.03
From Mexico	0.02	0.00	0.00	0.01	0.00	0.00	0.00		0.01	0.01	0.00
From Colombia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.01
From Chile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.01
From Peru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	

Table 12. Core inflation: forecast error variance decomposition into global shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

	Forecast error variance of core inflation in:										
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
Percent of forecast error variance explained by											
Global shocks	30.34	34.73	39.49	21.79	32.11	29.03	31.70	41.04	37.51	32.44	30.78
Global uncertainty shocks	27.25	31.32	36.28	19.20	29.33	26.90	29.26	38.51	36.18	31.10	28.43
Global risk aversion shocks	2.60	2.65	2.98	2.56	2.35	1.83	2.26	2.13	1.11	1.12	2.12
Global financial cycle shocks	0.49	0.76	0.24	0.03	0.43	0.31	0.19	0.41	0.22	0.22	0.22
Local shocks	64.76	57.06	50.99	55.89	59.07	66.14	60.85	49.01	55.72	61.39	62.82
Interest rate shocks	11.88	22.38	3.31	2.77	8.32	9.56	12.89	7.42	6.52	4.51	7.17
Country financial cycle shocks	0.02	0.03	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Other shocks	52.86	34.65	47.68	53.12	50.75	56.57	47.92	41.59	49.20	56.88	55.64
Spillovers	4.88	8.19	9.49	22.31	8.82	4.83	7.43	9.87	6.74	6.15	6.39
Inflation and inflation expectations shocks	1.94	4.41	4.84	16.99	4.24	2.88	4.11	6.16	4.02	2.68	2.85
Exchange rate shocks	0.35	0.31	0.31	0.25	0.58	0.28	0.29	0.17	0.20	0.29	0.23
Latent shocks	1.52	2.16	2.25	1.41	1.58	0.13	1.66	1.24	1.16	1.26	1.41
Interest rate shocks	0.93	1.05	1.81	3.25	2.11	1.40	1.17	1.96	1.15	1.68	1.70
Other shocks	0.15	0.26	0.27	0.41	0.30	0.15	0.21	0.34	0.21	0.24	0.21
	Breakdown of interest rate spillovers										
From the United States		0.48	0.58	1.29	0.39	0.37	0.34	1.23	0.42	0.38	0.47
From Europe	0.60		0.68	0.57	1.29	0.97	0.53	0.42	0.46	0.67	0.66
From Japan	0.01	0.01		0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.01
From China	0.02	0.03	0.05		0.02	0.04	0.02	0.01	0.02	0.11	0.08
From the United Kingdom	0.01	0.02	0.01	0.02		0.01	0.01	0.01	0.01	0.01	0.01
From the rest of the world	0.28	0.50	0.49	1.33	0.39		0.26	0.28	0.23	0.47	0.45
From Brazil	0.00	0.01	0.00	0.01	0.00	0.00		0.00	0.01	0.02	0.01
From Mexico	0.01	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
From Colombia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
From Chile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
From Peru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Table 13. Country financial cycle: forecast error variance decomposition into global shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

	Forecast error variance of country financial cycle in:										
	The United States	Europe	Japan	China	The United Kingdom	The rest of the world	Brazil	Mexico	Colombia	Chile	Peru
Percent of forecast error variance explained by											
Global shocks	67.93	56.33	27.21	5.17	66.63	4.94	6.44	7.09	6.58	2.24	7.02
Global uncertainty shocks	11.45	9.50	24.89	4.54	11.23	4.47	5.92	6.32	5.95	1.80	6.56
Global risk aversion shocks	0.82	0.68	2.13	0.61	0.80	0.33	0.47	0.60	0.55	0.38	0.37
Global financial cycle shocks	55.66	46.16	0.19	0.02	54.59	0.14	0.06	0.18	0.09	0.06	0.09
Local shocks	18.97	27.24	66.59	84.43	3.90	93.37	91.64	90.06	91.32	96.25	90.91
Interest rate shocks	9.17	5.07	9.29	18.41	0.28	24.55	28.99	24.19	34.49	31.68	37.03
Country financial cycle shocks	1.36	18.19	38.85	42.29	3.24	53.95	51.25	59.48	45.40	57.55	40.43
Other shocks	8.44	3.98	18.45	23.73	0.38	14.88	11.40	6.39	11.42	7.02	13.45
Spillovers	13.09	16.42	6.17	10.40	29.46	1.69	1.91	2.81	2.09	1.50	2.07
Inflation and inflation expectations shocks	5.70	7.73	2.82	7.86	13.34	0.88	1.02	1.49	1.17	0.55	0.77
Exchange rate shocks	0.07	0.04	0.23	0.11	0.06	0.11	0.08	0.05	0.07	0.08	0.08
Latent shocks	0.43	0.34	1.46	0.55	0.46	0.04	0.43	0.36	0.36	0.29	0.43
Interest rate shocks	6.76	8.14	1.47	1.68	15.34	0.59	0.33	0.78	0.42	0.52	0.70
Other shocks	0.14	0.16	0.20	0.20	0.26	0.06	0.06	0.13	0.08	0.07	0.08
	Breakdown of interest rate spillovers										
From the United States		7.61	0.46	0.67	9.00	0.13	0.09	0.54	0.14	0.11	0.19
From Europe	6.11		0.49	0.26	5.99	0.43	0.15	0.13	0.16	0.18	0.24
From Japan	0.00	0.00		0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.00
From China	0.00	0.00	0.05		0.00	0.02	0.01	0.00	0.01	0.05	0.04
From the United Kingdom	0.29	0.24	0.01	0.01		0.00	0.00	0.00	0.00	0.00	0.00
From the rest of the world	0.35	0.29	0.46	0.72	0.34		0.08	0.11	0.09	0.16	0.21
From Brazil	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.01
From Mexico	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
From Colombia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
From Chile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
From Peru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

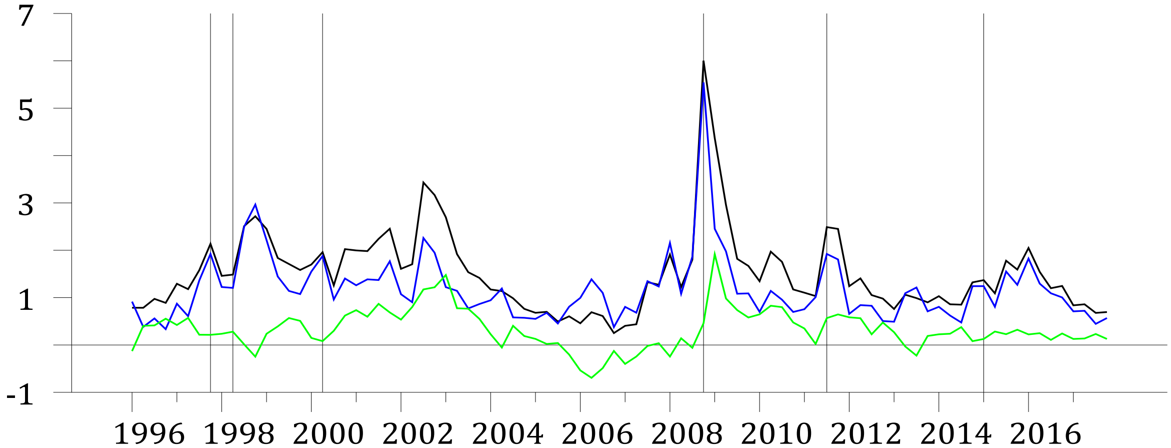
Table 14. The trade balance: forecast error variance decomposition into global shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

	Forecast error variance of trade balance in:										
	The United States	Europe	Japan	China	The United Kingdom	The rest of the World	Brazil	Mexico	Colombia	Chile	Peru
Percent of forecast error variance explained by											
Global shocks	42.80	25.95	35.19	25.92	31.41	3.80	59.77	49.62	34.89	38.99	12.09
Global uncertainty shocks	39.88	22.15	30.24	22.50	29.20	0.42	55.84	39.33	13.69	26.62	7.39
Global risk aversion shocks	0.62	3.10	3.84	3.04	1.66	1.72	3.71	9.10	20.73	12.21	4.35
Global financial cycle shocks	2.30	0.70	1.12	0.38	0.55	1.66	0.22	1.19	0.46	0.16	0.35
Local shocks	50.47	55.99	38.62	20.54	58.78	81.18	35.30	36.92	58.95	57.36	81.29
Interest rate shocks	37.65	38.92	12.67	4.62	36.37	43.14	25.30	14.50	41.54	45.31	66.54
Country financial cycle shocks	0.29	0.19	0.09	0.01	0.20	0.21	0.36	0.09	0.28	0.35	0.12
Other shocks	12.52	16.88	25.85	15.91	22.21	37.83	9.64	22.34	17.13	11.71	14.63
Spillovers	5.93	18.29	26.01	53.54	9.81	15.03	4.91	13.17	6.08	3.63	6.61
Inflation and inflation expectations shocks	0.61	3.15	4.63	34.05	1.38	3.14	1.24	1.60	1.25	0.59	1.03
Exchange rate shocks	0.52	1.05	1.07	0.59	0.81	0.84	0.25	0.15	0.20	0.20	0.27
Latent shocks	1.01	2.89	3.92	1.25	0.89	0.20	0.77	0.50	0.62	0.43	0.91
Interest rate shocks	3.52	9.92	15.14	16.40	6.27	10.20	2.44	10.11	3.68	2.21	4.09
Other shocks	0.28	1.27	1.26	1.25	0.45	0.63	0.21	0.82	0.33	0.20	0.31
	Breakdown of interest rate spillovers										
From the United States		2.49	4.59	6.26	0.89	2.93	0.68	8.91	1.87	0.40	1.12
From Europe	1.19		2.21	1.67	3.53	6.66	0.55	0.33	0.67	0.49	0.91
From Japan	0.02	0.03		0.11	0.01	0.08	0.01	0.00	0.01	0.02	0.02
From China	0.07	0.15	0.65		0.04	0.39	0.06	0.02	0.04	0.25	0.29
From the United Kingdom	0.03	0.37	0.05	0.07		0.11	0.01	0.01	0.01	0.01	0.01
From the rest of the world	2.15	6.84	7.60	8.23	1.80		1.11	0.83	0.99	0.99	1.68
From Brazil	0.02	0.03	0.02	0.03	0.01	0.03		0.01	0.03	0.03	0.03
From Mexico	0.03	0.01	0.02	0.01	0.00	0.01	0.00		0.01	0.00	0.00
From Colombia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.01
From Chile	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01		0.01
From Peru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	

Figure 1. Global implicit volatility, global uncertainty and global risk aversion

Black line: global implicit volatility; blue line: global uncertainty; green line: global risk aversion



The grid indicates, in order, the Asian Crisis, the Latinamerican crisis, the burst of the dotcom bubble, Lehman brankruptcy, the European crisis and the drop in commodity prices due to the drop in output growth in China.

Figure 2. Global uncertainty and country uncertainty

Black line: global uncertainty; blue line: country uncertainty

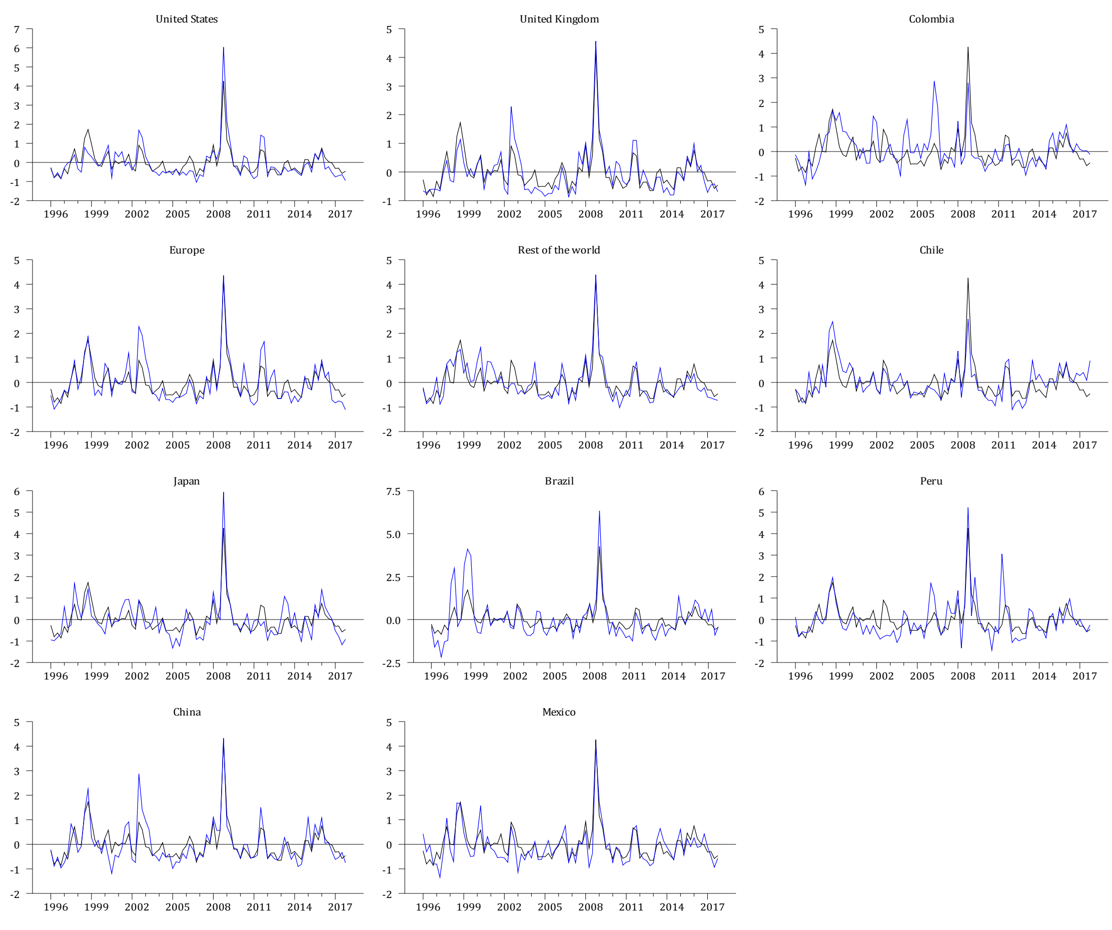


Figure 3. Global risk aversion and country risk aversion

Black line: global risk aversion; blue line: country risk aversion

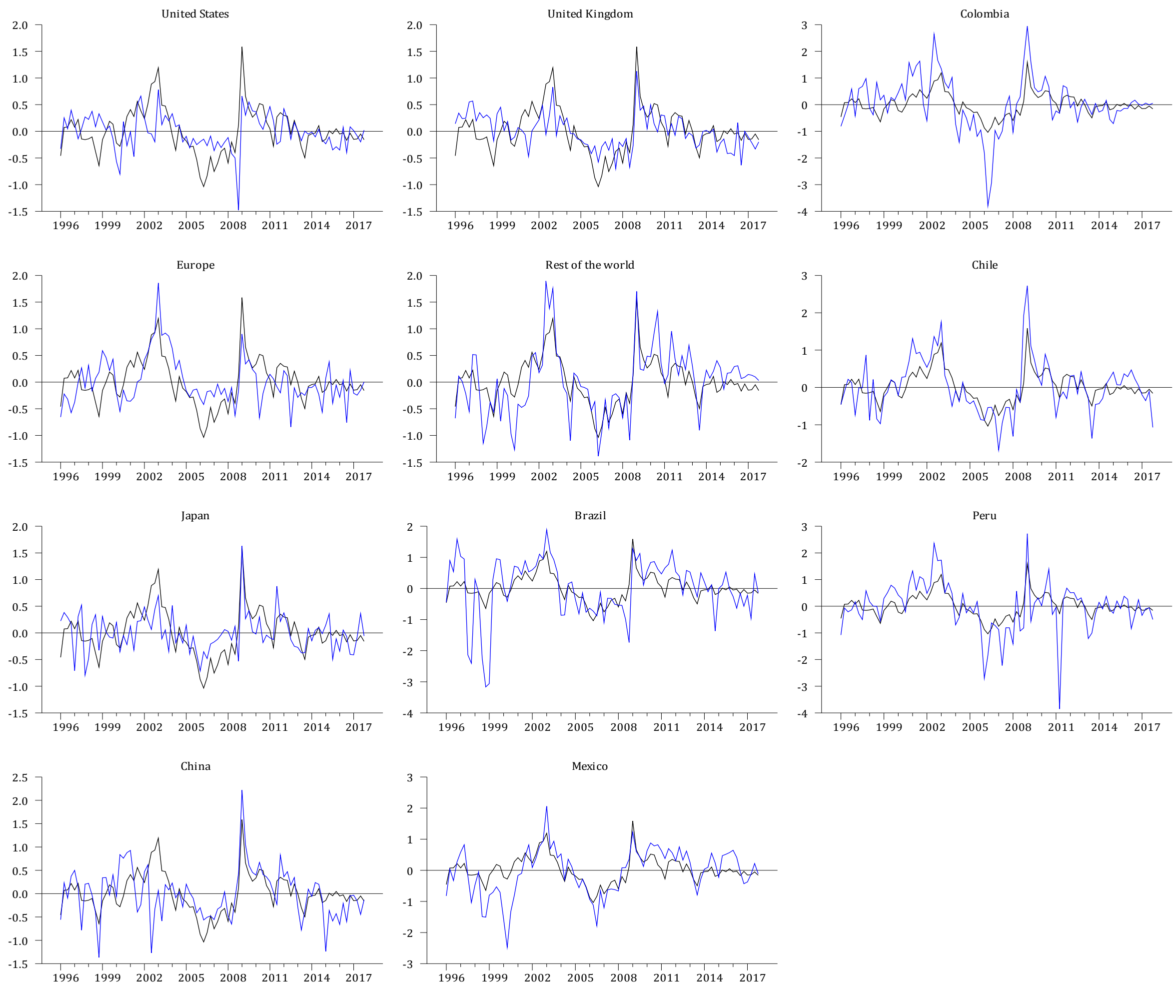


Figure 4. Global financial cycle and advanced economies financial cycle

Black line: global financial cycle; blue line: country financial cycle

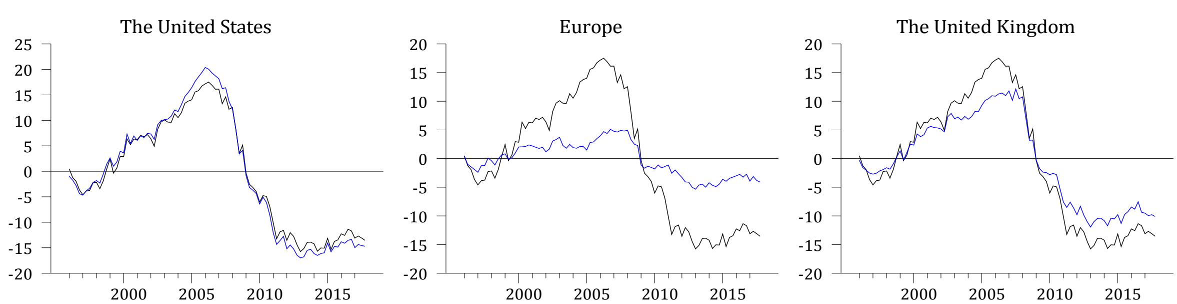


Figure 5. Global financial cycle and country financial cycle

Black line: global financial cycle; blue line: country financial cycl

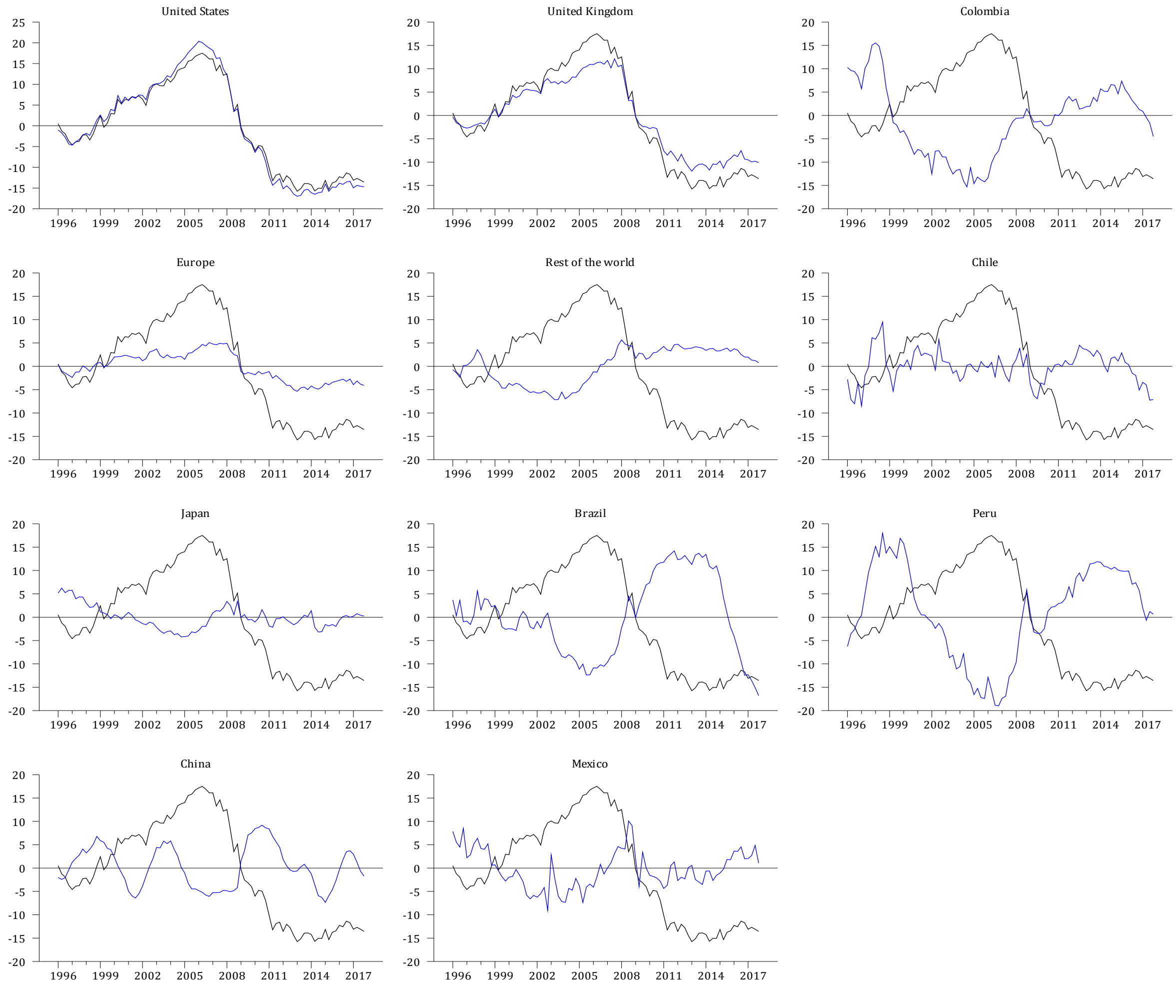


Figure 6. Country financial cycle

Black line: country financial cycle; blue line: country credit; green line: country property prices

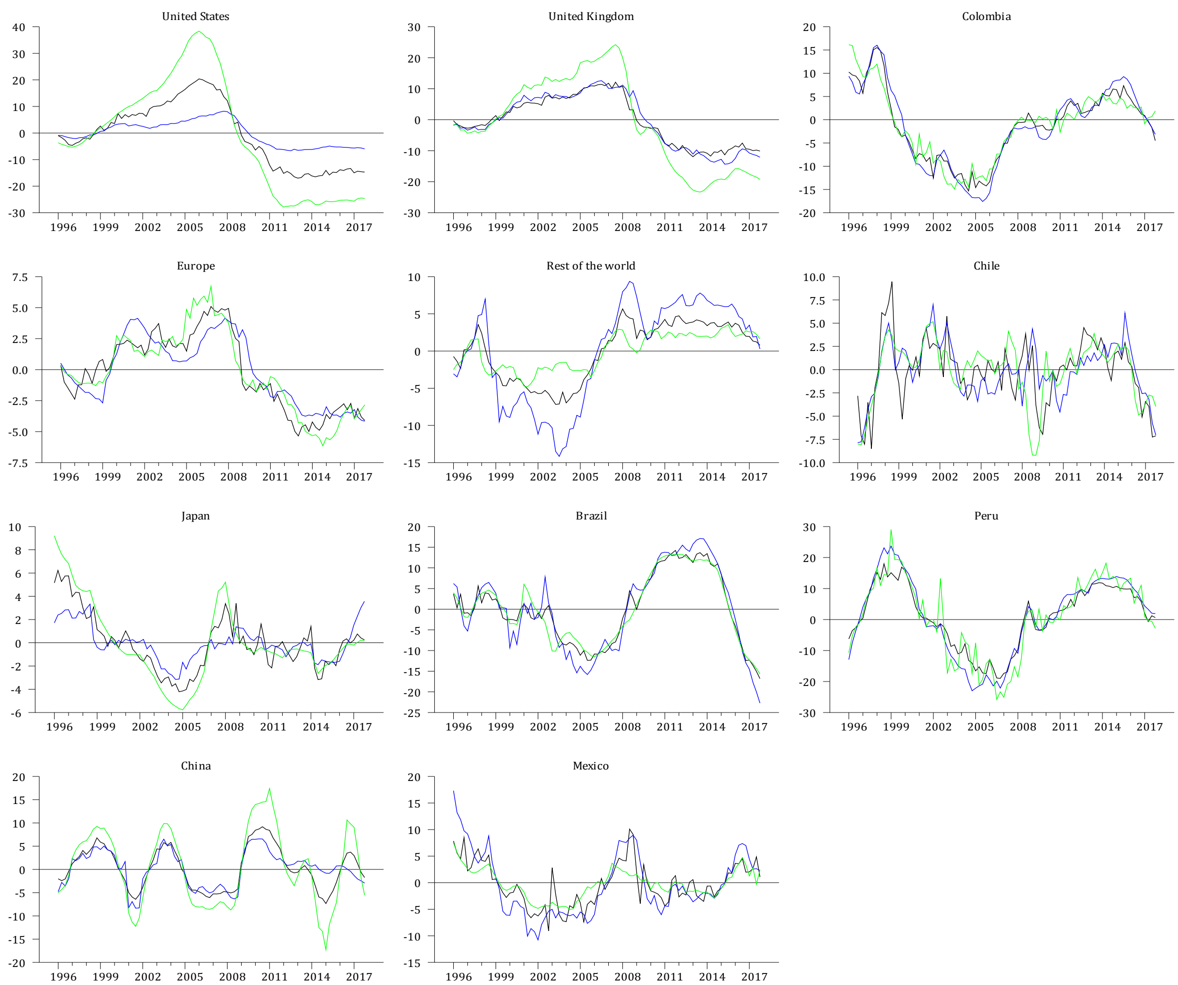
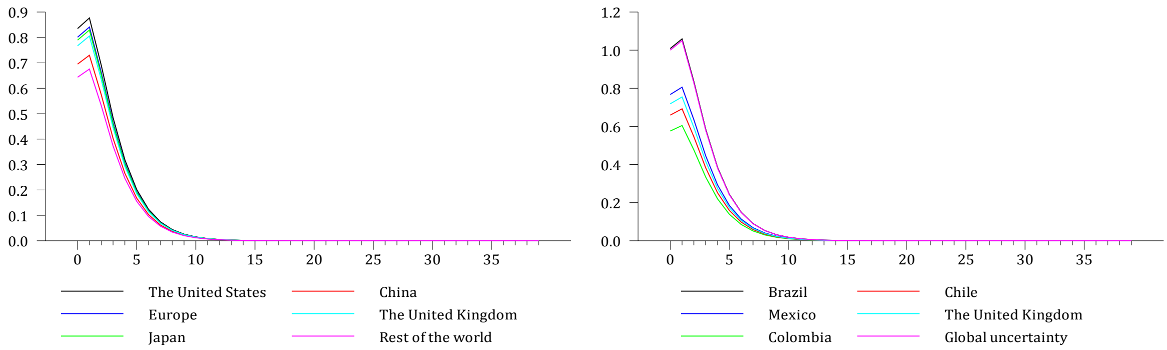
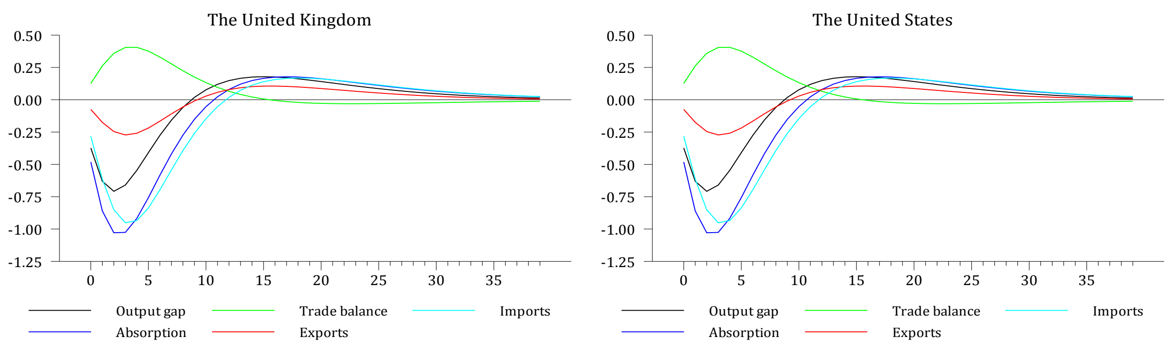


Figure 7. Shock to global uncertainty

Panel A. Response of country uncertainty



Panel B. Response of the main macroeconomic flows



Panel C. Response of real prices and inflation

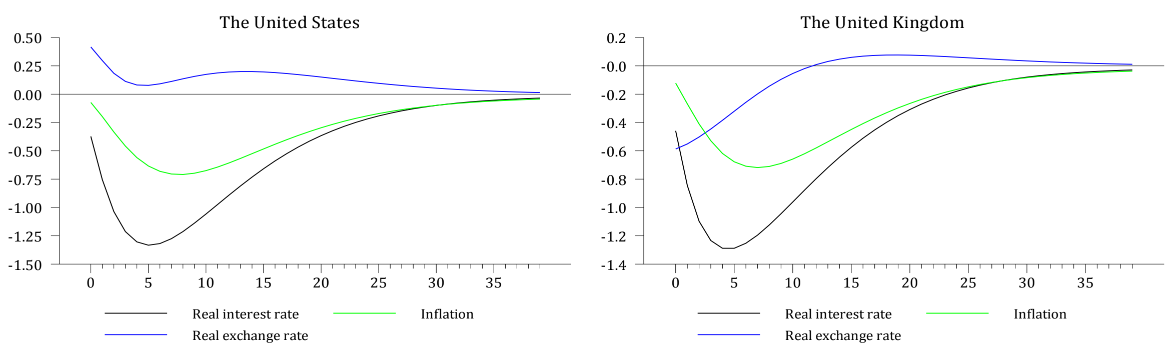
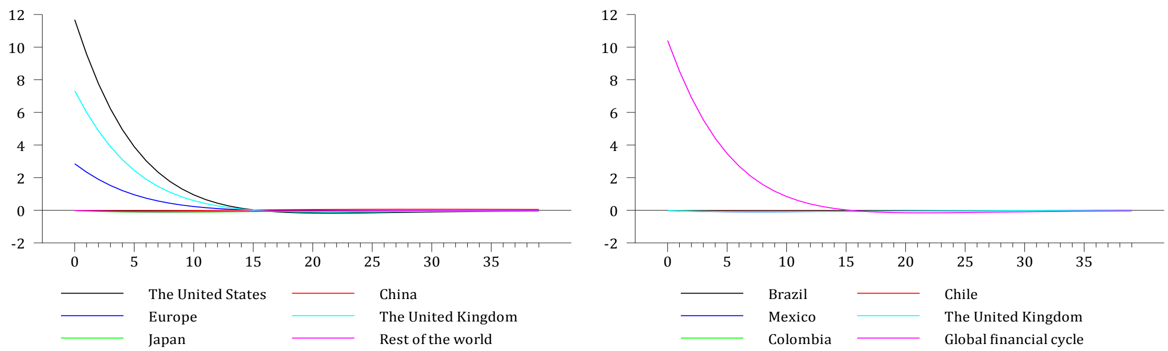
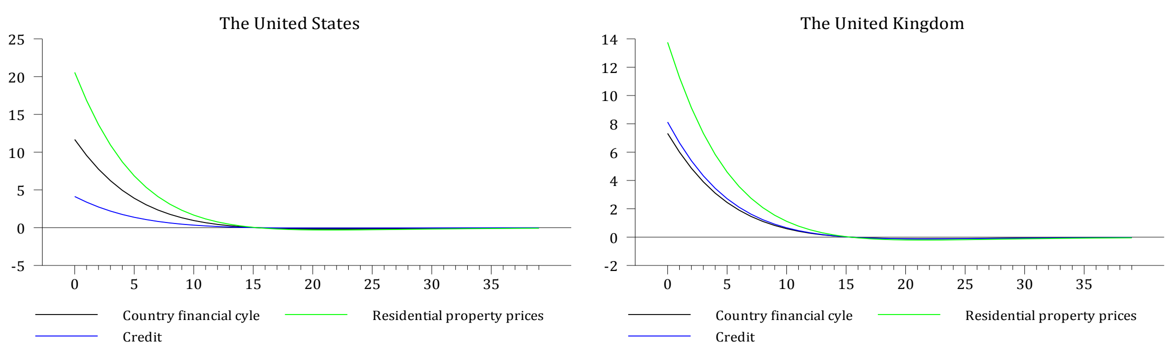


Figure 8. Shock to the global financial cycle

Panel A. Response of the country financial cycle



Panel B. Response of credit and property prices



Panel C. Response of main macro variables

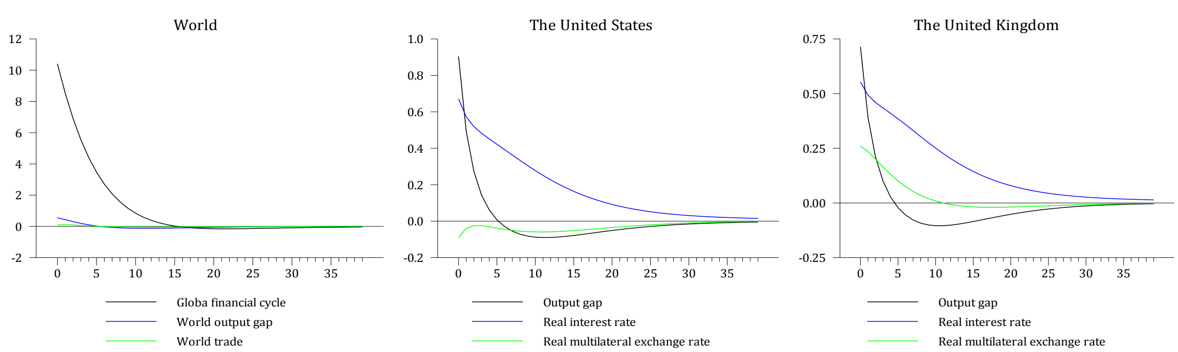


Figure 8. Shock to the global financial cycle (continued)

Panel D. Response of the main macroeconomic flows

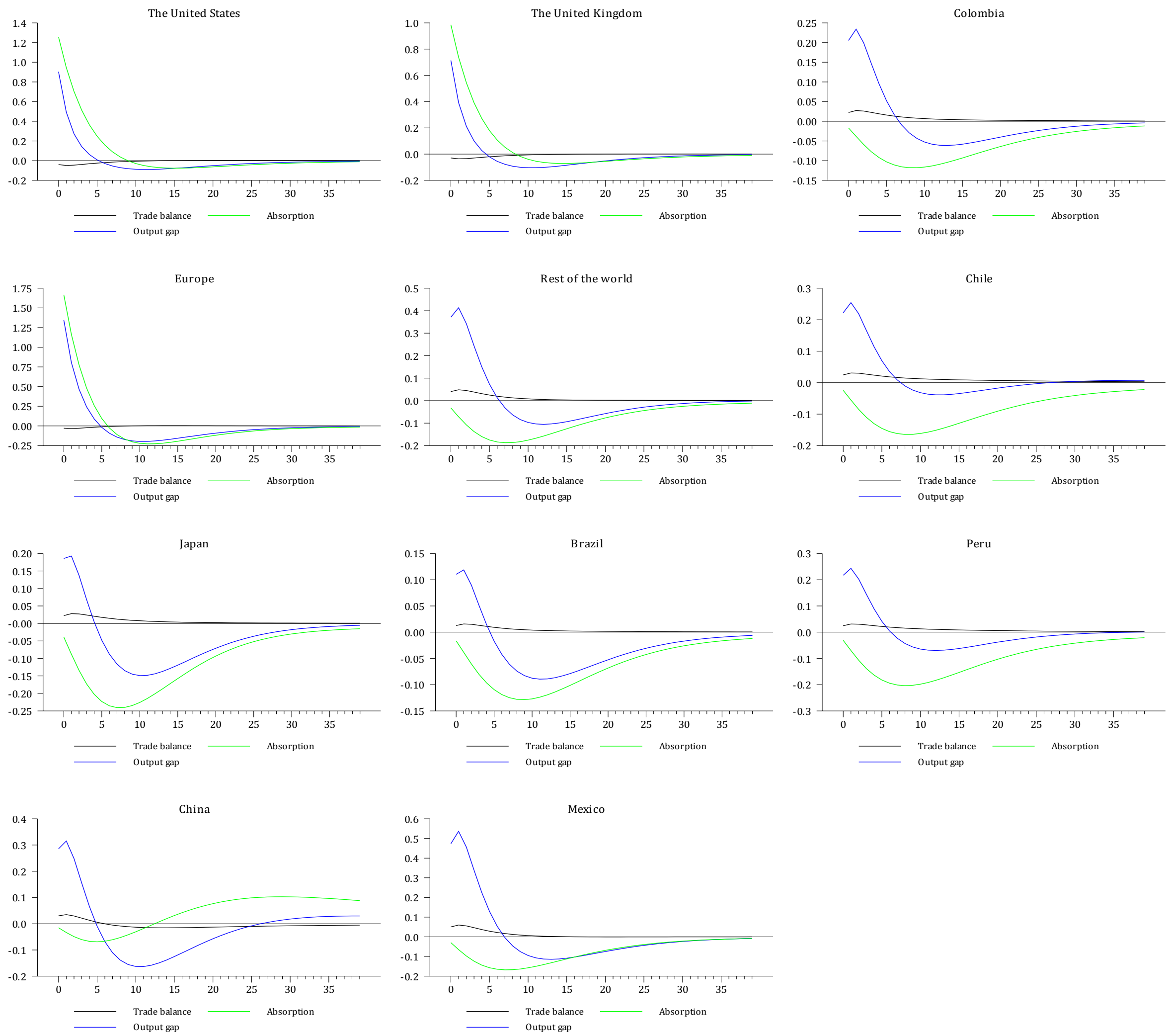


Figure 9. Shock to aggregate demand in the United States, response of the main macroeconomic flows

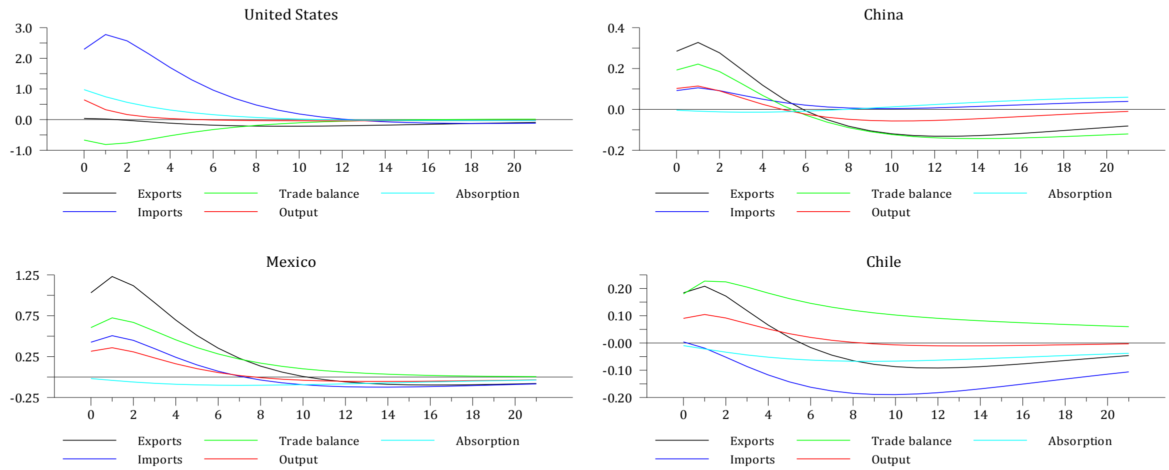


Figure 10. Shock to interest rates in the United States, response of main macroeconomic prices and flows in Colombia

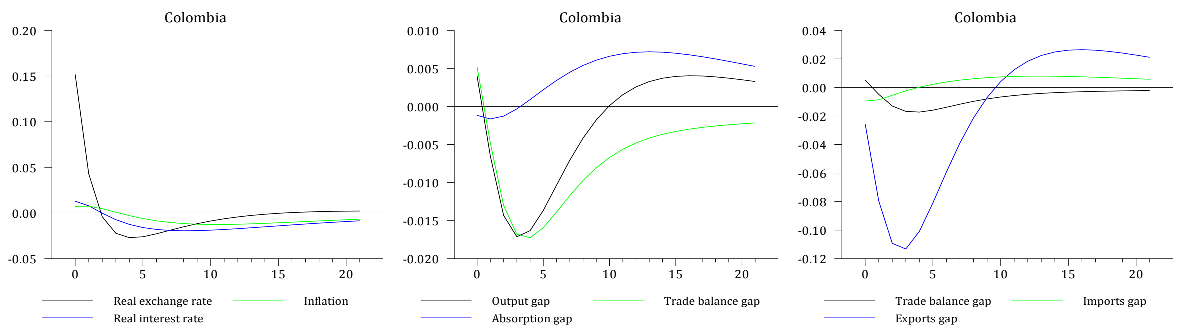


Figure 11. Shock to interest rates in the United States,
transmission to inflation in advanced and emerging economies

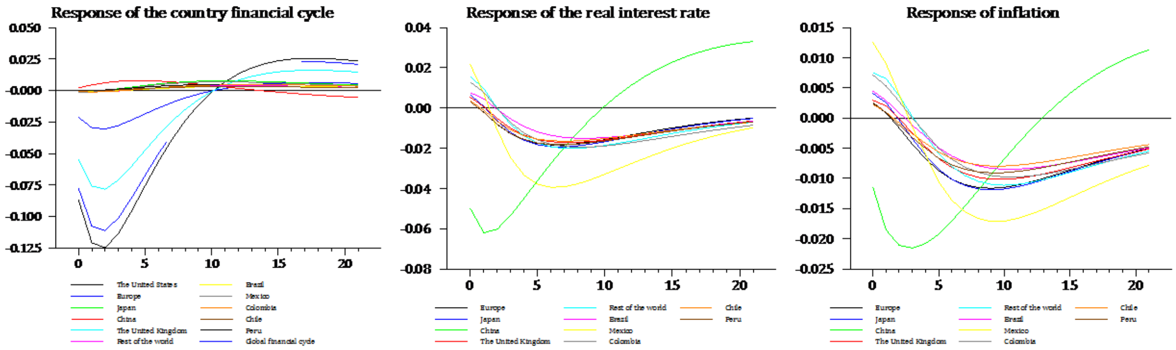


Figure 12. Shock to interest rates in Europe,
transmission to inflation in advanced and emerging economies

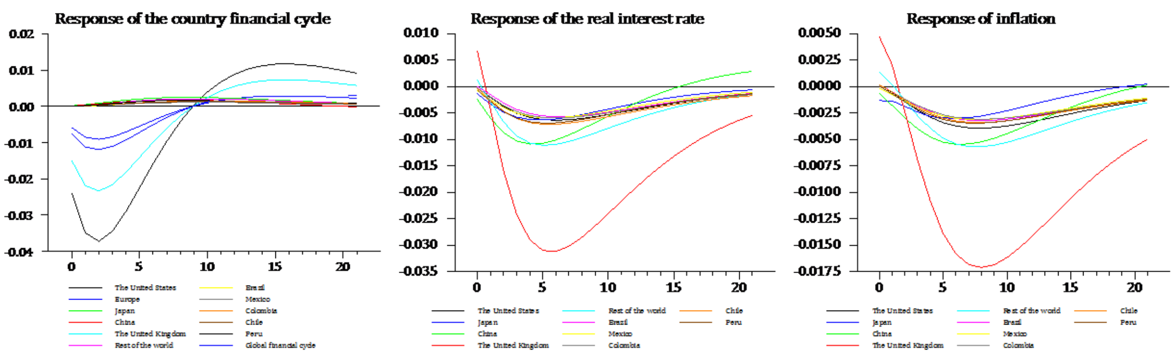


Figure 13. Shock to interest rates in the United Kingdom,
transmission to inflation in advanced and emerging economies

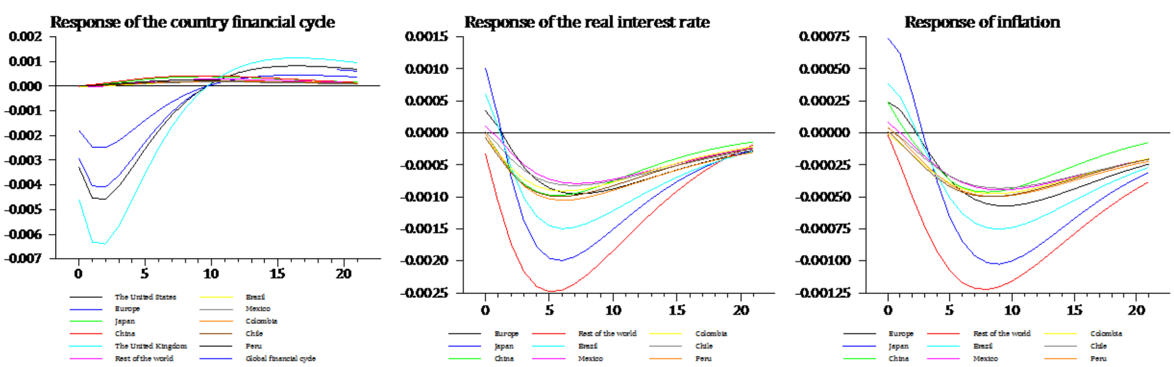


Figure 14. Global uncertainty

Black bars: initial conditions; orange bars: global uncertainty shocks

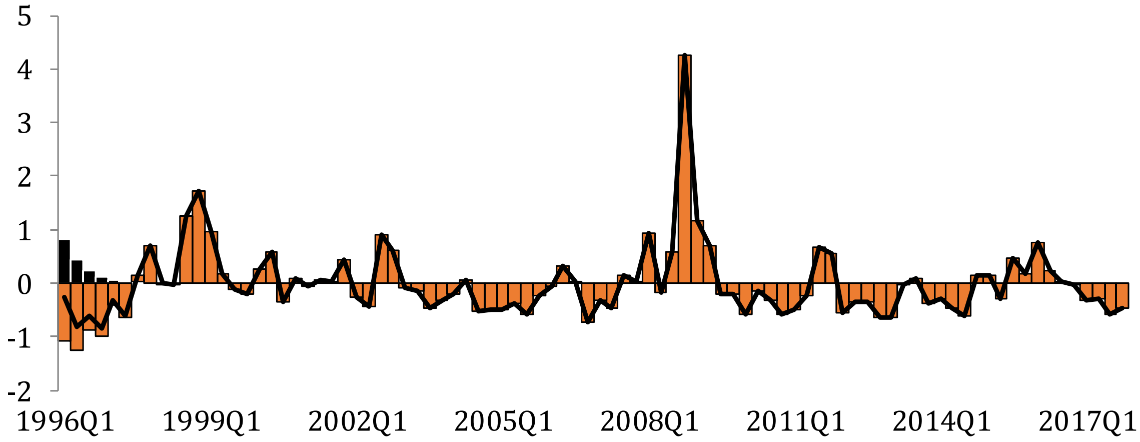


Figure 15. Global risk aversion

Black bars: initial conditions; blue bars: global risk aversion shocks

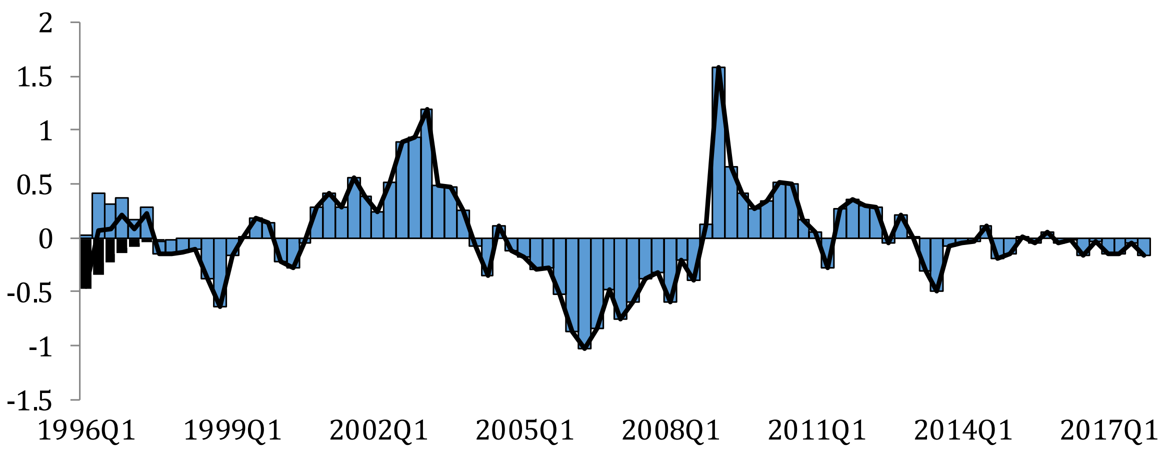


Figure 16. Implicit volatility

Black bars: initial conditions; orange bars: global uncertainty shocks;
red bars: country uncertainty shocks; blue bars: global risk aversion shocks;
green bars: country risk aversion shocks; white bars; remaining shocks

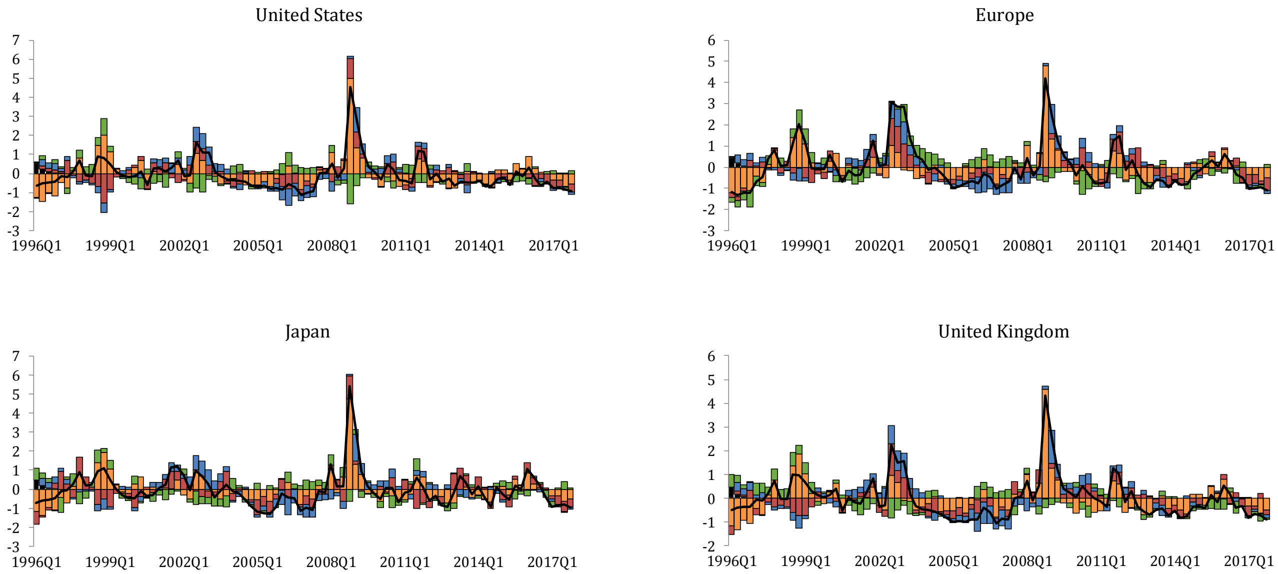


Figure 17. Country uncertainty

Black bars: initial conditions; orange bars: global uncertainty shocks;
blue bars: country uncertainty shocks

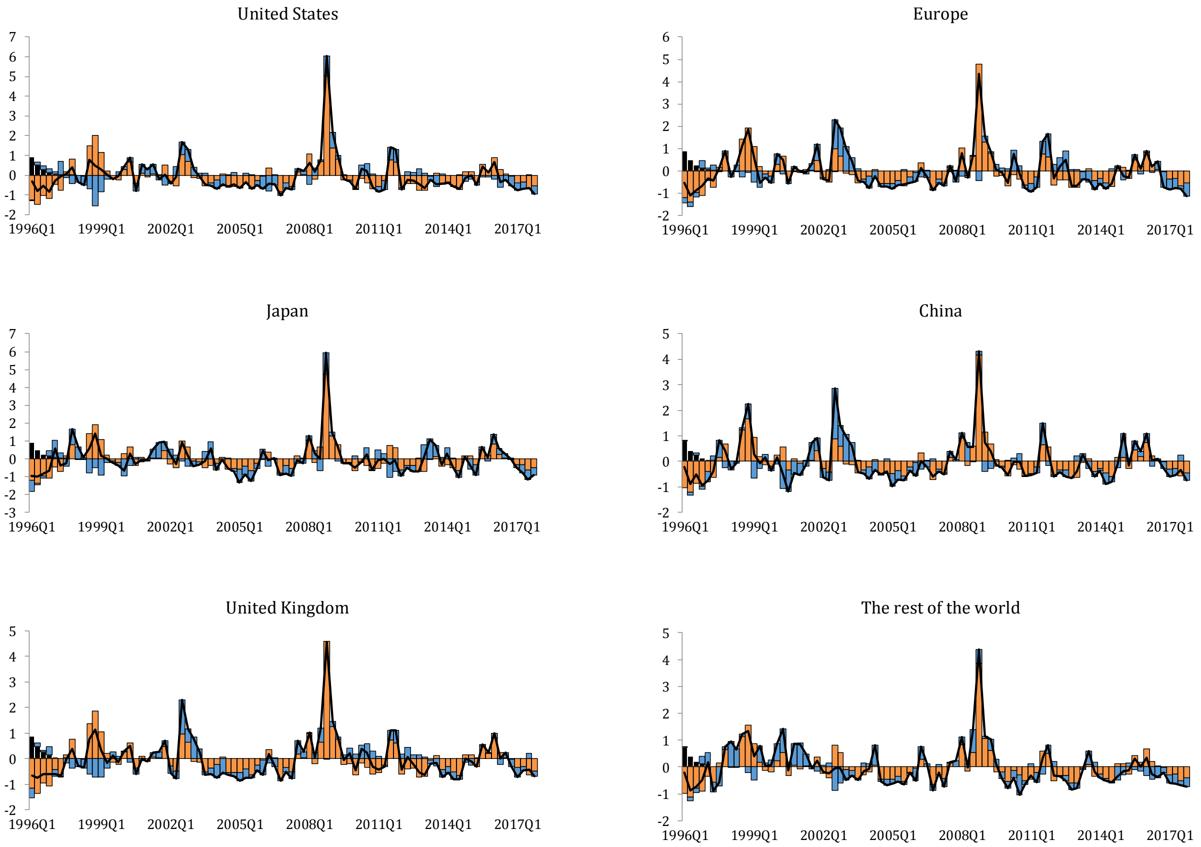


Figure 17. Country uncertainty (continued)

Black bars: initial conditions; orange bars: global uncertainty shocks; blue bars: country uncertainty shocks

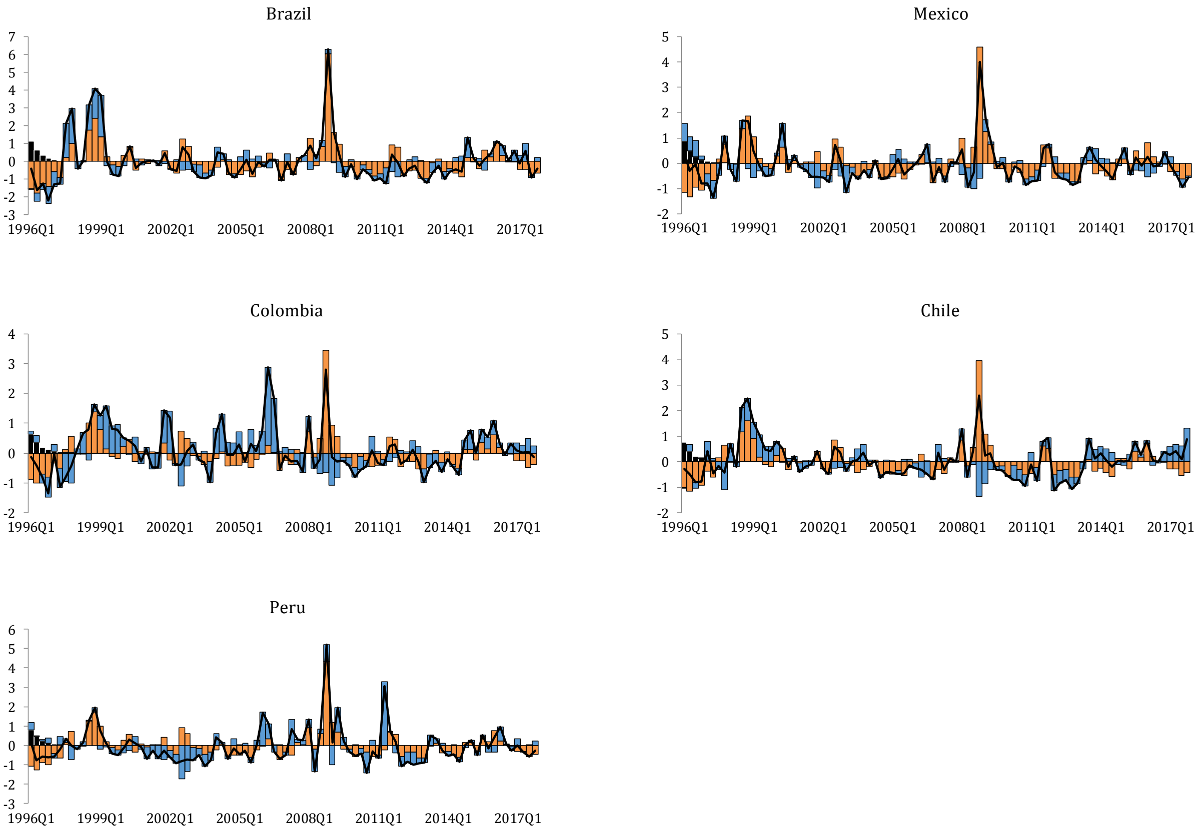


Figure 18. Country risk aversion

Black bars: Initial conditions; blue bars: global risk aversion shocks; green bars: country risk aversion shocks

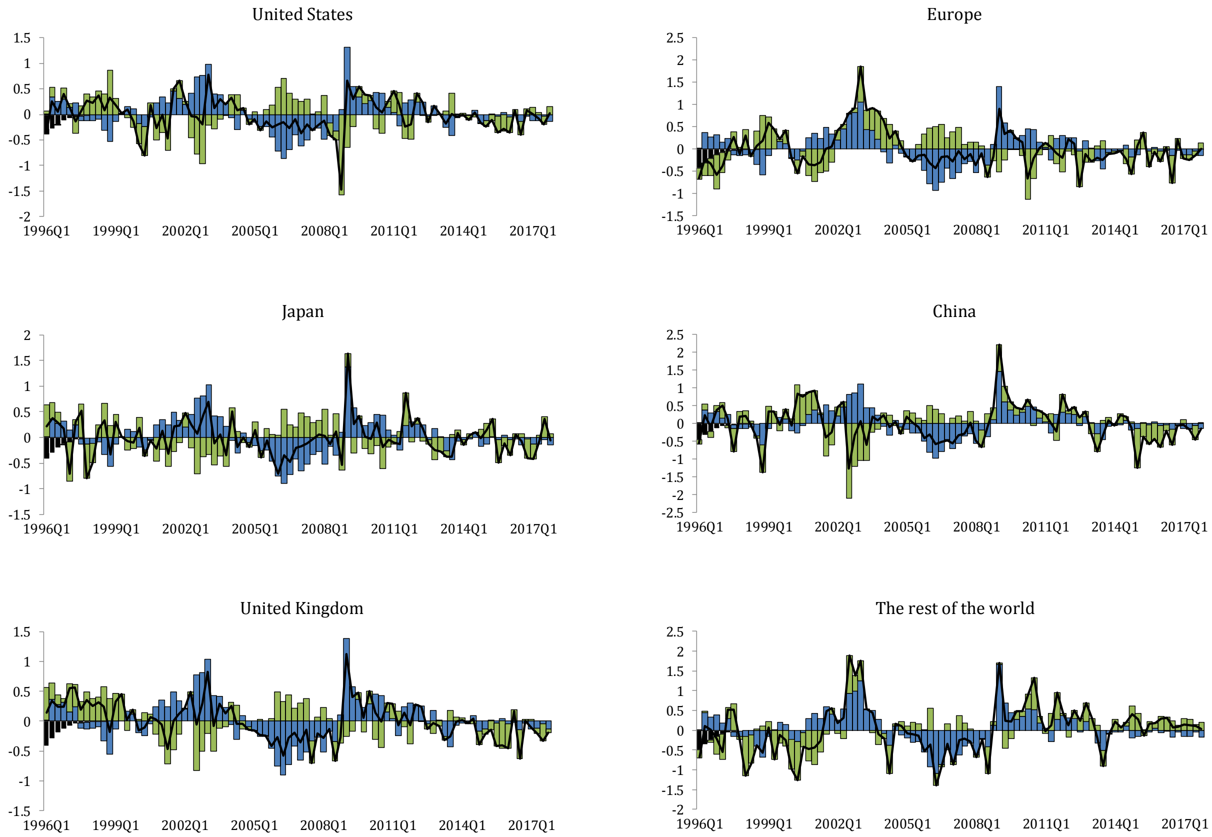


Figure 18. Country risk aversion (continued)

Black bars: Initial conditions; blue bars: global risk aversion shocks; green bars: country risk aversion shocks

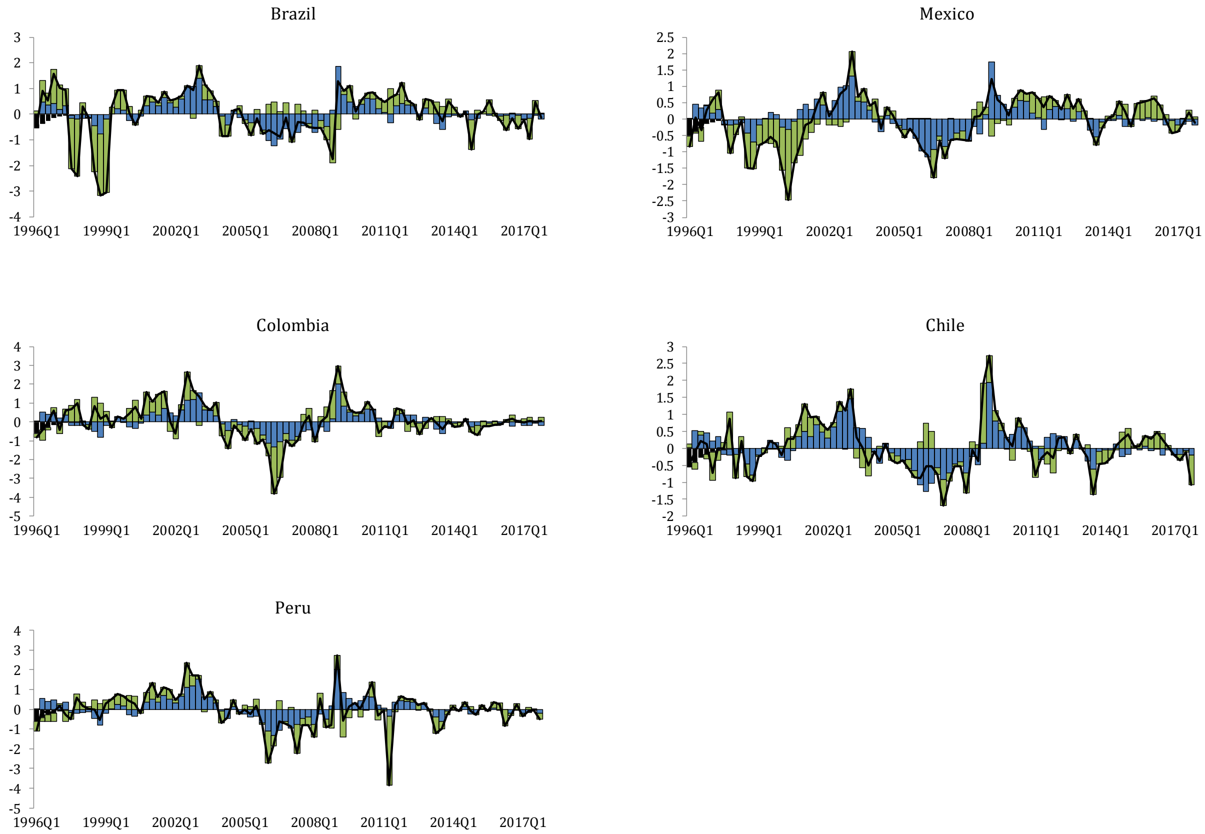


Figure 19. Global financial cycle

Black bars: initial conditions; orange bars: implicit volatility shocks;
red bars: real interest rate shocks; blue bars: output gap;
green bars: global financial cycle shocks; white bars: remaining shocks

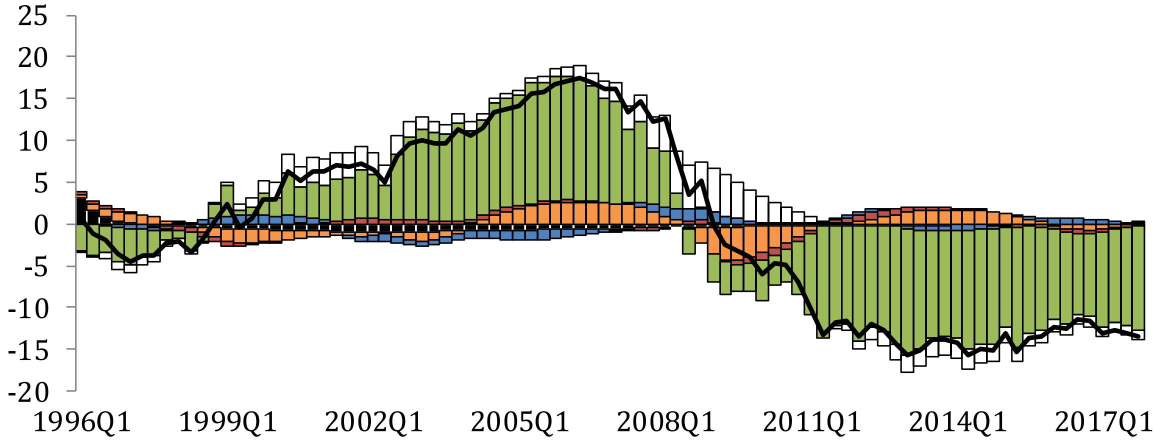


Figure 20. Country financial cycle

Black bars: initial conditions; orange bars: implicit volatility shocks;
red bars: real interest rate shocks; blue bars: global financial cycle shocks;
green bars: country financial cycle shocks; white bars: remaining shocks

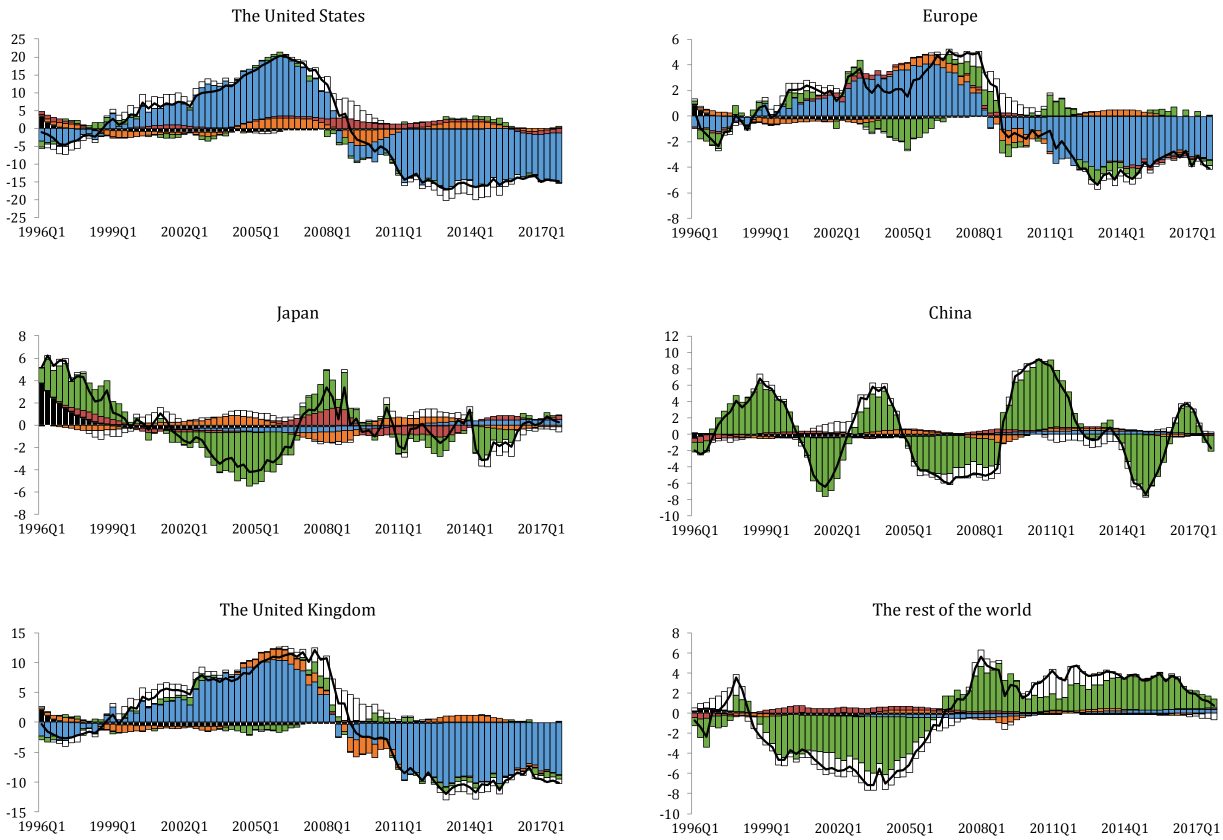


Figure 20. Country financial cycle (continued)

Black bars: initial conditions; orange bars: implicit volatility shocks;
red bars: real interest rate shocks; blue bars: global financial cycle shocks;
green bars: country financial cycle shocks; white bars: remaining shocks

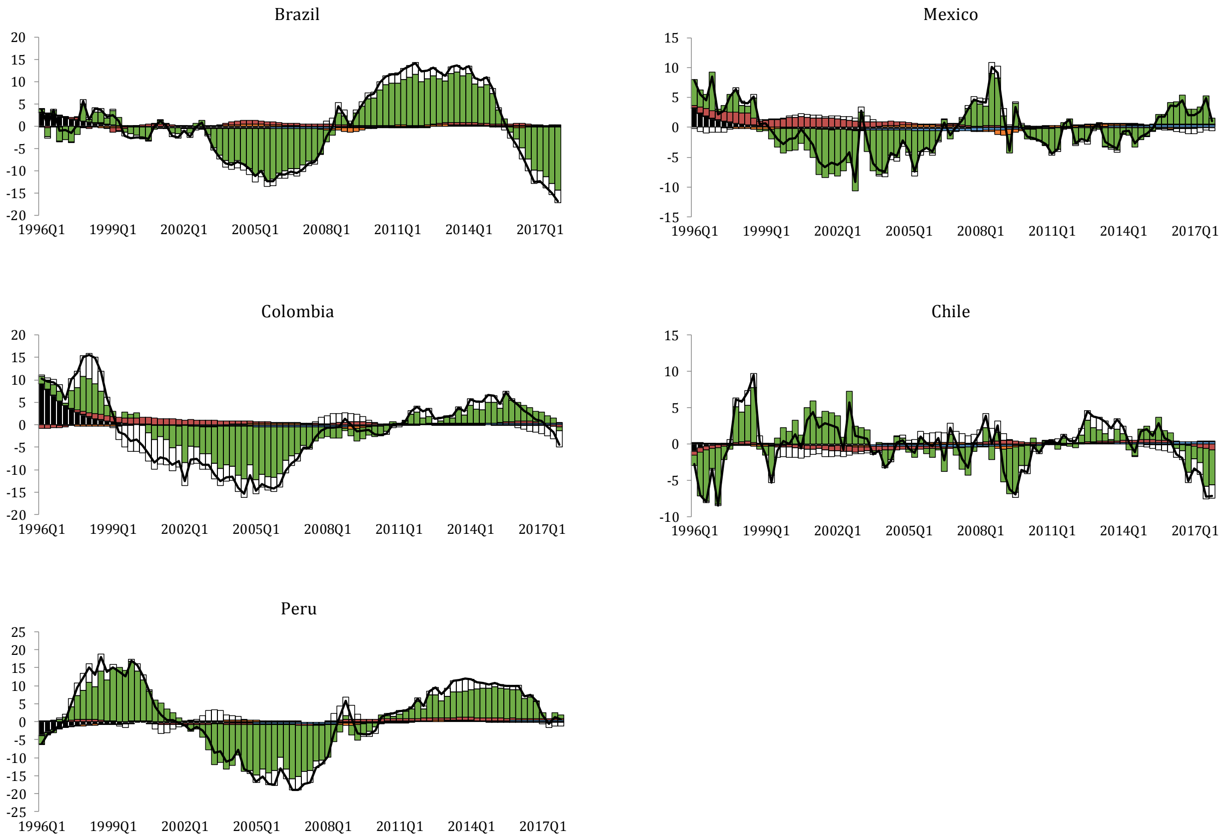


Figure 21. Output gap

Black bars: initial conditions; orange bars: implicit volatility shocks;
red bars: global financial cycle shocks; blue bars: real interest rate shocks;
green bars: exchange rate shocks; purple bars: output gap shocks;
white bars: remaining shocks

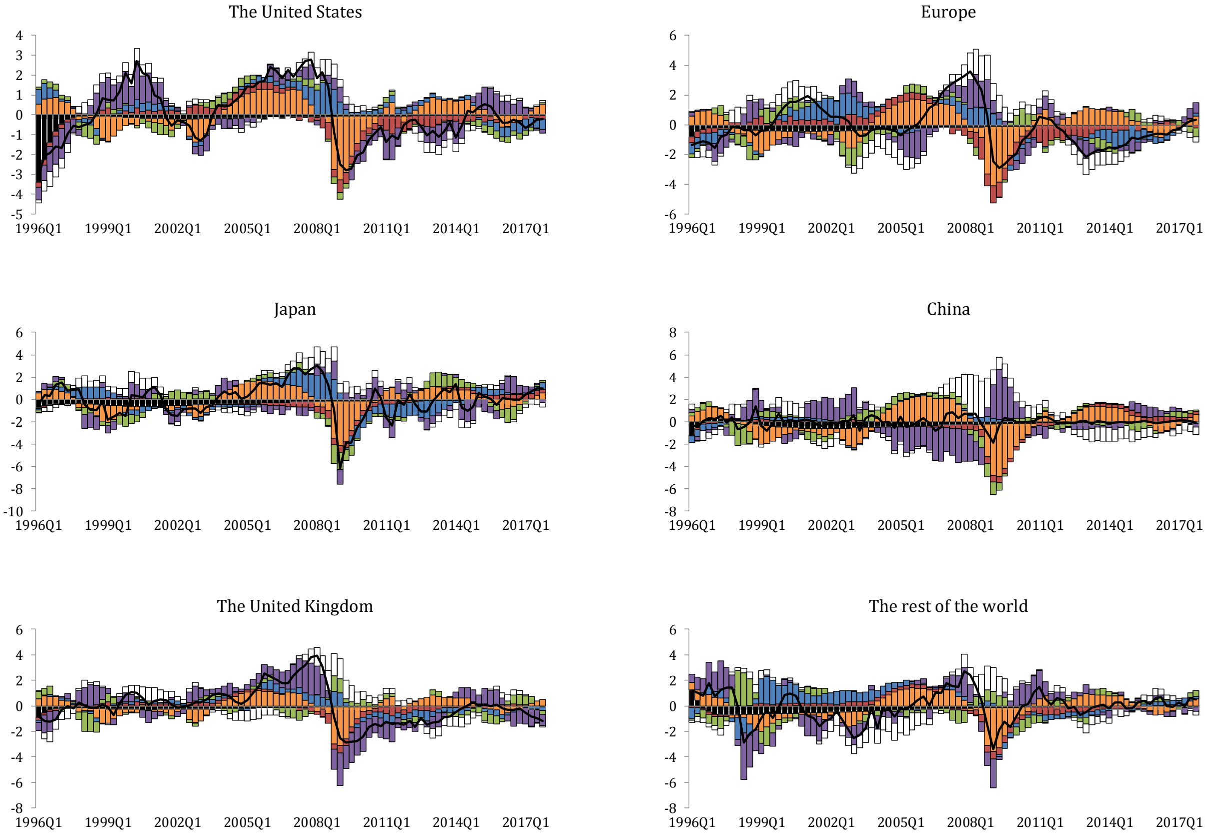


Figure 21. Output gap (continued)

Black bars: initial conditions; orange bars: implicit volatility shocks;
red bars: global financial cycle shocks; blue bars: real interest rate shocks;
green bars: exchange rate shocks; purple bars: output gap shocks;
white bars: remaining shocks

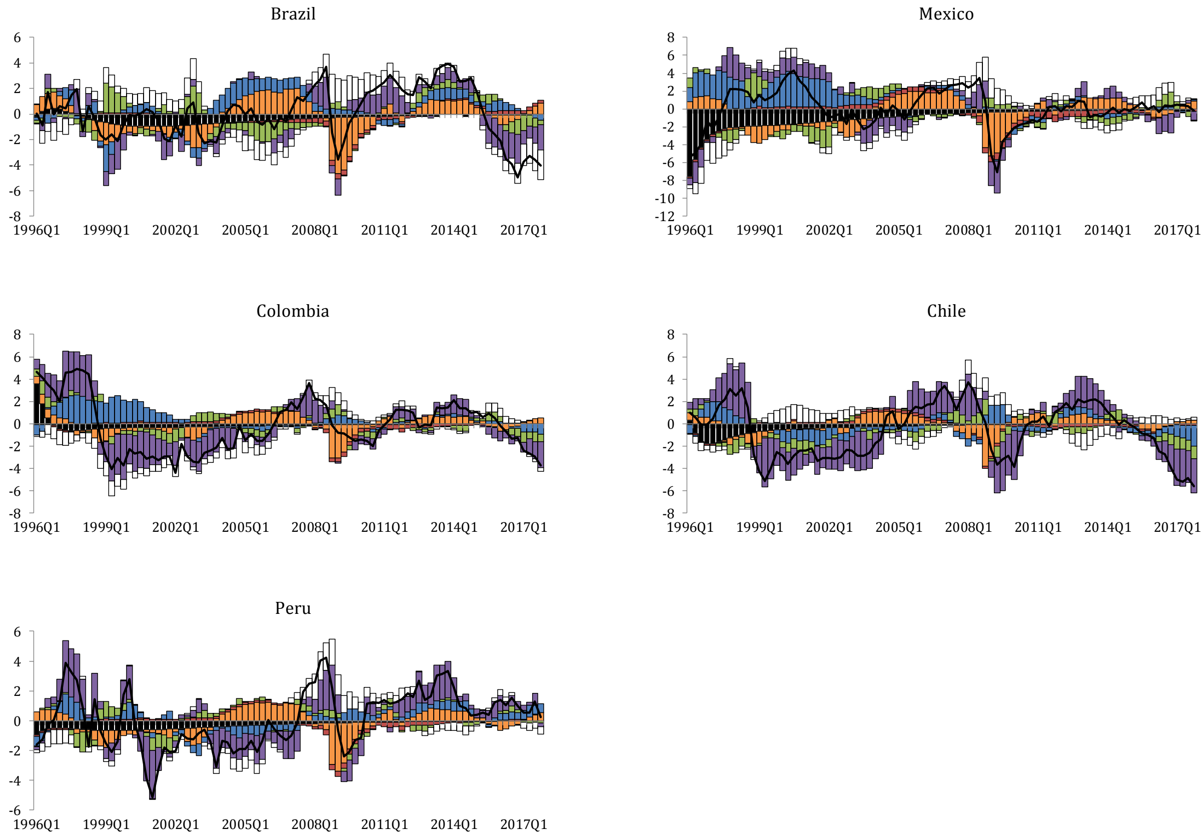


Figure 22 . Absorption

Black bars: initial conditions; orange bars: implicit volatility shocks; red bars: real interest rate shocks; blue bars: country financial cycle shocks; green bars: absorption shocks; white bars: remaining shocks

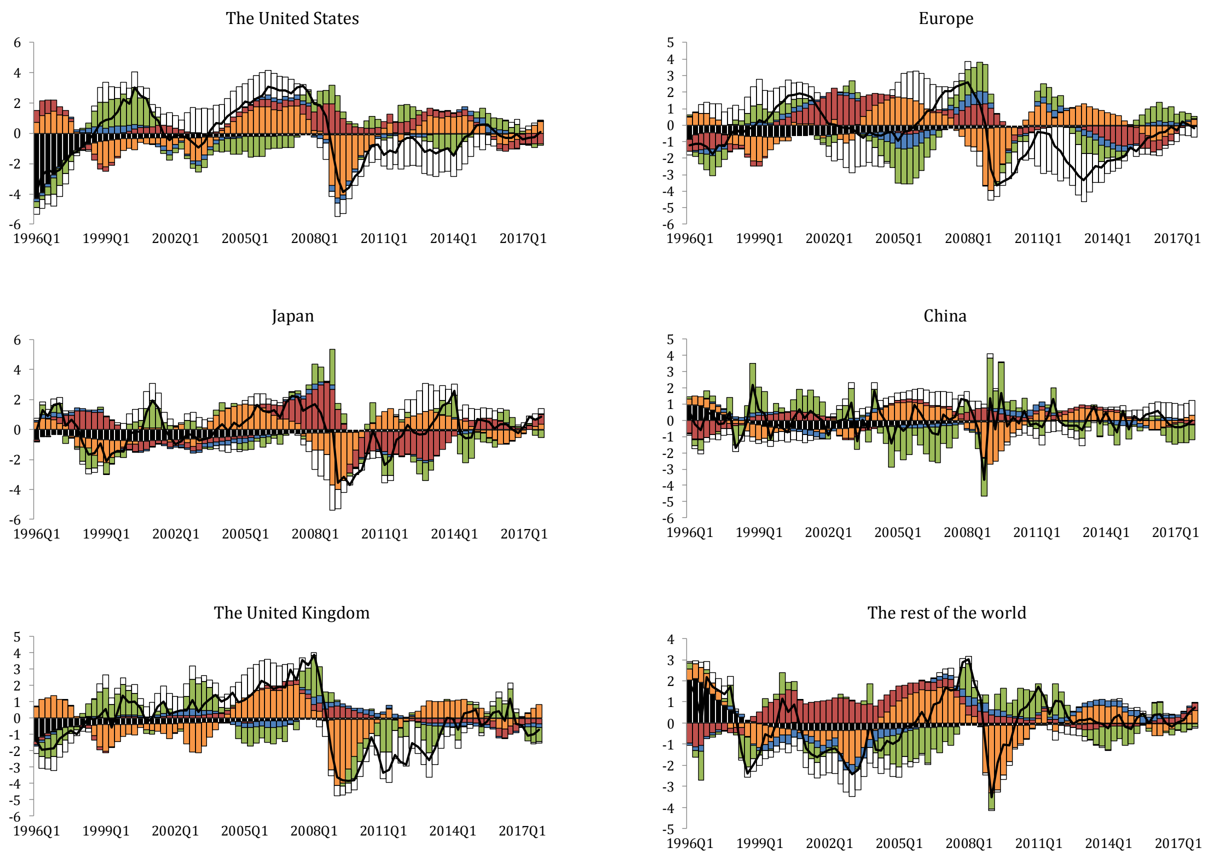


Figure 22. Absorption (continued)

Black bars: initial conditions; orange bars: implicit volatility shocks;
red bars: real interest rate shocks; blue bars: country financial cycle shocks;
green bars: absorption shocks; white bars: remaining shocks

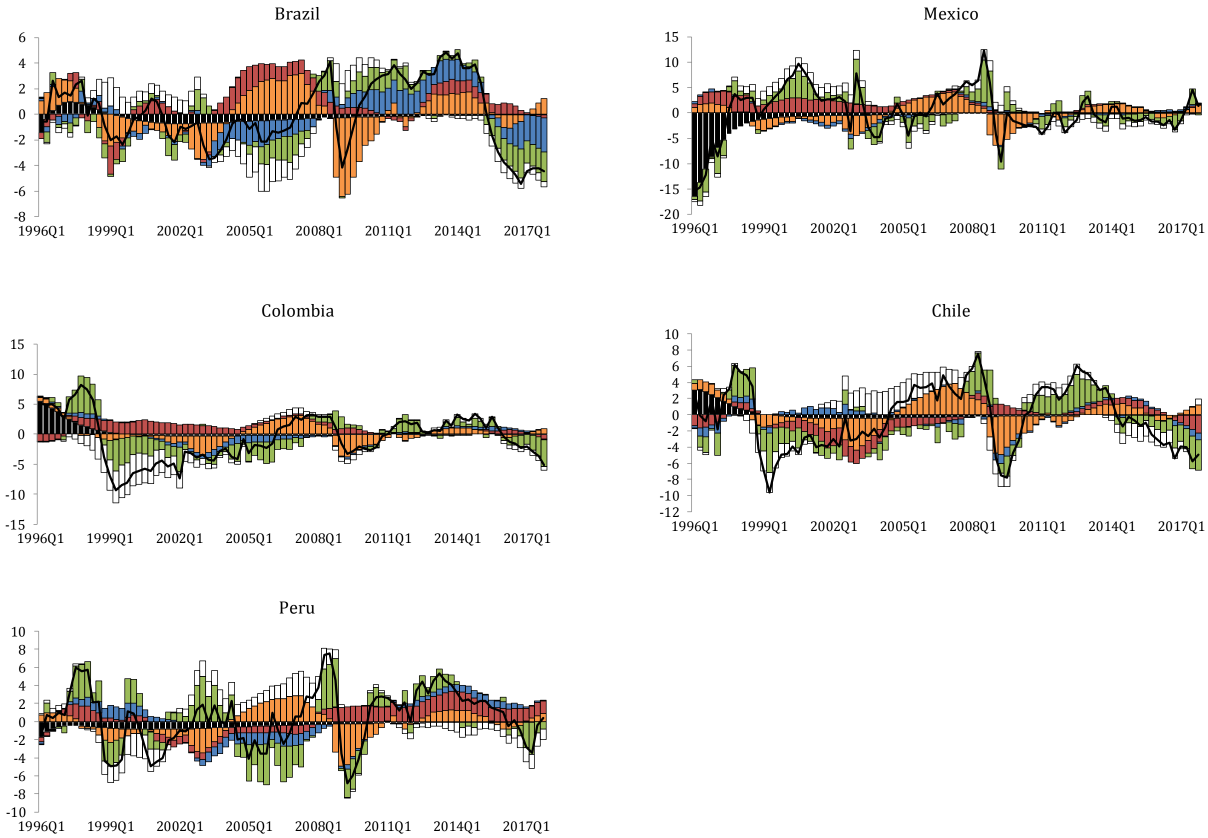


Figure 23. Exports

Black bars: initial conditions; orange bars: financial variable shocks;
blue bars: absorption shocks; green bars: exchange rate shocks;
yellow bars: exports shocks; white bars: remaining shocks

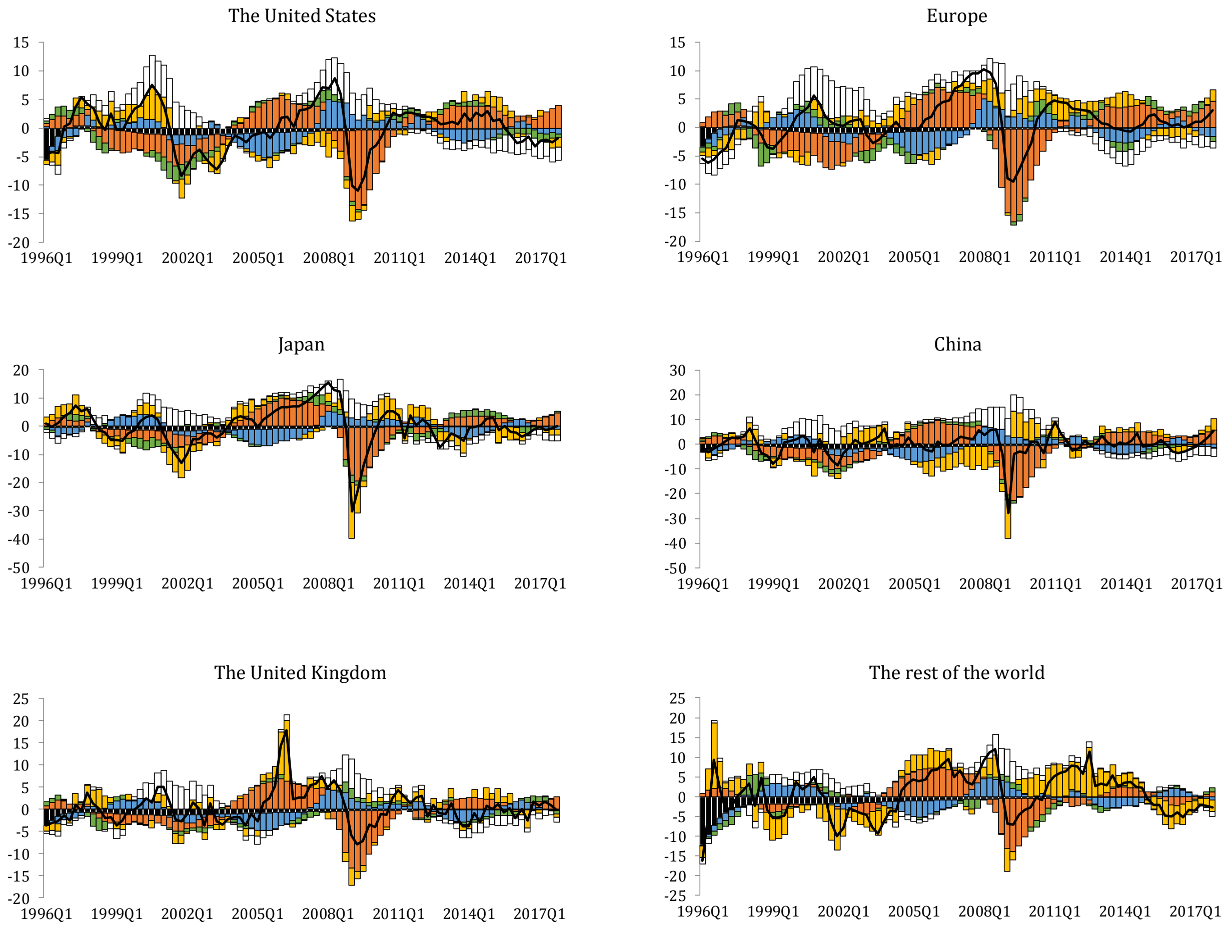


Figure 23. Exports (continued)

Black bars: initial conditions; orange bars: financial variable shocks;
blue bars: absorption shocks; green bars: exchange rate shocks;
yellow bars: exports shocks; white bars: remaining shocks

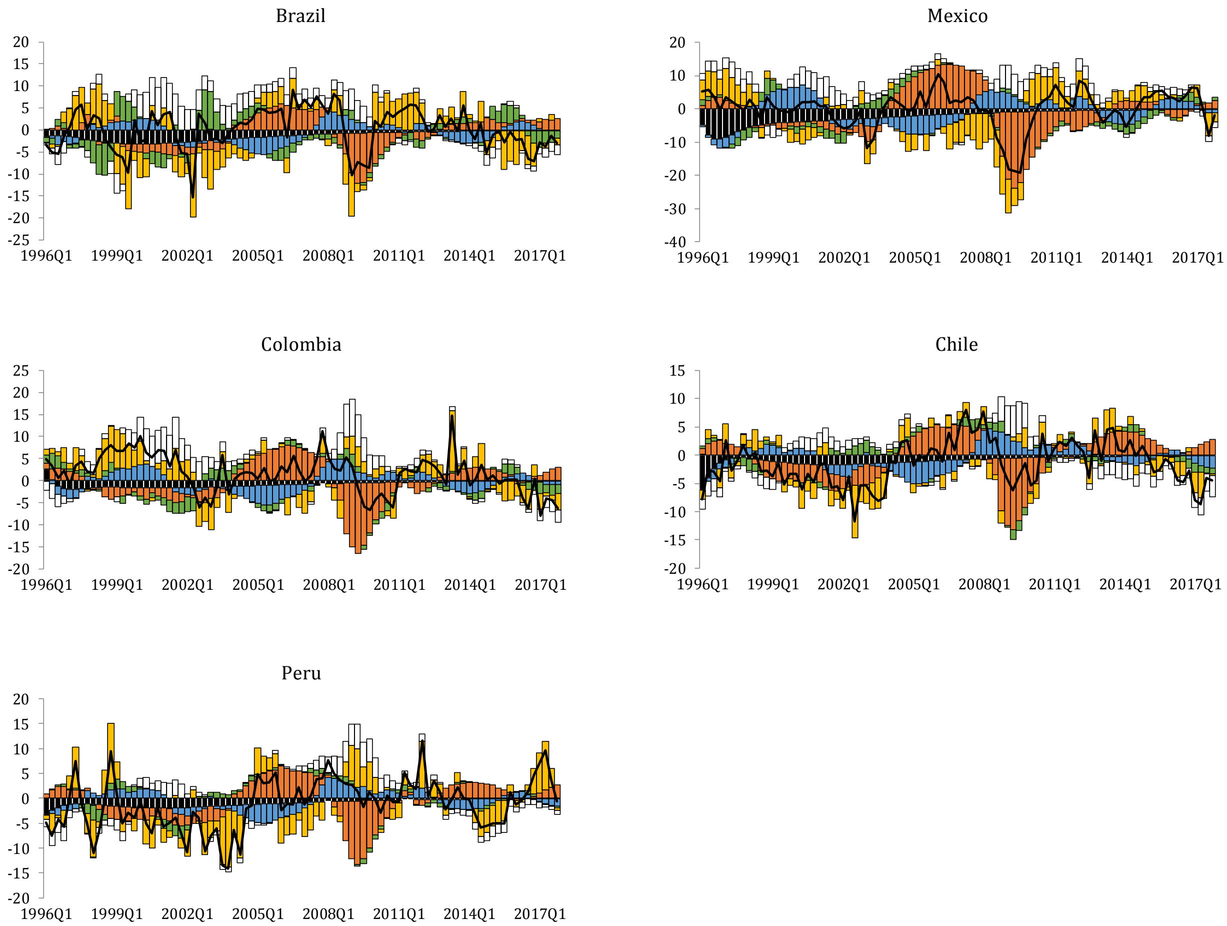


Figure 24. Imports

Black bars: initial conditions; orange bars: financial variable shocks;
blue bars: absorption shocks; green bars: exchange rate shocks;
yellow bars: imports shocks; white bars: remaining shocks

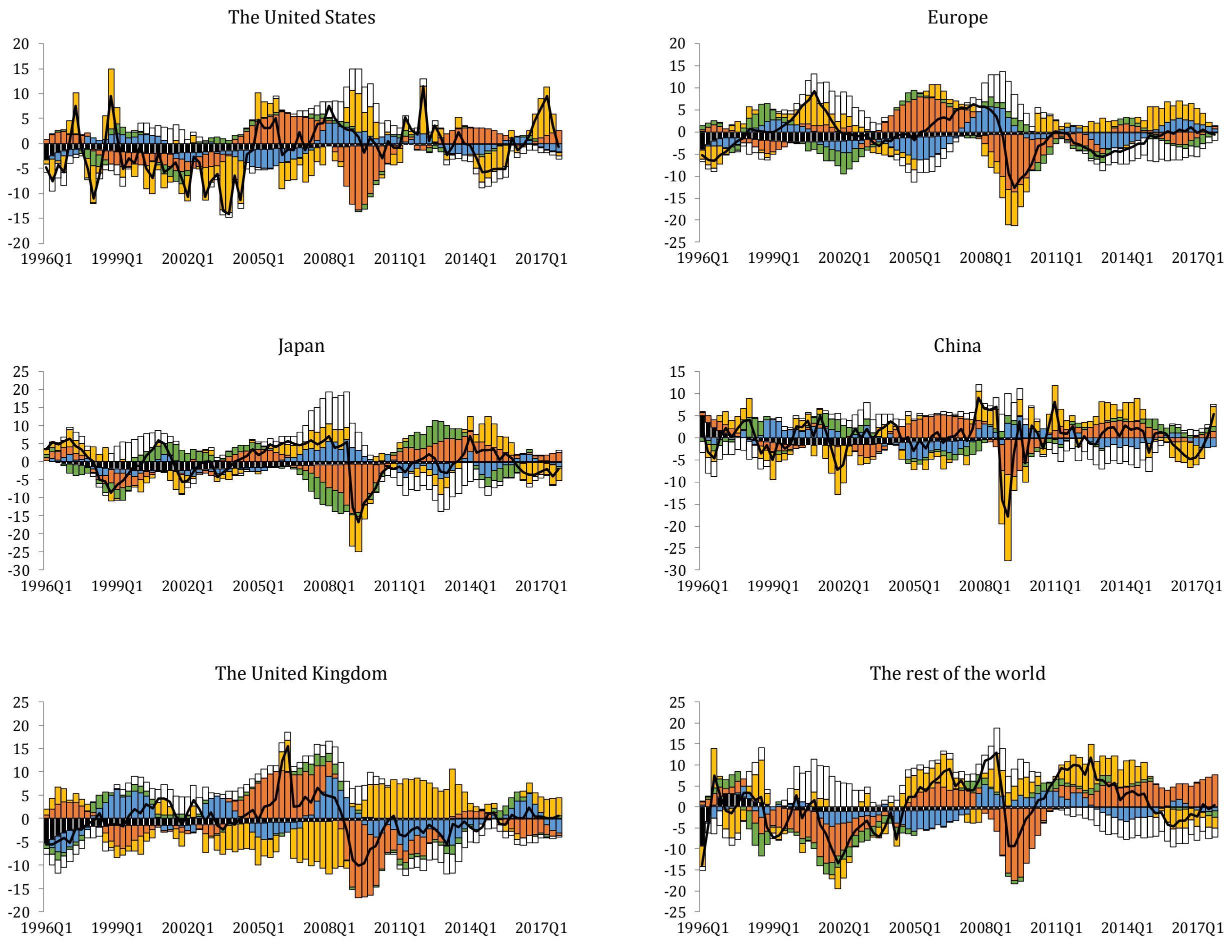


Figure 24. Imports (continued)

Black bars: initial conditions; orange bars: financial variable shocks;
blue bars: absorption shocks; green bars: exchange rate shocks;
yellow bars: imports shocks; white bars: remaining shocks

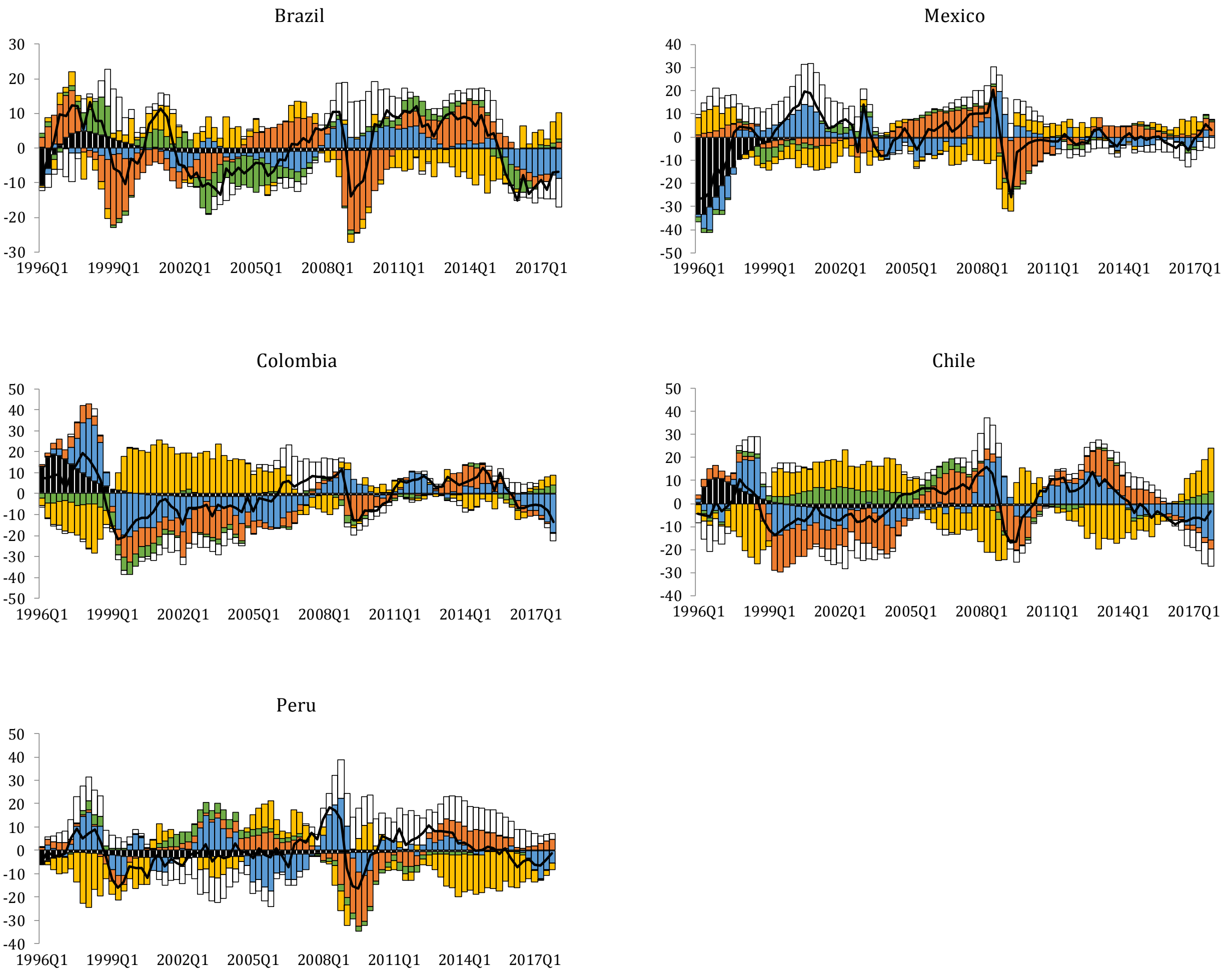


Figure 25. Core inflation

Black bars: initial conditions; orange bars: real interest rate shocks;
red bars: global financial cycle shocks; blue bars: country financial cycle shocks;
green bars: exchange rate shocks; purple bars: absorption shocks;
white bars: remaining shocks

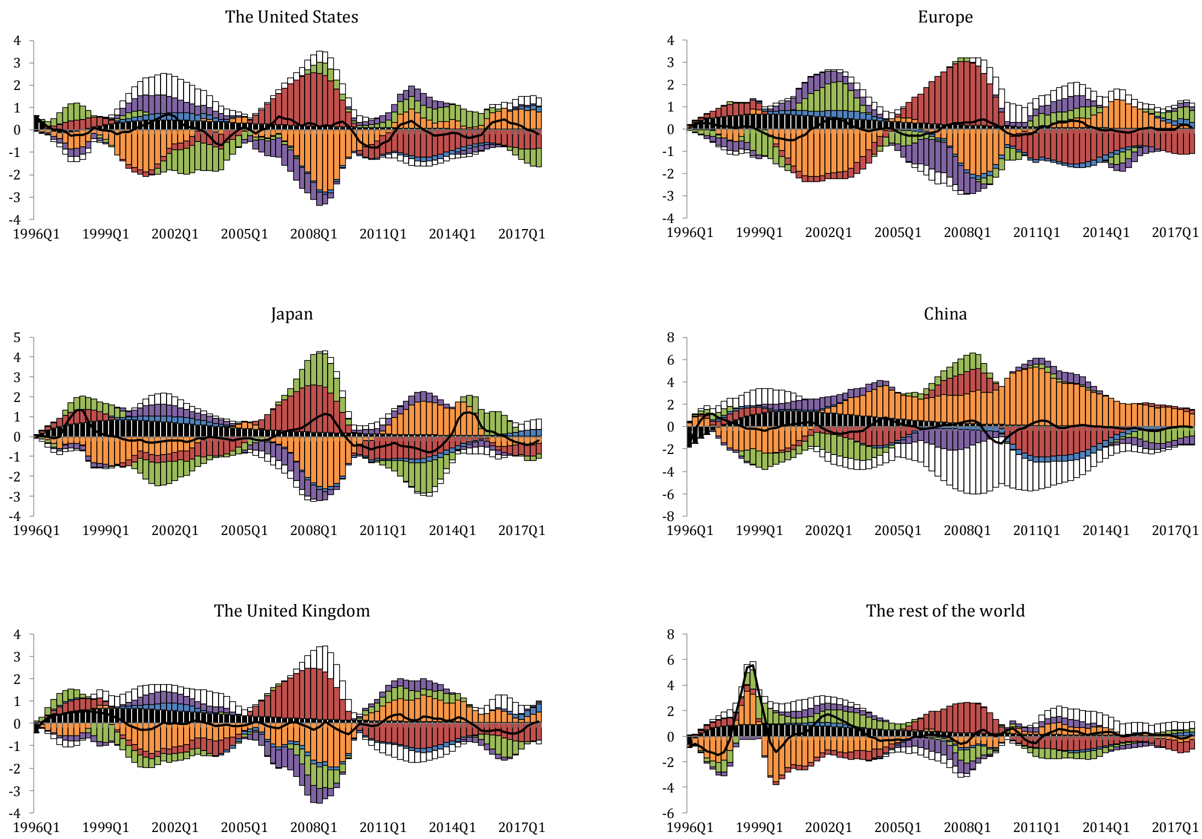
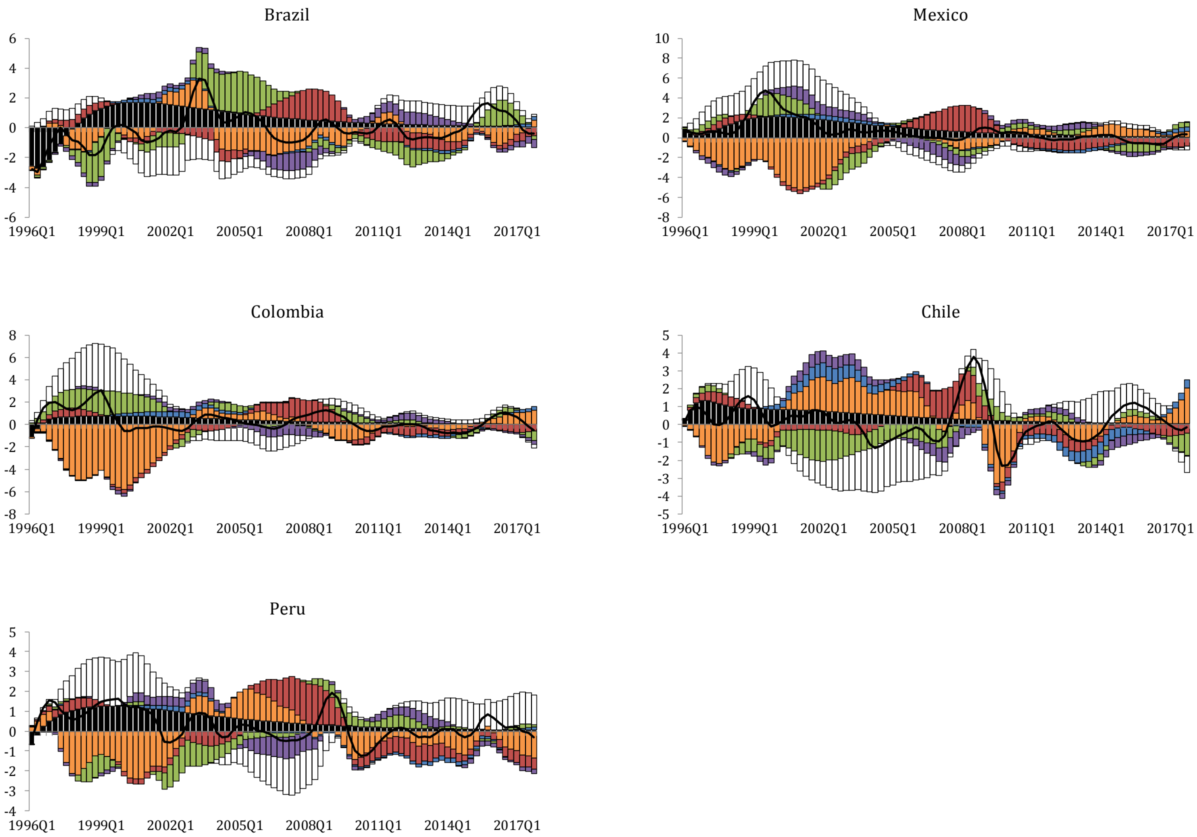


Figure 25. Core inflation (continued)

Black bars: initial conditions; orange bars: real interest rate shocks;
red bars: global financial cycle shocks; blue bars: country financial cycle shocks;
green bars: exchange rate shocks; purple bars: absorption shocks;
white bars: remaining shocks

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