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Volatility Spillovers and Systemic Risk Across Economies: Evidence from a Global Semi-Structural Model

Javier G. Gómez-Pineda
Banco de la República (the central bank of Colombia)

Chemin Eugène-Rigot 2
P.O. Box 136
CH - 1211 Geneva 21
Switzerland

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Javier G. Gómez-Pineda*†

Abstract

The paper presents some evidence on the overwhelming relevance of systemic risk and the lesser importance of US interest rates in the global transmission of shocks. This evidence suggests that the literature could benefit from incorporating global confidence variables into global frameworks in the study of the global transmission of shocks. As framework, we used a global semi-structural model (GSSM) augmented with common factors for country risk and country credit. We approximated country risk with historical stock volatility, a measure that is uniform and available across countries; in addition, we measured spillovers as the share of forecast error variance explained by different volatility factors. We found that systemic risk is the main volatility factor in all systemic economies, and also accounts for the bulk of spillovers into non systemic economies. Other volatility factors such as global credit, foreign interest rates and trade-related factors rarely accounted for shares of forecast error variance above one percent.

JEL classification: E58; E37; E43; Q43

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Author' email address: jgomezpi@banrep.gov.co

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1 Introduction

Spillovers are a topic of increasing relevance, but spillovers from US interest rates, as the literature has emphasized (Yellen, 2016), may not be the most relevant ones. The literature on spillovers seems to have given a rather excessive relevance to US interest rate spillovers, while ignoring other sources of volatility spillovers, particularly systemic risk. The policy implications of this gap should not be downplayed: analysts and authorities may be leaving aside a true source of output and inflation volatility.

Systemic risk is a shock to confidence and uncertainty involving several financial markets and countries.[1] It typically involves movements in credit, leverage and asset prices. Although systemic risk is pervasive in real economies, it is absent in macroeconomic models.[2]

We show that shocks to systemic risk, measured as a common factor of country risk, have important spillovers across economies. By contrast, shocks to credit, trade−and particularly shocks to US interest rates−have effects of second order relevance. In the policy implications, systemic risk is by far a key variable to monitor by authorities and analysts in systemic and non systemic economies alike and a critical variable to include in macroeconomic models. Authorities should follow the global transmission of financial shocks and confidence measures such as implicit and historical stock volatility, while analysts probably need de-emphasize on the relevance of US policy-rate developments. To the extent that policy analysis is informed by models, research needs to develop on the global financial transmission channels, otherwise policy analysis can have important gaps and give undue emphasis to variables with limited true influence.

We distinguish between a group of economies that regard as systemic, or that are relevant system-wide, and a group of economies that we call non systemic: in this article we deal with the largest Latin American economies. We use as theoretical framework a Global Semi-Structural Model (GSSM), enhanced with common factors for country risk and country credit. Country and global credit serve as proxy for the financial cycle, which is the cycle in credit and property prices, see for instance Borio (2012) and Drehmann et al (2012).

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 foreign shock.[3] The forecast error variance can be broken-down into different shocks or volatility factors. These factors can be systemic and non systemic. Systemic factors are those with system-wide relevance, such as shocks to systemic risk and the global financial cycle. Non systemic factors are

[1] For a definition of systemic risk see Bisias et al (2012).

[2] Akerlof and Schiller (2009) point out that animal spirits are the root cause of boosts and busts of economic activity but that they have been consistently ignored in macroeconomic models.

[3] This definition borrows from the concept of directional spillovers in Diebold and Yilmaz (2008, p. 58−59).

idiosyncratic, such as shocks to the country risk premium, country credit, interest rates and inflation.[4]

We proxy the country risk premium with the historical volatility of stock returns. The correlation between stock volatility, the equity premium and the bond premium should be maintained by arbitrage and is well established in the literature (see for instance Famma and French, 1993, or French et al, 1987). Our country risk proxy enable us to use a single uniform measure of the country risk premium across economies. Given the correlation between stock volatility and the country risk premiums, we proxy systemic risk as the common factor, across systemic economies, of historical stock volatility. The factor model that helps extract systemic risk is embedded into a GSSM with five systemic economies (S−5) plus one synthetic economy for the rest of the world. In addition, the GSSM in this paper has another set of five economies, called non systemic, appended to the GSSM model as small open economies (SOEs). The systemic economies are those that are important for global financial and trade variables, namely, the United States, Europe, Japan, China, the United Kingdom. The non systemic economies are those that are not relevant for global financial and trade variables, here we deal with Brazil, Mexico, Colombia, Chile and Peru.

The factor-augmented GSSM enables us to study the systemic risk channel of monetary policy (systemic risk, country risk, aggregate demand, inflation) and the global credit channel (global credit, country credit, aggregate demand, inflation).

A semi structural model, like the one dealt with here, belongs in spirit to the New Neoclassical Synthesis (NNS). The equations in semi structural models can be derived from optimization but explicit optimization is set aside out of a desire to simplify.[5] 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 were rapidly incorporated into actual policy formulation with the implementation of inflation targeting around the world. In this global version of the model, common factors for country risk and country credit serve as proxies for systemic risk and the global financial cycle. The conclusions are staggering,

[4]Because a spillover is a transmission of volatility to another country, the convention here is that systemic factors may not spill volatility to the countries where they originate, only to non systemic economies. Nonetheless, in important papers elsewhere, commonalities have been regarded as a source of spillover or contagion, see for instance Canova (2005).

[5]See for instance the working paper version of Svensson (2000) were the appendix shows the derivation of the Phillips curve and he aggregate demand equations. In another paper, 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."

as systemic risk claims the bulk of forecast error variance decompositions, a conclusion a that is in line with the findings in Georgiadis and Jancokova who argue that, absent financial spillovers, global macroeconomic models may be misspecified.

As a GSSM, the model in the paper is related to the IMF Global Projection Model (GPM) developed by Douglas Laxton and colleagues (see Caravenciob et al, 2013). The GPM features a linkage from financial to real variables in the form of a financial-conditions variable, included in the output gap equation. Compared to the GPM, the model in this paper differs in three aspects. First, our measure of financial conditions, as said above, is the historical volatility of stock returns, instead of the Fed senior loan officer opinion survey on bank lending practices, as in the GPM. Second, we use common factors for historical volatility and country credit. Third, we use a set of countries intended to help study systemic and non systemic shocks and interest rate spillovers from different economies, instead of the countries in the GPM, that perhaps help serve analytical purposes more specific to the IMF.

One paper that deals with historical stock volatility and the global financial cycle is the one by Miranda-Agripino and Rey (2015). They construct two indicators of historical volatility. First, a factor model for a large number of risky asset returns and commodity prices. Second, the historical volatility of world stock markets, using the MSCI index. They show that both indicators relate well with the business cycle and also that they highlight some major financial events. In addition, using a Bayesian VAR, they show that bank leverage, credit and other financial variables are well explained by US monetary policy. Our paper differs from theirs in that systemic risk is estimated with a uniform measure across countries and that it is incorporated into a GSSM where we can measure systemic risk spillovers by means of a forecast error variance decomposition. Our paper also differs in the conclusions, as we argue that the literature could relieve some of the emphasis given to US interest rates.

The literature on spillovers has not addressed systemic shocks to date, but has instead focused on the effect of US interest rates on foreign output. Three papers are in order.

Ammer et al (2016), considers spillovers from US interest rates to foreign output. The authors use the SIGMA model of the Federal Reserve, with the United States and one foreign country. They consider three spillover channels: the exchange rate, aggregate demand and foreign financial conditions channels. 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. They also conclude that spillovers are stabilizing for foreign countries if they are in the same phase of the business cycle as the United States, and that they may be destabilizing if they are in the opposite phase.

Georgiadis (2015), studies spillovers from US interest rates to foreign output also. The author uses a VAR with 61 countries. He explains that spillovers increase with financial integration, trade integration and exchange rate rigidity. The author finds that spillovers are important, in some cases larger that the effect of US policy interest rates on US output. Also, the author points out that spillovers to emerging economies can be smaller than those to advanced economies.

Fukuda et al (2013), also studies the spillovers from US interest rates to foreign output. Using a DSGE, the authors explain that spillovers increase with financial and trade integration and decrease with the drop in the weight of the US in the world economy. They also explain that spillovers decrease with exchange rate flexibility, which increased as central banks shifted to inflation targeting. Also using a VAR for 28 developed and emerging economies, the authors conclude that spillovers dropped during the 2000s compared to the 1990s.

The paper is organized as follows. In the second section we present some of the features of the economies in the model. In the third section we explain the GSSM. Then, section four presents the detail of the data. Section five shows the calibration and estimation of the model. The sixth section presents the results. Section seven offers some conclusions and the Appendix presents some derivations.

2 The systemic and non systemic economies

As we mentioned in the introduction, systemic economies have relevance in financial markets, world output and trade. The output of the five largest systemic economies amounts to roughly half of world output (Table 1). The United Kingdom has the lowest weight in world output, about 2.6 percent; however, its relevance as systemic economy owes primarily to its importance as a financial center. Japan is still a rather large economy and it used to be among the largest three. Nonetheless, currently the largest three economies are the United States, Europe and China, accounting to 46.3 percent of world output.

Concerning 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.[6] Among the non systemic economies, Mexico is relatively opened while Brazil is relatively closed.

Regarding the weight of the economies as trade partners, the largest systemic economies, or the current G3, are the main trade partners for each and every systemic economy (Table 1). From the standpoint of the Latin American non systemic economies, only the United States and China are the main trade partners. For Mexico, the United States alone is the main trade

[6] European exports and imports reach 40.7 and 38.6 percent of output; however, as these figures also inlclude trade within European states, they were revised downwards by 7 percent so as to account only for the trade openness of Europe vis a vis the rest of the world.

partner.

As to financial integration, we deal with two measures. First the loading factor of country risk in the model. By this measure, the United States, Europe and the United Kingdom are the most integrated while China is less integrated (Table 1). In the systemic economies, Brazil appears as highly integrated while Colombia appears as less integrated. Turning to the second measure of financial integration, it is the correlation of country risk with the available measures of implicit volatility. By this measure, China, Colombia and Peru are less integrated. In Colombia and Peru, stock market volatility may be influenced by the movement in stocks related to commodity exports. A more comprehensive measure of country risk, involving not only stocks but also other financial markets, is a matter of future research.

Overall, we include the United States, Europe and China as systemic 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, in the former case, and relevance as a financial center, in the latter case. In the group of non systemic economies we include the largest Latin American economies even though the country risk indicator for Colombia and Peru may need to be enhanced in future research with the inclusion of data for other financial markets.

3 The model

A proper account of spillovers from systemic economies should cope with the world economy beyond the standard paradigms of the two-country and small open economy paradigms. It should involve a global model, ideally incorporating a large number of economies and interconnections. However, with the number of economies and interconnections, the time devoted to analysis and computations increases.[7] The GSSM in this paper deals with a relatively small number of systemic economies.[8] It also intends to shrink the number of interconnections by appending the five non systemic economies into the GSSM as small open economies; the non systemic economies do not add to world output or weight as trade partners for other economies. In other words, the systemic economies trade with themselves while the non systemic economies trade only with the systemic economies.[9]

In addition to the systemic risk and global credit channels, the GSSM in this paper splits

[7] Using a standar computer, the time devoted to computations in a global model with a standar computer can become an issue beyond three economies.

[8] For a set up were the world economy is one country, the S−1 model, see Julio, Gómez and Hernández (2017). In that set up, a small open economy for Colombia is appended into the global model.

[9] The aggregates for Latin America presented in some graphs and tables are PPP-weighted averages for the variables in each of the models for the economies in the region.

aggregate demand into absorption, exports and imports. This breakdown enables us to model and track trade spillovers more transparently than in models that simply include the exchange rate and foreign output in an aggregate demand equation.

Systemic risk and transmission to country risk premiums. At the country level, risk is denoted as $\hat{\rho}_t$, while at the global level, by $\hat{\rho}_t^S$. Country and systemic risk are given by the equations

$$\hat{\rho}_t = \alpha_1 \hat{\rho}_{t-1} + \alpha_s \hat{\rho}_t^S + \varepsilon_t^{\hat{\rho}} \tag{1}$$

and

$$\hat{\rho}_t^S = \alpha_5 \hat{\rho}_{t-1}^S - \alpha_y \hat{y}_{t+1|t}^{WO} + \alpha_r \hat{r}_t^{WO} + \varepsilon_t^{\hat{\rho}^S}, \tag{2}$$

where a hat denotes deviation from latent values, $\varepsilon_t^{\hat{\rho}}$ is a country-specific risk shock, $\varepsilon_t^{\hat{\rho}^S}$ is a systemic risk shock, $\hat{y}_t^{WO}$ is the world output gap, $\hat{r}_t^{WO}$ is the world real interest rate, defined as a PPP weighted average, and the α_S are the loading factors in the estimation of unobserved systemic risk. There is one equation of the type (1) for every economy.

The term $\hat{y}_{t+1|t}^{WO}$ is at the right hand side of Equation (2) as an accelerator mechanism. When expected world output gap drops, systemic risk rises, which emphasizes the drop in the world output gap. The term $\hat{r}_t^{WO}$ is at the right hand side of equation (2) following the literature on the effect of the US interest rate on (one of the meanings of) the world financial cycle, in our terminology, on systemic risk, see Miranda-Agripino and Rey (2015). The variables world output and world real interest rates are at the right hand side of equation (2) not only as an accelerator mechanism. They also belong to the equation following the literature on the effect of information, particularly, systemically-relevant information, on a common factor of stock volatility (called systemic risk here), see for instance King and Wadhwani (1989).

Latent country risk is given by

$$\bar{\rho}_t = \alpha_{14} \bar{\rho}_{t-1} + (1 - \alpha_{14}) \bar{\rho}^{ss} + \varepsilon_t^{\bar{\rho}}. \tag{3}$$

while latent systemic risk is given by a weighted average of the country risk premiums with weights given by PPP-adjusted shares in world GDP as follows:

$$\bar{\rho}_t^S = \Sigma_i \lambda_i \bar{\rho}_t. \tag{4}$$

Global and country credit. In like fashion, observed credit $\hat{\mu}_t$ and unobserved global credit $\hat{\mu}_t^S$ follow

$$\hat{\mu}_t = \beta_1 \hat{\mu}_{t-1} + \beta_y \hat{y}_t + \varepsilon_t^{\hat{\mu}}, \tag{5}$$

$$\varepsilon_t^{\hat{\mu}} = \beta_2 \varepsilon_{t-1}^{\hat{\mu}} + \beta_s \hat{\mu}_t^S + e_t^{\hat{\mu}} \tag{6}$$

and

$$\hat{\mu}_t^S = \beta_3 \hat{\mu}_{t-1}^S + \beta_4 \hat{y}_t^3 + \varepsilon_t^{\hat{\mu}^S}, \tag{7}$$

with one equation of the form (5) for each economy. In equation (5), the error term $\varepsilon_t^{\hat{\mu}}$ is the credit shock which will be made part of aggregate demand equation below, while the error term $\varepsilon_t^{\hat{\mu}^S}$ in equation (7) is the global credit shock.

Latent country credit follows

$$\bar{\mu}_t = \bar{\mu}_{t-1} + \frac{1}{4}\gamma_t^{\bar{\mu}} + \varepsilon_t^{\bar{\mu}} \tag{8}$$

and

$$\gamma_t^{\bar{\mu}} = \alpha_{13}\gamma_{t-1} + (1 - \alpha_{13})\gamma^{\bar{\mu},ss} + \varepsilon_t^{\gamma^{\bar{\mu}}}, \tag{9}$$

while latent global credit is given by

$$\bar{\mu}_t^S = \Sigma_i \lambda_i \bar{\mu}_t, \tag{10}$$

where $\varepsilon_t^{\hat{\mu}^S}$ a global credit shock and all coefficients are nonnegative.

Aggregate demand block. The output gap is obtained from the basic macroeconomic equation[10] that in deviation form can be written as

$$\hat{y}_t = \bar{c}\hat{c}_t + \bar{x}\hat{x}_t - \bar{m}\hat{m}_t, \tag{11}$$

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. Following the "minimalistic" approach of Rotemberg and Woodford (1998) and McCallum and Nelson (2001), there is no explicit variable for investment, for simplicity. Hence, absorption, denoted as c_t, accounts for consumption, investment, change in inventories, and government expenditure.

The task now is to propose behavioral equations for the terms at the right side of equation (11). Absorption is to follow the following augmented Euler equation:[11]

$$\hat{c}_t = \sigma_1 \hat{c}_{t+1|t} + \sigma_2 \hat{c}_{t-1} - \sigma_r^{-1}\hat{r}_t - \sigma_\rho^{-1}\hat{\rho}_t + \sigma_\mu \varepsilon_t^{\hat{\mu}} + \varepsilon_t^{\hat{c}}, \tag{12}$$

where $\hat{r}_t$ is the real interest rate, $\hat{\rho}_t$ is the country risk premium and $\varepsilon_t^{\hat{\mu}}$ is the credit shock explained before. The measure of country risk ρ_t, as said above, is proxied with historical stock volatility so that the measure is uniform across countries and the data are available. An also in the spirit of the financial accelerator, the equation is augmented with country credit, in the form of the credit shock explained above, see equation (5).

[10]The basic macroeconomic equation is $Y = C + I + G + X - M$ where the variables at the right hand side of the equation stand for real consumption, investment, government expenditure, exports and imports.

[11]For simplicity we denote $\mathrm{E}_t c_{t+1}$ as $c_{t+1|t}$.

Intuitively, the interest rate r_t accounts for the risk free, short term interest rate while the risk premium ρ_t accounts for risk in long term interest rates. In addition, the credit shock $\varepsilon_t^{\hat{\mu}}$ allows aggregate demand to be driven also by a stock variable, after controlling for the effect of output gap on the credit cycle as in equation (5). A derivation of equation (12) from fundamentals would have consumption and investment depend on household and firm wealth and credit, with wealth moving inversely with a risk premium—a standard set up under financial accelerator theory.[12]

We now turn to the exports and imports aggregates in equation (11), equations that are derived in more detail in the appendix. Exports rise with foreign absorption and the real exchange rate:

$$\hat{x}_t = \upsilon_1 \hat{x}_{t+1|t} + \upsilon_2 \hat{x}_{t-1} + (1 - \bar{m}_F)\upsilon_q \hat{q}_t + \upsilon_c \hat{c}_{F,t} + \varepsilon_t^{\hat{x}}, \tag{13}$$

where parameter $\bar{m}_F$ is the share of imports in output abroad, υ_q is the elasticity of substitution between domestic and imported goods, $q_t \equiv s_t + p_{F,t} - p_t$ is the real exchange rate, $p_{F,t}$ is the price of the foreign good and $c_{F,t}$ is foreign absorption.

In turn, imports increase with domestic absorption and decrease with the real exchange rate:

$$\hat{m}_t = \upsilon_1 \hat{m}_{t+1|t} + \upsilon_2 \hat{m}_{t-1} - (1 - \bar{m})\upsilon_q \hat{q}_t + \upsilon_c \hat{c}_t + \varepsilon_t^{\hat{m}}, \tag{14}$$

where $\bar{m}$ is the share of imports in output and υ_q is the elasticity of substitution between domestic and imported goods.

A standard approach in incorporating the absorption, exports and imports equations is to plug equations (12), (13) and (14) into equation (11) and derive a behavioral equation for the output gap where variables such as interest and exchange rates appear at the right hand side. This type of construct is commonly known as an aggregate demand equation. Under this approach, however, shocks to the output gap equation may include shocks to foreign absorption that affect exports. So, in order to account for foreign shocks clearly, the model runs with separate equations, and shocks, for absorption, exports and imports for each country.

Latent absorption is given by the stochastic processes

$$\bar{c}_t = \bar{c}_{t-1} + \frac{1}{4}\gamma_t^{\bar{c}} + \varepsilon_t^{\bar{c}} \tag{15}$$

and

$$\gamma_t^{\bar{c}} = \alpha_{13}\gamma_{t-1} + (1 - \alpha_{13})\gamma^{\bar{c},ss} + \varepsilon_t^{\gamma^{\bar{c}}}, \tag{16}$$

[12] The literature on the financial accelerator, originated in Gertler and Gilchrist (1999), was extended to a two country model in Gilchrist, Hairault and Kempf (2004). Other papers extended the financial accelerator from the balancesheet of enterpreneurs to those of the household (Aoki, Proudman and Vlieghe, 2002) and the banking sector (Choi and Cook, 2004). An important research topic is the study of these sectors' net worth in relation with the global financial cycle.

while latent exports and imports follow similar stochastic processes.

Potential output is obtained as

$$\bar{y}_t = y_t - \hat{y}_t, \tag{17}$$

where output is given by

$$y_t = \bar{c}c_t + \bar{x}x_t - \bar{m}m_t + \varepsilon_t^y, \tag{18}$$

where the error term ε_t^y is an accounting error allowing for changes in the share of absorption, exports and imports overtime.

Core inflation. Core inflation follows the Phillips curve

$$\pi_t^c = (1-\kappa_1)\pi_{t+1|t}^c + \kappa_1\pi_{t-1}^c + \kappa_y\hat{y}_t + \kappa_q\hat{q}_t^{RER} + \varepsilon_t^{\pi^c}, \tag{19}$$

where $\hat{q}_t^{RER}$ is the gap of the multilateral real exchange rate.

Core inflation is relevant for the estimation of potential output and the latent exchange rate. The reason is that level jumps in latent (potential) output and latent real multilateral exchange rate help improve the fit of the Phillips curve. But not all movements in core inflation are related to the output and exchange rate gaps. Core inflation, denoted as $\pi_{NS,t}^c$,[13] is in part noise, the part $\pi_{N,t}^c$, and in part signal, the part π_t^c. The later component is related with the output and exchange rate gaps. We then break down core inflation into the noise and signal components as follows:

$$\pi_{NS,t}^c = \pi_t^c + \pi_{N,t}^c. \tag{20}$$

An implicit inflation target for core inflation is given by detrended and trend components as follows:

$$\bar{\pi}_t = \bar{\pi}_t^{Det} + \bar{\pi}_t^{Trend}, \tag{21}$$

where

$$\bar{\pi}_t^{Det} = \kappa_2\bar{\pi}_{t-1}^{Det} + (1-\kappa_2)\pi_t^{Det,ss} + \varepsilon_t^{\bar{\pi}^{Det}}, \tag{22}$$

$$\bar{\pi}_t^{Trend} = \bar{\pi}_{t-1}^{Trend} + \frac{1}{4}\gamma_t^{\bar{\pi}^{Trend}} + \varepsilon_t^{\bar{\pi}^{Trend}} \tag{23}$$

and

$$\gamma_t^{\bar{\pi}^{Trend}} = \gamma_{t-1}^{\bar{\pi}^{Trend}} + \varepsilon_t^{\gamma^{\bar{\pi}^{Trend}}}. \tag{24}$$

Latent inflation $\bar{\pi}_t$ is unobserved while trend inflation $\bar{\pi}_t^{Trend}$ is observed and estimated outside the model with a local linear trend model with exogenous interventions.

[13] Notation $\pi_{NS,t}^c$ stands for noise and signal.

The policy rule. The central bank reaction function is a variant[14] of the Taylor (1993) rule $i_t = \bar{\imath}_t + 1.5\hat{\pi}_t^4 + 0.5\hat{y}_t + \varepsilon_t^i$, where $\hat{\pi}_t^4$ is CPI inflation over four quarters. As we do not deal with non core inflation, for simplicity, the Taylor rule is defined here on the basis of core inflation as follows:

$$i_t = \bar{\imath}_t + 1.5\hat{\pi}_t^{4,c} + 0.5\hat{y}_t + \varepsilon_t^i, \tag{25}$$

where the latent interest rate is $\bar{\imath}_t \equiv \bar{r}_t + \bar{\pi}_t^c$ and the real interest rate is defined as $r_t \equiv i_t - \pi_{t+1|t}^c$.

Following the stochastic processes for the implicit inflation targets, latent real interest rates $\bar{r}_t$ are also broken down into detrended and trend components, with latent real interest rates estimated as unobserved and trend interest rates estimated outside the model with a local linear trend model with exogenous interventions.

Uncovered interest rate parity. The uncovered interest rate parity condition (UIP) is augmented by risk as follows:[15]

$$q_t^{j|US} = q_{t+1|t}^{j|US} - \frac{1}{4}\left[r_t^{j,Det} - r_t^{US,Det} - \alpha_{12}\left(\rho_t^j + \rho_t^{US}\right)\right] + \chi_t^{j|US}, \tag{26}$$

where j denotes the country, $q_t^{j|US}$ is the log of the real bilateral exchange rate of country j against the US, $r_t^{j,Det}$ is the detrended real interest rate, $\rho_t^{j,Det}$ is the country risk premium and $\chi_{t-1}^{j|US}$ is a UIP shock.

The latent bilateral real exchange rate of country j against the US, $\bar{q}_t^{j|US}$, follows

$$\bar{q}_t^{j|US} = \gamma_t^{\bar{q}^{j|US}} + \bar{q}_{t-1}^{j|US} + \varepsilon_t^{\bar{q}^{j|US}} \tag{27}$$

and

$$\gamma_t^{\bar{q}^{j|US}} = \zeta\gamma_{t-1}^{\bar{q}^{j|US}} + (1-\zeta)\gamma^{\bar{q}^{j|US},ss} + \varepsilon_t^{\gamma^{\bar{q}^{j|US}}}. \tag{28}$$

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

$$\chi_{t-1}^{j|US} = \hat{\chi}_{t-1}^{j|US} + \bar{\chi}_{t-1}^{j|US}, \tag{29}$$

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

$$\bar{\chi}_{t-1}^{j|US} \equiv \bar{q}_t^{j|US} - \bar{q}_{t+1|t}^{j|US} + \frac{1}{4}\left[\bar{r}_t^{j,Det} - \bar{r}_t^{US,Det} - \alpha_{12}\left(\bar{\rho}_t^{j,Det} + \bar{\rho}_t^{US,Det}\right)\right]. \tag{30}$$

and the former is obtained as a residual.

[14] This variant is proposed by Svensson (1998).

[15] Note that unlike other equations in the model, the variable at the left hand side of equation (26) is not in deviation form. Hence, the UIP residual $\chi_t^{j|US}$ involves both deviation and latent components.

4 The data

Data are quarterly for the period 1996Q1−2016Q2. Table 3 presents the data sources for each variable and country as well as the seasonal adjustment and splicing, if any.[16]

First we deal with the historical volatility and the stock market data. Our measure of volatility σ_t, at every quarter t, is defined as the average of daily volatility

$$\sigma_t = \Sigma_{t=1}^{90} \boldsymbol{\sigma}_t^D / 90, \tag{31}$$

where daily volatility σ_i^D is the standard deviation of daily stock returns during the previous month, at an annual rate defined as

$$\boldsymbol{\sigma}_i^D = \sqrt{12 \frac{\Sigma_{i=1}^{30}(R_i - \bar{R})}{i-1}}, \tag{32}$$

where, $R_i = 30(\log x_i - \log x_{i-1})$ is the daily stock return at a monthly rate, $\bar{R}$ is the average daily stock return at a monthly rate and x_i is the stock market index on day i. Daily stock returns were calculated for the seven days of the week. Weekends and holidays were obtained by interpolation.[17]

Historical volatility for Europe was built as a weighted average for Germany, France, Italy, Spain, Hungry and Poland, with weights given by the shares in world output, rescaled so that the weights would add up to one.

For Colombia, Indonesia and Italy, the country stock market indexes had to be spliced with older stock market indexes. We choose those indexes that would include the largest number of stocks in each country.[18]

Second, we discuss the National Income and Product Accounts (NIPA) data. The macroeconomic variables extracted from the NIPA data were output (GDP), 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 Russia and Indonesia where yearly data was transformed into quarterly frequency with the Boot et al (1967) method. For Russia, yearly data covered the period 1996−2003, afterwards quarterly data was obtained from the OECD Statistics database. For Indonesia, quarterly data was obtained from the yearly data for the entire sample.

Third, 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).

[16] For the seasonal adjustment we used the x11 method.

[17] Because in the absorption equation (12) historical volatility is multiplied by the inverse of an inter-temporal elasticity of substitution, σ_ρ^{-1}, we multiplied historical volatility by 5/100 so as to obtain σ coefficients comparable to those that multiply interest rates in the absorption equation.

[18] Indonesia is in a second group of non systemic economies to be expleined below in the data section.

Fourth, we take a look at the core inflation data. Inflation refers to the CPI excluding food and energy, available for a large number of countries from the country statistics departments and central banks. 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 Mexico, Colombia, Chile and Peru.

Fifth, we consider the trade data necessary for the calibration of the model. On one hand these trade data is the share of the countries in exports and imports trade. These shares were calculated from the World Trade Organization (WTO) Statistics Database. The share of the rest of the world in export and import trade were obtained as residuals. The shares of the systemic economies in the exports and imports of the rest of the world was calculated as a PPP weighted average for a second group of non systemic economies, to be explained below. On the other hand the trade data needed for the calibration of the model are the shares of exports and imports in output. These shares were calculated from the NIPA at current prices, using the same sources as in the NIPA in real terms.

Sixth, we deal with the credit data. The source was the Federal Reserve Bank of Saint Louis database (FRED). Credit data entered the model in real terms, using as deflator the CPI.

Seventh, we consider the exchange rate data. The source is Bloomberg Financial Services.

We now turn to the aggregation method. Aggregates for the rest of the world and Latin America were calculated as weighted averages with weights given by the share of country output in world output, evaluated at PPP exchange rates. These shares correspond to the year 2015 and were taken from the World Economic Outlook database of October 2016. The weights for the systemic and non systemic economies in the model appear in Table 1. The systemic economies add up to 54 percent of world output. The rest of the world output should add up to 46 percent but for simplicity we proxied this block with data for a second group of non systemic economies whose aggregate share in world GDP is 17 percent. In the second group of non systemic economies, each economy has a share in world GDP larger than one percent and does not belong to the group of non systemic, Latin American economies. The economies in the second group of non systemic economies are India, Russia, Korea, Canada, Indonesia, Turkey and Australia, with weights in world output of 6.5, 3.0, 2.0, 1.6, 1.6, 1.3 and 1.1, respectively. The aim of the second group of non systemic economies is to approximate the variables for rest of the world. Still, in the model, the share of the rest of the world in world variables is 46 percent. As for Latin America, the weight of the five non systemic economies in world output is 6.3 percent. Importantly, Brazil and Mexico have shares in world output larger than one percent: of 2.9 and 2.0 percent, respectively.

Within the second group of non systemic economies, data for output, absorption, exports and imports was first rebased to 2014Q2 = 100. The data was then aggregated using shares in world GDP at PPP exchange rates. These weights were rescaled so that they would add up to one.

Finally, we consider the data that for any reason we could not use. On one hand, data for implicit volatility are available for a few countries with markets for stock volatility options. We then used data for implicit volatility outside the model, for comparison with the estimated indicator of systemic risk. On the other hand, residential property prices were not available for the whole sample for some countries (Table 3). We then did not use residential property prices in our measure of the financial cycle.

5 Calibration and estimation

The estimated coefficients were obtained by Bayesian maximum likelihood. The estimated parameters were those related to the systemic risk channel, α_s, the global financial channel, β_s, the absorption equations, σ_ρ, σ_r and σ_μ, the exports equations, υ_q and υ_c, and the imports equations, ν_q and ν_c. Priors for the estimated parameters, as well as the values of the calibrated coefficients, were set so as to obtain reasonable impulse responses, latent variables, historical error decompositions and forecast error variance decompositions.

Table 4 reports some of the calibrated and estimated parameters for equations (2) and (7). Systemic risk has some persistence, $\alpha_5 = 0.63$. The financial accelerator coefficients $\alpha_y = \alpha_r = 0.04$ are set at rather conservative values to prevent oscillations in impulse responses. Global credit has a persistence comparable to that of business cycles $\beta_3 = 0.8$. The demand for real credit also depends of the output gap in the transatlantic economies, $\beta_4 = 0.5$. The persistence of country credit β_1 and its response to the country output gap β_y are zero in the transatlantic economies because in these economies global credit helps explain the country credit cycle. In turn, global credit is explained by some persistence, $\beta_3 = 0.8$, and a response to the output gap, $\beta_4 = 0.5$.

Table 5 reports the results of the estimation. Posterior estimates are different from prior means, reflecting the contribution of the historical information to the estimated parameters. Nonetheless, the estimated posterior modes are also close to the prior modes, reflecting the tightness of the imposed priors as they also satisfy criteria such as reasonable impulse responses, historical decompositions and forecasting performance.[19]

[19] The estimation was computationally demanding. 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 with each run taking about 172 hours in computer time with an i7 processor and 16GB in memory. For more detail on the estimation process see Gómez and Julio (2016).

Stochastic processes for the unobserved latent values were estimated jointly with the estimated coefficients, the usual practice with the multivariate Kalman filter. However, as a detailed calibration of the 285 variances in the model proved time expensive, we incorporated extra-model information for some latent variables, namely, latent absorption, exports and imports, the implicit inflation target and the natural real interest rate. The remaining latent variables, namely, systemic and country risk, global and country credit and exchange rates, remained estimated with the multivariate Kalman filter. The extra model information was estimated with local-linear-trend filters, augmented with priors. These latent values were incorporated in the model with a slack constraint so that the information could feed the global model up to the point deemed necessary. For example, the slack variable for absorption, exports and imports in Japan and China was infinite so that in these cases potential output was estimated solely with the multivariate Kalman filter.

The error terms in equations (1), (2), (5), (7), (12), (13), (14), (19), (25), (26), and the deviation part of equation (29) were correlated so as to improve the fit of the model. The correlation coefficient was set at 0.5 to maintain reasonable impulse responses and historical decompositions.

6 Results

The results section begins with the impulse responses. In particular, we deal with those shocks that can help illustrate the role of financial and trade linkages; namely, systemic risk, foreign interest rates and foreign aggregate demand shocks.

Then, we show the smoothing results or the estimated unobserved variables in latent and deviation form. Here we present the estimated systemic risk, the global credit cycle and gaps for variables such as output, absorption, exports, imports and the trade balance. We also discuss the behavior of other important latent variables such as the natural rate of interest and the implicit inflation targets for core inflation.

We then turn to the historical decomposition exercises. The emphasis here is twofold. First, we highlight the relevance of the systemic risk channel. Systemic risk shocks are shown to be key in the historical decompositions of systemic risk, country risk, and country output gaps. Second, we ask about the role of US interest rates, as the literature emphasizes, and more generally, the role of world interest rates, in the global financial cycle.

Next, the results deal with forecast error variance decompositions. Here the focus is on the overwhelming relevance of systemic-risk spillovers and the surprising unimportance, in contrast with the literature, of US interest rate spillovers.

Impulse responses. A first approach to spillovers takes recourse to impulse responses. Table 6 shows the peak response of output, core inflation and interest rates to some relevant shocks. Shocks to systemic risk have large effects on output, inflation and interest rates worldwide. In contrast, interest rate shocks, the workhorse of the spillovers literature, affect output and inflation to a lesser extent. The response of output and inflation to an interest rate shock abroad (a measure of spillovers) is about a tenth of the effect of a shock at home. Spillovers are largest for shocks to US interest rates, although the effect is only of about 3/100 per unit shock in the US rate. Shocks to interest rates in the rest of the world appear important; however, this result should be read with caution as interest rate shocks in the rest of the world do not represent the monetary policy of a real economy, merely the residual of the policy rule of a synthetic economy, a weighted average of group of countries. Shocks to absorption, in Table 7, should show the relevance of trade effects, as foreign absorption begets exports, but the size of the effect is negligible. Trade effects are small, particularly when compared to the effect of financial, systemic risk shocks.

The heterogeneity in the response to systemic risk shocks depends primarily on the loading factors α_s, which we have used as an indicator of financial integration. In turn, the heterogeneity in the response to foreign interest rate shocks depends on factors such as trade openness, which have been highlighted in the literature.

Global credit shocks can have some effects beyond the transatlantic economies. The reason is that credit affects output in the transatlantic economies and (expected) output in turn affects systemic risk as well as trade. The response of the output gap to a global credit shock, nonetheless, appears small compared to the response to a systemic risk shock or even to a policy interest rate shock.

Smoothing results. Estimated, unobserved systemic risk follows the shape and turning points of implicit volatility (Figure 1). The correlation between the estimated unobserved systemic risk with implicit volatility in the United States, Europe, Japan and the United Kingdom is 88.3, 77.3, 87.2 and 84.4, respectively.[20]

As for global credit, in Figure 2, it is merely a transatlantic phenomenon, involving the United States, Europe and the United Kingdom. Other countries in the model, systemic or non systemic, do not appear to contribute to this cycle.

Other important smoothing information refers to output, absorption, exports, imports and the trade balance. The output gap dropped in all countries during the global financial crisis. In

[20] The correlation is for quarterly data for the period 1996Q1−2016Q2. Implicit volatility in the United States was measured with the VIX index, in Europe (Germany) with the VDAX, in the United Kingdom with the IVUKX30 and in Japan with the VXJ.

the aftermath, the output gap recovered quickly in the non systemic economies but stagnated in the systemic, developed economies. In Europe, economic activity went through a prolonged recession of idiosyncratic nature (Figure 3). The prolonged recession intensified in 2012 with the European crisis.

During the great recession imports dropped more than exports in the United States and the United Kingdom so that the trade balance improved. Correspondingly, absorption dropped more than output. Surprisingly, the European trade balance does not seem to have improved during the great recession. It only improved since 2012 with the European crisis; yet, the improvement was mild (Figure 3 and 4).[21]

The surge in the Chinese output gap after the global financial crisis can help explain the recovery in the emerging economies output gap in the aftermath of the global financial crisis. It is surprising that the Chinese output gap has shown a negative correlation with that of the US.

The Latin American output gap correlates well with the world output gap, and also has larger variance (Figures 3 and 4). During the global financial crisis, and also since mid-2015, absorption fell more than output with a slight improvement in the trade balance.

Natural interest rates are decreasing in all countries, systemic and not systemic alike (Figure 5). In turn, implicit inflation targets are decreasing in the rest of the world as well as in most non systemic economies (Figure 6).

Historical error decompositions. Baekert et al (2013) and Miranda and Rey (2015) point at the relevance of the US policy interest rate as the driver of the global financial cycle.[22] To translate their argument into the terms of this paper, they argue about an effect of US interest rates on systemic risk. US policy interest rate shocks are one of the drivers of systemic risk (Figure 7, Panel A); nonetheless, the historical decomposition results indicate that the most important volatility factor explaining systemic risk is systemic risk shocks, while other drivers such as US, as well as other-country interest rates, appear unimportant (Figure 7, Panel A).

Likewise, US interest rates are but one element triggering the global credit cycle (Figure 7, Panel B). Shocks to the output gap and to systemic risk are also important factors (Figure 7, Panel B).

At the country level, some important historical decompositions are those to country risk, credit gaps and output gaps. The historical decomposition of country risk premiums (Figure 8) shows that US interest rates are not an important element explaining country risk, even in the

[21] In Figures 3 and 4, absorption, exports and imports are depicted as approximate percent of GDP and obtained as $\tilde{c}_t = \bar{c}\hat{c}_t$, $\tilde{x}_t = \bar{x}\hat{x}_t$, and $\tilde{m}_t = \bar{m}\hat{m}_t$, respectively.

[22] Bekaert et al (2013) argues that the two components of implied volatility, historical volatility and risk aversion, are both driven by US monetary policy and that they seem to drive the business cycle.

United States. The relevant volatility factor is systemic risk shocks.

The historical decomposition of country credit gaps (Figure 9) also shows that the emphasis in US interest rate shocks seems overrated (Figure 9). Shocks to systemic risk and to the output gap are the important volatility factors.

The relevance of systemic risk shocks stands out in the historical decomposition of output gaps (Figure 10). Systemic risk shocks help explain the expansion during the great moderation and the contraction that ensued. Likewise, in the rest of the world as well as in Latin America, systemic risk shocks help explain the run up to the end of the century crisis and its aftermath.

Forecast error variance decomposition. As said above, our measure of spillovers is the fraction of the forecast error variance explained by a given shock. Systemic risk shocks explain most of the forecast error variance at long horizons. Figure 11 shows the contribution of systemic risk shocks to the forecast error variance of inflation, the output gap and the policy interest rate.[23] At about 16 quarters, when the forecast decomposition settles on a constant for most variables, systemic risk shocks explain 87.8 percent of the forecast error variance of inflation, on average across countries, 77.5 percent of the output gap and 73.1 percent of the policy interest rate.

The remainder of the forecast decomposition results is presented in six tables, the first three split the forecast error variance of output growth, core inflation and interest rates into systemic shocks, local shocks and spillovers. The last three split the spillover part of the proceeding three tables into the spillovers from interest rates and core inflation.

Tables 8 to 10 show that, compared with systemic risk shocks, other volatility factors are of second order relevance, particularly interest rate spillovers, the focus of the existing literature. Tables 8 to 10 also show the secondary role played by local shocks. Local shocks are volatility factors with country-specific relevance, particularly shocks to interest rates and core inflation. Finally, tables 8 to 10 show the much-diminished importance of spillovers.

Tables 11 to 13 present a breakdown of interest rate and core inflation spillovers across source countries. Spillovers from the United States are relatively important but do not explain more than one percent of the forecast error variance of output growth, core inflation or interest rates, except for output growth in Mexico. Spillovers from the rest of the world appear important as well; although their relevance owes to the weight of the the-rest-of-the-world synthetic economy in the world economy, not to the role of the monetary policy of a real-world economy. All in all, only with one exception, US interest rate spillovers are unimportant as they do not explain

[23] In tables 7 to 12 the countries under study are along the columns while the volatility factors are along the rows. Note that from the stand pont of the nonsystemic economies, systemic shocks are spillovers. In addition, the world as a whole does not receive spillovers.

more than one percent of the forecast error variance of output growth, core inflation and interest rates in each country.

7 Conclusions

Systemic risk was the main volatility factor in all economies. It is also the main factor explaining impulse responses, historical decompositions and forecast error variance decompositions. Other financial factors such as global credit and foreign interest rates rarely accounted for shares of forecast error variance above one percent. Trade-related volatility factors, such as shocks to foreign absorption, did not help explain relevant shares of forecast error variance either.

In contrast with the literature, US interest rate spillovers were surprisingly small, explaining under one percent of the forecast error variance decomposition of output growth, core inflation and interest rates.

Also in contrast with the literature, US interest rates were not the main driver of the global financial cycle (of systemic risk in our terminology). Instead, interest rate shocks in the US and in other countries explained limited fractions of the forecast decomposition of systemic risk. Indeed, the main volatility factor explaining systemic risk were the shocks to systemic risk themselves.

The paper presented some evidence about the overwhelming relevance of systemic risk and the lesser importance of US interest rates in the global transmission of shocks. This evidence suggests that the literature could benefit from incorporating global confidence variables into global frameworks in the study of the global transmission of shocks.

As framework, we used a GSSM augmented with common factors for country risk and country credit. In the model, we approximated country risk with historical stock volatility, a measure that is uniform and available across countries, in addition, we measured spillovers as the share of forecast error variance explained by different volatility factors.

Among the policy implications the first conclusion is the relevance of the global financial context. Authorities need to follow the global financial context, particularly, they need to monitor confidence variables, risk measures and measures of financial volatility, including implicit volatility. The current rise in country risk in Brazil is pointing to a crisis of idiosyncratic nature, but careful monitoring of systemic risk measures may indicate when these crises are systemic. In these cases international cooperation may be called for.

Another policy implication is that markets for stock volatility options may need to be promoted or developed, owing to the value of the information contained in implicit volatilities. In addition, analysts probably need to weight the relevance of US policy rate developments.

At present, policy analysis at central banks and international institutions is informed by model forecasts and model scenarios. Although models can help formalize our understanding of the transmission of shocks, failure to include the global financial transmission channels in models can bias the analysis, giving undue emphasis to variables with otherwise limited influence. In this light, our policy implications are in line with those of Georgiadis and Jancokova (2017).

The paper has a number of important limitations. Systemic risk is measured as the common factor of historical stock volatility. Ideally, we would use risk measures from other financial markets, particularly for Colombia and Peru, but the task is beyond the scope of this paper. Data needs may be demanding. For instance, data for implicit volatility are available only for a few countries with markets for stock volatility options. Likewise, the financial cycle was measured with a factor model for real credit alone because data for property prices was not available for some countries for the period under study.

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Appendix: Exports and imports equations

For simplicity, let us assume there are two economies in the world, Europe and the United States. There is one household in each economy that consumes a composite of the goods produced in Europe and in the US. The good consumed in Europe $C_{EU,t}$ is defined as a composite of both the good produced in Europe $C_{EU|EU}$ and the good produced in the US $C_{EU|US}$ according to the following aggregator:

$$C_{EU,t} = \left[(1-\bar{m}_{EU})^{\frac{1}{\upsilon}} \left(C_{EU|EU,t} \right)^{\frac{\upsilon-1}{\upsilon}} + \bar{m}_{EU}^{\frac{1}{\upsilon}} \left(C_{EU|US,t} \right)^{\frac{\upsilon-1}{\upsilon}} \right]^{\frac{\upsilon}{\upsilon-1}}, \tag{33}$$

where $\bar{m}_{EU}$ is the share of imports in total consumption in Europe and υ is the elasticity of substitution between European- and US-produced goods.

Let $P_{EU|EU,t}$ be the price in Europe of the good produced in Europe and $P_{EU|US,t}$ the price in Europe of the good produced in the US. Using these prices, household expenditure is

$$P_{EU|EU,t}C_{EU|EU,t} + P_{EU|US,t}C_{EU|US,t}. \tag{34}$$

Define the exchange rate of Europe against the US as $S_{EU|US}$. Arbitrage ensures that the following conditions hold

$$S_{EU|US}P_{US|US} = P_{EU|US} \tag{35}$$

and

$$S_{EU|US}P_{US|EU} = P_{EU|EU}. \tag{36}$$

In words, price arbitrage holds in both goods.

The household problem is to minimize (34) subject to (33). The solution to the problem gives the demand functions

$$C_{EU|EU,t} = (1 - \bar{m}_{EU})\,(Q_{EU|US,t})^{\bar{m}_{EU}\upsilon} C_{EU,t}, \tag{37}$$

$$C_{EU|US,t} = \bar{m}_{EU}(Q_{EU|US,t})^{-(1-\bar{m}_{EU})\upsilon} C_{EU,t}, \tag{38}$$

$$C_{US|US,t} = (1 - \bar{m}_{US})(Q_{EU|US,t})^{-\bar{m}_{US}\upsilon} C_{US,t} \tag{39}$$

and

$$C_{US|EU,t} = \bar{m}_{US}(Q_{EU|US,t})^{(1-\bar{m}_{US})\upsilon} C_{US,t}, \tag{40}$$

where $Q_{EU|US,t} = S_{EU|US}P_{EU}/P_{US}$.

For ease in exposition we denote exports $C_{US|EU,t}$ as $X_{EU,t}$ and imports $C_{EU|US,t}$ as $M_{EU,t}$. In addition, in log deviation form, equations (38) and (40) become

$$\hat{x}_t = (1 - \bar{m}_F)\upsilon\hat{q}_t + \hat{c}_{F,t} \tag{41}$$

and

$$\hat{m}_t = -(1 - \bar{m})\upsilon\hat{q}_t + \hat{c}_t, \tag{42}$$

where parameter $\bar{m}_F$ is the share of imports in output abroad, υ is the elasticity of substitution between domestic and imported goods, $q_t \equiv s_t + p_{F,t} - p_t$ is the real exchange rate, $p_{F,t}$ is the price of the foreign good and $c_{F,t}$ is foreign absorption and $\bar{m}$ is the share of imports in output.

Table 1. Some descriptive facts

	Share in world output (2)	Openess (3)		Weight as trade partner												Financial integration (5)	
				Share in exports (4)						Share in imports (4)						Loading factor for systemi c risk	Loading factor for global credit
		Export s	Impor ts	United States	Europ e	Japan	China	United Kingd om	Remai ning countr ies	United States	Europ e	Japan	China	United Kingd om	Remai ning countr ies		
United States	17.9	12.5	16.3		7.1	4.1	7.7	3.7	77.2		10.2	5.9	21.8	2.6	59.7	1.11	1.3
Europe	11.1	33.7	31.6	7.9		1.3	3.9	6	80.9	5.8		1.5	7.9	3.4	81.4	1.09	1.3
Japan	5.1	15.9	16.0	20.2	4.4		17.5	1.7	56.2	10.9	6.5		25.6	1.1	55.8	1.07	0
China	17.3	27.8	23.2	18	6.4	6		2.6	67	9.0	8.0	8.5		1.1	73.4	0.55	0
United Kingdom	2.6	27.9	30.2	14.9	21.4	1.4	5.9		56.3	9.2	28.6	1.6	10.0		50.7	1.05	1.1
Remaining countries (1	46.0	27.9	28.1	21.4	38.9	6.5	28.3	4.8		26.4	37.3	6.7	23.6	6.1		0.95	0
Brazil	2.9	12.2	12.7	12.7	7.2	2.5	18.6	1.5	57.5	15.6	6.0	2.9	17.9	1.7	55.9	1.4	0
Mexico	2.0	30.4	31.8	81.2	2.8	0.8	1.3	0.5	13.4	47.4	3.6	4.4	17.7	0.6	26.4	1	0
Colombia	0.6	16.9	20.2	28.1	7.5	1.4	6.3	1.8	54.7	28.9	11.0	2.3	18.6	1.0	38.4	0.6	0
Chile	0.4	37.1	32.8	13	6.4	8.6	26.3	1.1	44.5	18.7	3.8	3.3	23.5	0.8	49.9	0.75	0
Peru	0.4	27.3	24.3	15.1	8	3.4	22.1	1.4	49.5	20.5	3.5	2.8	22.7	0.8	50.5	0.95	0

1. Shares in nominal output and shares in exports and imports for the remaining countries are a PPP weigthed averages of India, Korea, Indonesia, Rusia, Canada, Turkey and Australia.
2. Source: WEO database, evaluated at PPP exchange rates on 2015.
3. Meadured as the share of nominal exports and impots in nominal GDP. Source: World Bank, average for 2006-2015.
4. Source: WTO.
5. The loading factors are taken from the model in the paper.

Table 2. Financial integration: correlation between risk measures

	Systemic risk	VIX	VUK	VDAX	VXJ
Systemicrisk	1	0.88	0.87	0.77	0.84
Country risk					
United States	0.87	0.94	0.91	0.78	0.83
Europe	0.85	0.88	0.93	0.89	0.76
Japan	0.82	0.73	0.73	0.59	0.94
China	0.38	0.41	0.29	0.19	0.32
United Kingdom	0.87	0.89	0.95	0.83	0.82
Rest of the world	0.71	0.72	0.69	0.58	0.63
Brazil	0.87	0.67	0.71	0.62	0.66
Mexico	0.85	0.71	0.65	0.58	0.57
Colombia	0.42	0.17	0.20	0.18	0.28
Chile	0.76	0.63	0.66	0.57	0.58
Peru	0.63	0.45	0.44	0.28	0.56

Correlations are for the period 1996Q1-2016Q2.

Table 3. Data sources

Variable	Source	Country	End of period or average, seasoal djustment and splicing
Historical volatility	Bloomberg Financial Services	All countries	Average for the quarter, not seasonally adjusted
Credit to the private non-nonfinancial sector	Federal Reserve Bank of Saint Louis	All countries	End of period, seasonally adjusted
Exchange rates	Bloomberg Financial Services	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
Shares in export and import trade	World Trade Organization	All countries	The shares are for the year 2015
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 excluding food and energy	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 services	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	We did not find data for the price of real state since 1996 for Japan, China, Brazil, Mexico and Chile and Peru.	

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. Some calibrated
and estimated parameters

Calibrated paramemters		Estimated parameters		
		Coefficient	Prior	Posterior
α_5	0.63	α_y	0.04	0.04
β_3	0.8	α_r	0.04	0.04
		β_4	0.50	0.498

Table 4. Some calibrated parameters (continued)

	β_1	β_y	α_1	σ_1	σ_2
United States	0	0	0	0.03	0.78
Europe	0	0	0	0.03	0.78
Japan	0.78	0.1	0	0.03	0.78
China	0.78	0.75	0.55	0.03	0.78
United Kingdom	0	0	0	0.03	0.78
Rest of the world	0.78	0.9	0.55	0.03	0.78
Brazil	0.78	1	0	0.03	0.78
Mexico	0.78	0.5	0	0.03	0.78
Colombia	0.78	0.5	0	0.03	0.78
Chile	0.78	0.5	0	0.03	0.78
Peru	0.78	0.8	0	0.03	0.78

Table 5. Estimation results

Coefficient	α_s		β_s		σ_ρ		σ_r	
	Prior	Posterior	Prior	Posterior	Prior	Posterior	Prior	Posterior
United States	1.11	1.078	1.3	1.299	1.2	1.211	5	4.999
Europe	1.09	1.082	1.3	1.277	1.5	1.507	5	4.980
Japan	1.07	1.062			1.42	1.436	5	4.996
China	0.55	0.551			1.5	1.526	5	4.994
United Kingdom	1.05	1.050	1.1	1.104	1.15	1.147	5	4.981
Rest of the world	0.95	0.953			1.45	1.459	5	4.990
Brazil	1.40	1.386			1.3	1.320	5	4.986
Mexico	1.00	0.998			1.3	1.301	5	5.037
Colombia	0.60	0.607			1.2	1.206	5	5.008
Chile	0.75	0.758			1.3	1.316	5	5.022
Peru	0.95	0.959			1.3	1.310	5	5.043

Coefficient	σ_μ		u_q		u_c		v_q	
	Prior	Posterior	Prior	Posterior	Prior	Posterior	Prior	Posterior
United States	0.03	0.029	0.15	0.151	0.7	0.692	0.15	0.15
Europe	0.03	0.030	0.15	0.151	0.5	0.509	0.15	0.15
Japan	0.05	0.050	0.15	0.150	0.6	0.596	0.15	0.15
China	0.05	0.050	0.15	0.150	0.5	0.501	0.15	0.15
United Kingdom	0.04	0.039	0.15	0.151	0.6	0.599	0.15	0.15
Rest of the world	0.05	0.049	0.15	0.151	0.3	0.297	0.15	0.15
Brazil	0.05	0.050	0.15	0.150	0.6	0.599	0.15	0.15
Mexico	0.04	0.039	0.15	0.150	0.6	0.602	0.15	0.15
Colombia	0.05	0.050	0.10	0.100	0.6	0.603	0.15	0.15
Chile	0.05	0.050	0.10	0.100	0.6	0.596	0.15	0.15
Peru	0.05	0.050	0.15	0.151	0.6	0.599	0.15	0.15

Coefficient	v_c		k_1	
	Prior	Posterior	Prior	Posterior
United States	0.6	0.600	0.9	0.906
Europe	0.6	0.601	0.9	0.903
Japan	0.6	0.600	0.9	0.905
China	0.6	0.600	0.9	0.903
United Kingdom	0.6	0.599	0.9	0.904
Rest of the world	0.6	0.599	0.9	0.901
Brazil	0.6	0.600	0.9	0.906
Mexico	0.6	0.600	0.9	0.905
Colombia	0.6	0.600	0.9	0.905
Chile	0.6	0.601	0.9	0.904
Peru	0.6	0.600	0.9	0.904

α_y	
Prior	Posterior

α_r	
Prior	Posterior

β_4	
Prior	Posterior

Table 6. Peak responses to systemic risk, global credit and interest rate shocks

	Shock to systemic risk (one standard deviation shock)	Shock to global credit (one standard deviation shock)	Shock to the policy interest rate (unit shock)										
			Shock in the United States	Shock in Europe	Shock in Japan	Shock in China	Shock in United Kingdom	Shock in the rest of the world	Shock in Brazil	Shock in Mexico	Shock in Colombia	Shock in Chile	Shock in Peru
Peak response of the output gap													
United States	-1.37	0.10	-0.21	-0.02	-0.01	-0.02	-0.02	-0.09	0.00	0.00	0.00	0.00	0.00
Europe	-1.39	0.08	-0.03	-0.21	-0.01	-0.02	-0.01	-0.10	0.00	0.00	0.00	0.00	0.00
Japan	-1.25	0.02	-0.03	-0.01	-0.21	-0.02	0.00	-0.07	0.00	0.00	0.00	0.00	0.00
China	-1.05	0.02	-0.03	-0.01	-0.01	-0.20	0.00	-0.08	0.00	0.00	0.00	0.00	0.00
United Kingdom	-1.55	0.09	-0.04	-0.04	-0.01	-0.02	-0.19	-0.10	0.00	0.00	0.00	0.00	0.00
Rest of the world	-1.06	0.03	-0.03	-0.03	-0.01	-0.03	-0.01	-0.21	0.00	0.00	0.00	0.00	0.00
Brazil	-1.50	0.02	-0.03	-0.02	-0.01	-0.03	0.01	-0.08	-0.21	0.00	0.00	0.00	0.00
Mexico	-1.35	0.06	-0.09	-0.02	-0.01	-0.03	0.01	-0.07	0.00	-0.19	0.00	0.00	0.00
Colombia	-1.08	0.02	-0.03	-0.01	0.00	-0.02	0.00	-0.06	0.00	0.00	-0.20	0.00	0.00
Chile	-1.38	0.03	-0.04	-0.02	-0.01	-0.01	0.01	-0.10	0.00	0.00	0.00	-0.18	0.00
Peru	-1.37	0.03	-0.03	-0.02	-0.01	-0.02	0.00	-0.09	0.00	0.00	0.00	0.00	-0.19
Peak response of core inflation													
United States	-1.56	0.10	-0.11	-0.03	-0.01	-0.02	-0.02	-0.09	0.00	0.00	0.00	0.00	0.00
Europe	-1.38	0.07	-0.04	-0.10	-0.01	-0.02	-0.01	-0.09	0.00	0.00	0.00	0.00	0.00
Japan	-1.22	0.04	-0.04	-0.02	-0.09	-0.02	-0.01	-0.07	0.00	0.00	0.00	0.00	0.00
China	-1.23	0.04	-0.02	-0.02	-0.01	-0.10	-0.01	-0.08	0.00	0.00	0.00	0.00	0.00
United Kingdom	-1.41	0.08	-0.05	-0.03	-0.01	-0.02	-0.08	-0.09	0.00	0.00	0.00	0.00	0.00
Rest of the world	-0.98	0.06	-0.04	-0.04	-0.01	-0.02	-0.01	-0.10	0.00	0.00	0.00	0.00	0.00
Brazil	-1.08	0.05	-0.04	-0.02	-0.01	-0.02	-0.01	-0.07	-0.06	0.00	0.00	0.00	0.00
Mexico	-1.02	0.04	-0.06	-0.02	-0.01	-0.02	-0.01	-0.05	0.00	-0.05	0.00	0.00	0.00
Colombia	-0.98	0.02	-0.03	-0.01	0.00	-0.01	0.00	-0.04	0.00	0.00	-0.06	0.00	0.00
Chile	-1.02	0.03	-0.03	-0.01	-0.01	-0.01	0.00	-0.05	0.00	0.00	0.00	-0.05	0.00
Peru	-0.97	0.03	-0.02	-0.02	-0.01	-0.01	0.00	-0.06	0.00	0.00	0.00	0.00	-0.05
Peak response of policy interest rates													
United States	-2.28	0.15	0.90	-0.04	-0.01	-0.03	-0.03	-0.13	0.00	0.00	0.00	0.00	0.00
Europe	-2.27	0.10	-0.06	0.89	-0.01	-0.03	-0.01	-0.14	0.00	0.00	0.00	0.00	0.00
Japan	-1.92	0.06	-0.06	-0.03	0.89	-0.03	-0.01	-0.11	0.00	0.00	0.00	0.00	0.00
China	-2.01	0.07	-0.04	-0.03	-0.01	0.90	-0.01	-0.12	0.00	0.00	0.00	0.00	0.00
United Kingdom	-2.30	0.12	-0.07	-0.05	-0.01	-0.03	0.90	-0.14	0.00	0.00	0.00	0.00	0.00
Rest of the world	-1.31	0.09	-0.06	-0.05	-0.01	-0.03	-0.01	0.89	0.00	0.00	0.00	0.00	0.00
Brazil	-1.51	0.06	-0.06	-0.03	-0.01	-0.03	-0.01	-0.10	0.90	0.00	0.00	0.00	0.00
Mexico	-1.57	0.07	-0.10	-0.03	-0.01	-0.02	-0.01	-0.08	0.00	0.90	0.00	0.00	0.00
Colombia	-1.73	0.04	-0.04	-0.02	-0.01	-0.02	-0.01	-0.07	0.00	0.00	0.90	0.00	0.00
Chile	-1.88	0.04	-0.05	-0.02	-0.01	-0.02	-0.01	-0.10	0.00	0.00	0.00	0.91	0.00
Peru	-1.67	0.05	-0.04	-0.02	-0.01	-0.02	-0.01	-0.09	0.00	0.00	0.00	0.00	0.90
Standard deviation of the shock	0.63	0.74	0.60	0.41	0.92	0.87	0.88	2.96	4.46	2.84	2.95	1.60	3.95

Table 7. Peak responses to an absorption shock

	Shock to absorption (One unit shock)										
	Shock in the United States	Shock in Europe	Shock in Japan	Shock in China	Shock in United Kingdom	Shock in the rest of the world	Shock in Brazil	Shock in Mexico	Shock in Colombia	Shock in Chile	Shock in Peru
						Peak response of the output gap					
United States	0.99	-0.08	-0.02	-0.04	-0.05	0.21	0.00	0.00	0.00	0.00	0.00
Europe	-0.10	0.89	-0.02	-0.04	0.03	0.27	0.00	0.00	0.00	0.00	0.00
Japan	0.08	-0.05	0.92	0.06	-0.02	0.17	0.00	0.00	0.00	0.00	0.00
China	0.09	-0.06	0.03	0.81	-0.02	0.27	0.00	0.00	0.00	0.00	0.00
United Kingdom	0.15	0.14	-0.02	0.04	0.78	0.29	0.00	0.00	0.00	0.00	0.00
Rest of the world	0.10	0.12	0.02	0.08	0.02	0.82	0.00	0.00	0.00	0.00	0.00
Brazil	-0.09	-0.06	-0.02	0.05	-0.02	0.16	0.94	0.00	0.00	0.00	0.00
Mexico	0.38	-0.06	0.02	0.06	-0.04	0.13	0.00	0.75	0.00	0.00	0.00
Colombia	0.10	-0.04	-0.01	0.04	-0.02	0.13	0.00	0.00	0.89	0.00	0.00
Chile	0.12	-0.07	0.04	-0.04	-0.03	0.29	0.00	0.00	0.00	0.79	0.00
Peru	0.10	-0.06	0.02	-0.04	-0.02	0.24	0.00	0.00	0.00	0.00	0.84
						Peak response of core inflation					
United States	0.44	0.10	0.03	0.05	0.12	0.25	0.00	0.00	0.00	0.00	0.00
Europe	0.15	0.28	0.02	0.03	0.04	0.27	0.00	0.00	0.00	0.00	0.00
Japan	0.16	0.07	0.28	0.05	0.03	0.20	0.00	0.00	0.00	0.00	0.00
China	0.08	0.07	0.03	0.26	0.02	0.25	0.00	0.00	0.00	0.00	0.00
United Kingdom	0.17	0.14	0.02	0.04	0.21	0.27	0.00	0.00	0.00	0.00	0.00
Rest of the world	0.18	0.16	0.03	0.08	0.04	0.31	0.00	0.00	0.00	0.00	0.00
Brazil	0.16	0.08	0.02	0.05	0.04	0.20	0.15	0.00	0.00	0.00	0.00
Mexico	0.28	0.06	0.02	0.03	0.04	0.14	0.00	0.09	0.00	0.00	0.00
Colombia	0.10	0.03	0.01	-0.01	0.02	0.08	0.00	0.00	0.13	0.00	0.00
Chile	0.10	0.03	0.02	-0.02	0.02	0.15	0.00	0.00	0.00	0.11	0.00
Peru	0.09	0.05	0.01	-0.02	0.02	0.16	0.00	0.00	0.00	0.00	0.12
						Peak response of policy interest rates					
United States	0.72	0.14	0.04	-0.07	0.18	0.35	0.00	0.00	0.00	0.00	0.00
Europe	0.21	0.56	0.02	0.04	0.06	0.43	0.00	0.00	0.00	0.00	0.00
Japan	0.22	0.09	0.58	0.08	0.04	0.30	0.00	0.00	0.00	0.00	0.00
China	0.14	0.09	0.04	0.49	0.03	0.40	0.00	0.00	0.00	0.00	0.00
United Kingdom	0.25	0.21	0.03	0.06	0.48	0.43	0.00	0.00	0.00	0.00	0.00
Rest of the world	0.26	0.25	0.05	0.13	0.06	0.52	0.00	0.00	0.00	0.00	0.00
Brazil	0.21	0.11	0.03	0.07	0.05	0.28	0.53	0.00	0.00	0.00	0.00
Mexico	0.49	0.09	0.03	0.06	0.06	0.19	0.00	0.42	0.00	0.00	0.00
Colombia	0.15	0.05	0.01	0.03	0.03	0.13	0.00	0.00	0.50	0.00	0.00
Chile	0.15	-0.05	0.04	-0.04	0.02	0.28	0.00	0.00	0.00	0.44	0.00
Peru	0.14	0.06	0.02	-0.03	0.02	0.27	0.00	0.00	0.00	0.00	0.46
Standard deviation of the shock	0.65	0.64	0.94	1.13	0.88	0.72	1.35	1.17	1.41	1.97	1.81

Table 8. Output growth: forecast error variance decomposition into systemic shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

Volatility factors	World	United States	Europe	Japan	China	United Kingdom	Remaining countries	Latin America	Brazil	Mexico	Colombia	Chile	Peru
Systemic shocks	91.1	87.9	87.2	95.1	78.0	89.3	79.4	94.4	90.2	83.7	85.5	88.2	88.8
To systemic risk	91.1	87.9	87.2	95.1	78.0	89.3	79.4	94.4	90.2	83.7	85.5	88.2	88.8
To the global financial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Local shocks	8.9	10.2	10.7	3.1	19.2	8.4	19.5	3.7	8.4	13.2	13.2	9.6	9.3
To interest rates	7.7	9.2	9.5	1.9	14.3	6.9	16.5	3.2	7.7	10.1	11.6	7.7	8.0
To core inflation	0.4	0.4	0.3	0.4	0.6	0.3	0.6	0.1	0.2	0.6	0.4	0.4	0.3
To output gaps	0.6	0.4	0.7	0.6	1.5	1.0	1.8	0.2	0.3	1.6	0.6	1.1	0.6
To exchange rates	0.0	0.0	0.1	0.1	0.2	0.1	0.2	0.0	0.0	0.2	0.1	0.1	0.1
Other shocks	0.2	0.2	0.2	0.2	2.6	0.2	0.4	0.1	0.2	0.7	0.5	0.4	0.3
Spillovers		1.8	2.1	1.8	2.8	2.3	1.1	1.9	1.4	3.1	1.3	2.2	1.9

Table 9. Core inflation: forecast error variance decomposition into systemic shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

Volatility factors	World	United States	Europe	Japan	China	United Kingdom	Remaining countries	Latin America	Brazil	Mexico	Colombia	Chile	Peru
Systemic shocks	88.6	81.7	92.6	93.4	90.3	93.5	66.0	93.3	84.0	85.6	91.8	91.1	88.3
To systemic risk	88.6	81.7	92.6	93.4	90.3	93.5	66.0	93.3	84.0	85.6	91.8	91.1	88.3
To global credit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Local shocks	11.4	14.7	5.4	4.5	8.0	4.4	29.8	3.1	12.2	10.8	7.3	7.7	10.2
To interest rates	5.3	4.4	2.0	0.4	2.5	1.2	11.6	0.6	2.2	1.2	1.1	0.8	1.1
To core inflation	5.8	10.1	3.1	3.8	5.1	2.8	16.4	2.3	8.0	5.8	4.3	5.0	7.4
To output gaps	0.3	0.2	0.1	0.1	0.1	0.2	0.9	0.0	0.0	0.2	0.0	0.1	0.0
To exchange rates	0.0	0.0	0.1	0.1	0.2	0.1	0.5	0.1	0.3	0.3	0.1	0.1	0.2
Other shocks	0.1	0.0	0.0	0.1	0.1	0.0	0.5	0.0	1.6	3.3	1.8	1.7	1.5
Spillovers		3.5	2.0	2.1	1.7	2.2	4.2	3.6	3.8	3.6	0.9	1.2	1.5

Table 10. Policy interest rates: forecast error variance decomposition into systemic shocks, local shocks and spillovers

Percent of forecast error variance at twelve quarters

Volatility factors	World	United States	Europe	Japan	China	United Kingdom	Remaining countri	Latin America	Brazil	Mexico	Colombia	Chile	Peru
Systemic shocks	83.9	78.2	87.1	93.4	82.5	86.7	45.2	85.5	64.2	70.2	72.3	84.3	71.2
To systemic risk	83.9	78.2	87.1	93.4	82.5	86.7	45.2	85.5	64.2	70.2	72.3	84.3	71.2
To global credit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Local shocks	16.1	19.3	11.2	4.7	16.0	11.4	52.7	6.8	34.1	27.4	27.0	14.5	27.7
To interest rates	9.4	14.7	9.5	2.2	11.5	8.5	28.5	5.9	15.5	14.2	12.1	11.8	12.3
To core inflation	2.7	4.4	1.4	1.9	2.3	1.1	4.7	0.8	2.2	1.4	1.7	1.7	2.3
To output gaps	0.2	0.2	0.1	0.1	0.2	0.2	0.6	0.0	0.0	0.3	0.1	0.1	0.1
To exchange rates	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1
Other shocks	3.7	0.1	0.2	0.4	1.9	1.5	18.8	0.0	16.1	11.4	13.0	0.9	12.9
Spillovers		2.5	1.7	1.8	1.5	1.9	2.1	7.7	1.8	2.4	0.7	1.2	1.1

Table 11. Output growth: forecast error variance explained by spillovers

Percent of forecast error variance at twelve quarters

Volatility factors	United States	Europe	Japan	China	United Kingdom	Remaining countri	Latin America	Brazil	Mexico	Colombia	Chile	Peru
Spillovers												
Shocks to interest rates	1.6	1.7	1.5	2.3	1.9	0.8	1.6	1.2	2.6	1.2	2.0	1.6
From the United States		0.2	0.2	0.2	0.2	0.2	0.4	0.1	1.5	0.2	0.2	0.2
From the remaining countries	1.3	1.5	1.1	2.0	1.4		1.0	0.9	0.9	0.8	1.6	1.3
From other countries	0.3	0.1	0.2	0.1	0.3	0.6	0.2	0.1	0.2	0.1	0.1	0.1
Shocks to core inflation	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.5	0.1	0.2	0.2
From the United States	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.4	0.1	0.1	0.0
From the remaining countries	0.0	0.2	0.1	0.3	0.2	0.0	0.1	0.1	0.0	0.1	0.1	0.1
From other countries	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0

Table 12. Core inflation: forecast error variance explained by spillovers

Percent of forecast error variance at twelve quarters

Volatility factors	United States	Europe	Japan	China	United Kingdom	Remaining countries	Latin America	Brazil	Mexico	Colombia	Chile	Peru
Spillovers												
Shocks to interest rates	1.9	1.2	1.2	1.0	1.4	1.3	1.5	1.6	1.8	0.6	0.9	0.9
From the United States		0.2	0.2	0.1	0.2	0.6	0.4	0.3	0.8	0.1	0.1	0.1
From the remaining countries	1.5	1.0	0.9	0.8	1.0		1.0	1.2	0.8	0.4	0.7	0.7
From other countries	0.4	0.1	0.1	0.1	0.2	0.8	0.2	0.2	0.2	0.1	0.1	0.1
Shocks to core inflation	1.4	0.7	0.8	0.6	0.6	2.6	1.3	2.0	1.8	0.3	0.3	0.4
From the United States		0.2	0.4	0.0	0.2	0.9	0.8	0.8	1.6	0.2	0.1	0.1
From the remaining countries	0.1	0.5	0.3	0.5	0.3		0.3	0.9	0.0	0.0	0.1	0.3
From other countries	1.3	0.0	0.1	0.1	0.1	1.7	0.2	0.4	0.2	0.0	0.0	0.1

Table 13. Interest rates: forecast error variance explained by spillovers

Percent of forecast error variance at twelve quarters

Volatility factors	United States	Europe	Japan	China	United Kingdom	Remaining countries	Latin America	Brazil	Mexico	Colombia	Chile	Peru
Spillovers												
Shocks to interest rates	1.7	1.2	1.3	1.0	1.4	0.8	1.3	1.0	1.5	0.5	1.0	0.9
From the United States	0.0	0.2	0.2	0.1	0.2	0.3	0.4	0.1	0.8	0.1	0.1	0.1
From the remaining countries	1.4	1.0	0.9	0.8	1.0	0.0	0.8	0.7	0.6	0.4	0.8	0.7
From other countries	0.3	0.1	0.1	0.1	0.2	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Shocks to core inflation	0.7	0.4	0.5	0.4	0.4	1.1	0.6	0.7	0.8	0.1	0.1	0.2
From the United States	0.0	0.1	0.2	0.0	0.1	0.4	0.4	0.3	0.7	0.1	0.1	0.0
From the remaining countries	0.1	0.3	0.2	0.3	0.2	0.0	0.1	0.3	0.0	0.0	0.1	0.1
From other countries	0.7	0.0	0.1	0.0	0.1	0.7	0.1	0.1	0.1	0.0	0.0	0.0

Figure 1. Country risk and systemic risk

Solid line: country credit; dotted line: latent country credit

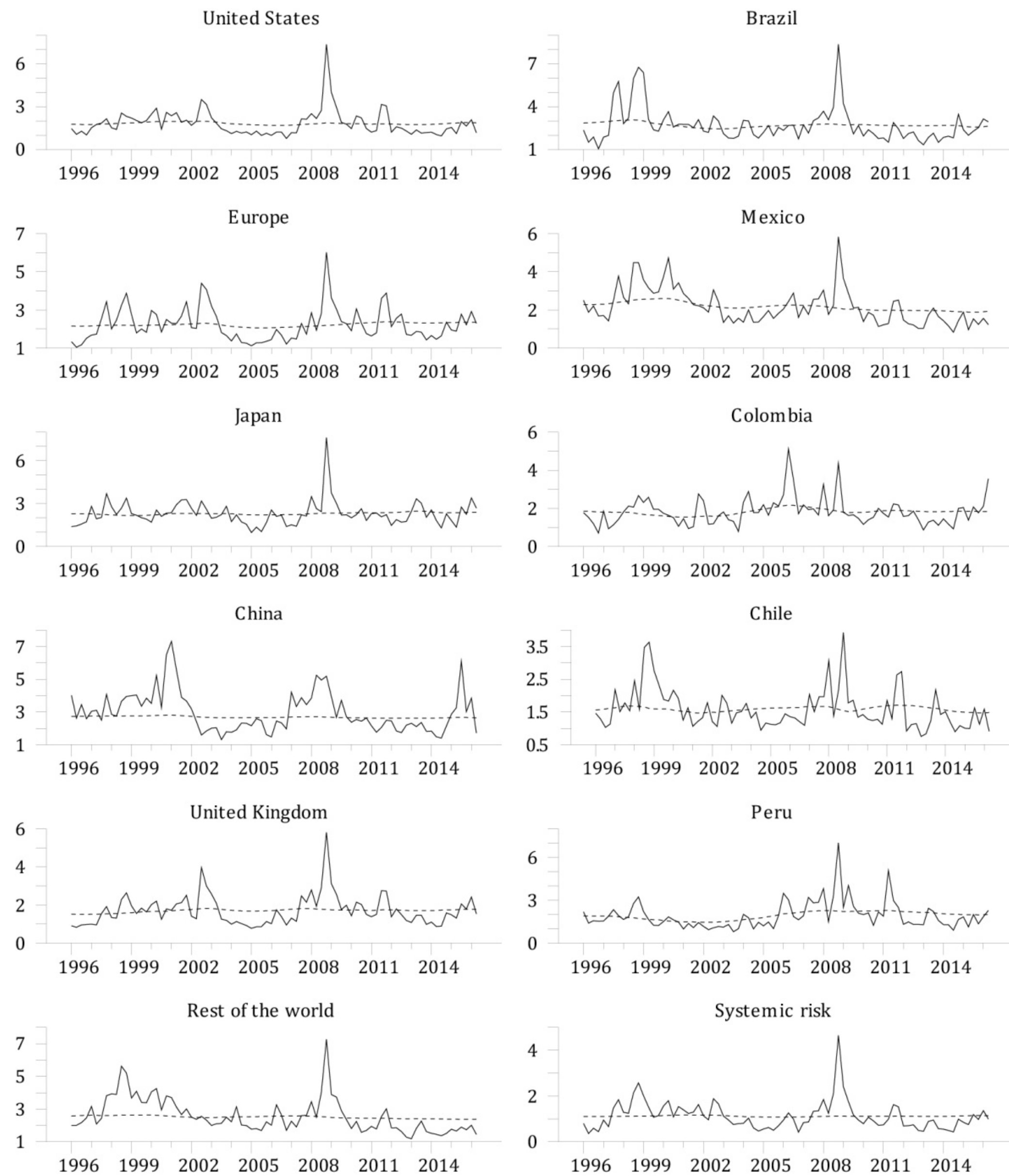

Figure 2. Country credit and global credit

Solid line: country credit: dotted line: latent country credit

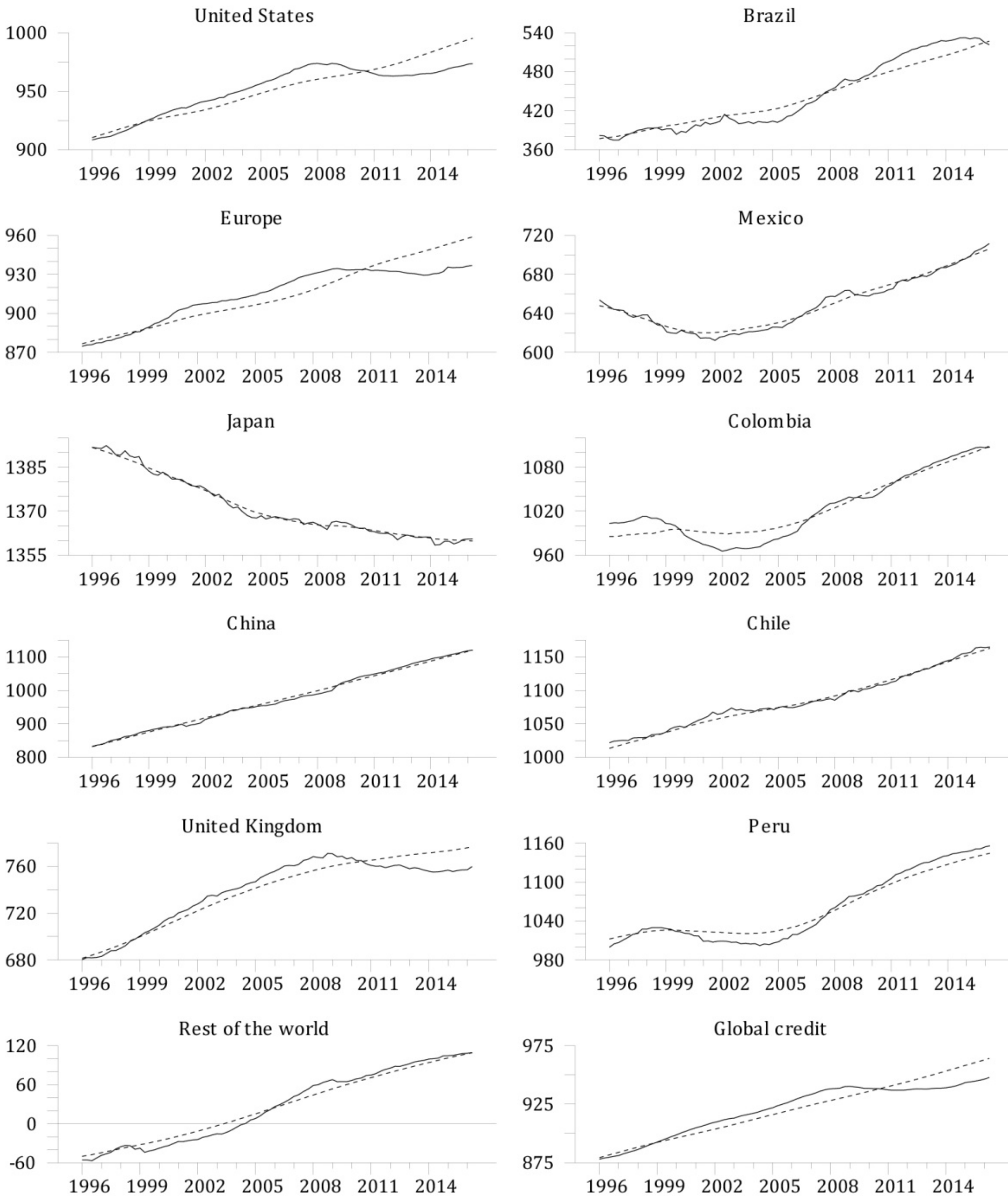

Figure 3. Output and absorption gaps

Solid line: output gaps; dotted line: absorption gaps (in percent of GDP)

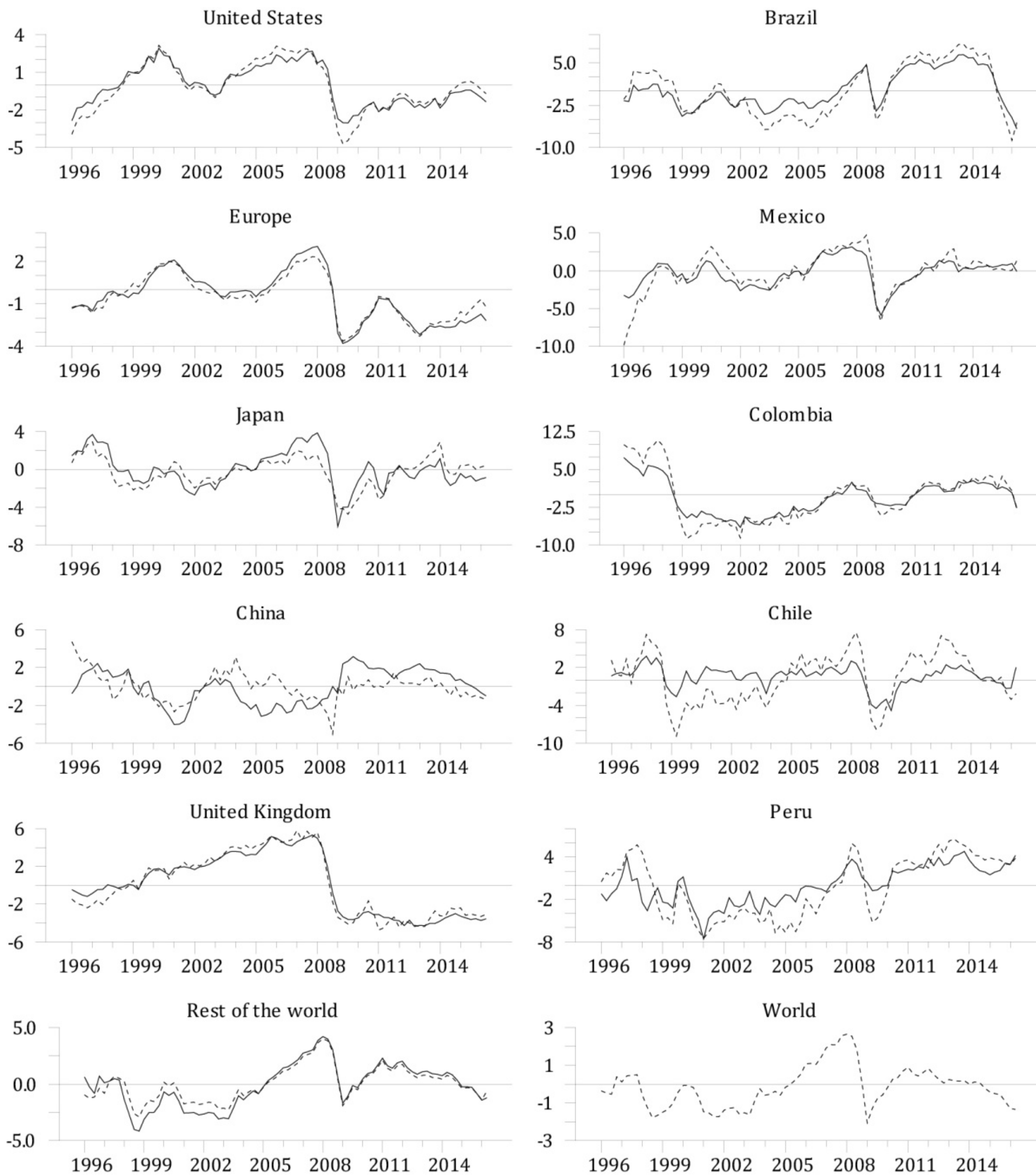

Figure 4. Exports and imports gaps

Solid line: exports gaps; dotted line: imports gaps (in percent of GDP)

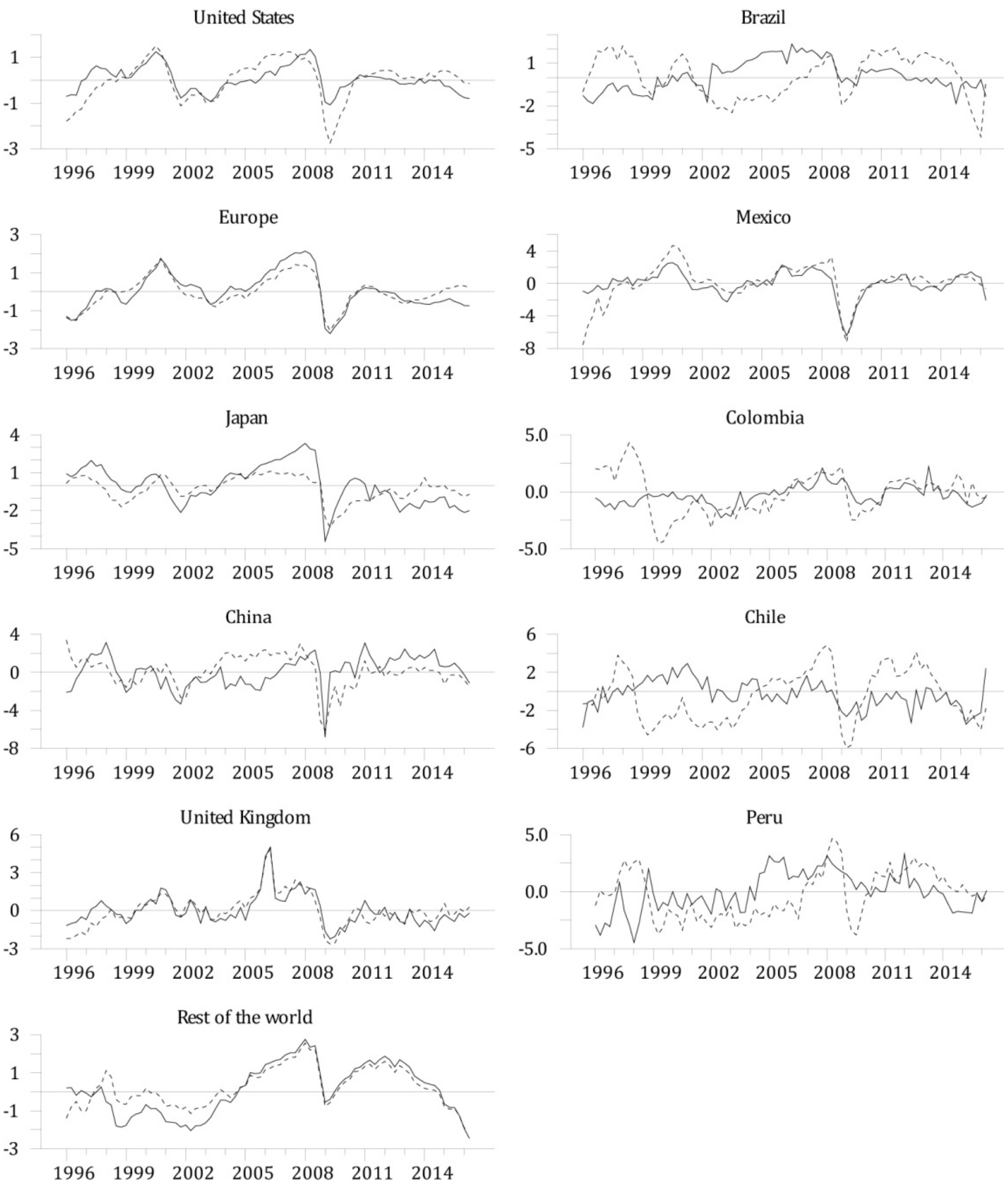

Figure 5. Real interest rate and natural rate of interest

Solid line: real interest rate; dotted line: natural rate of interest

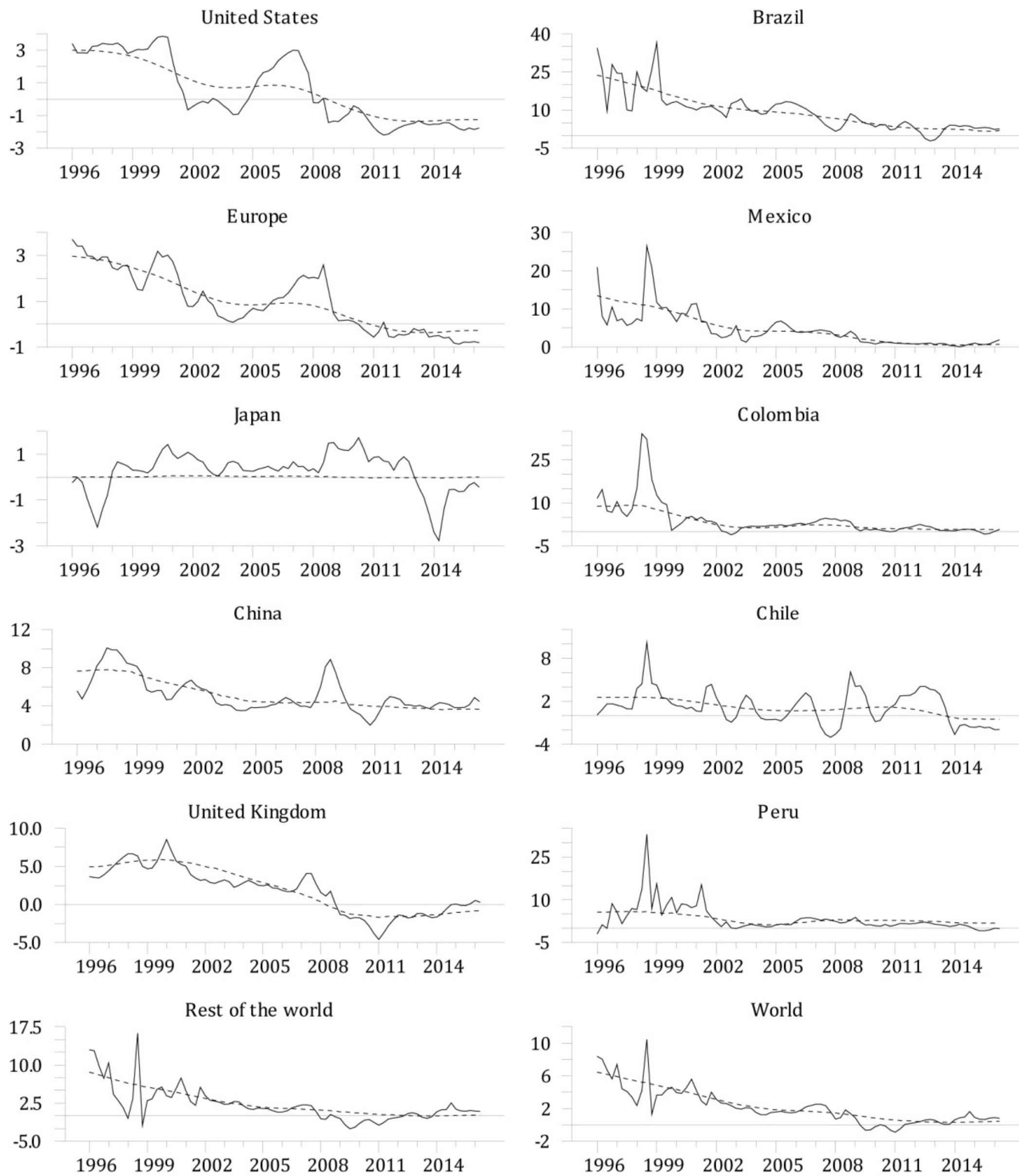

Figure 6. Core inflation and implicit inflation targets

Solid line: core inflation; dotted line: implicit inflation targets

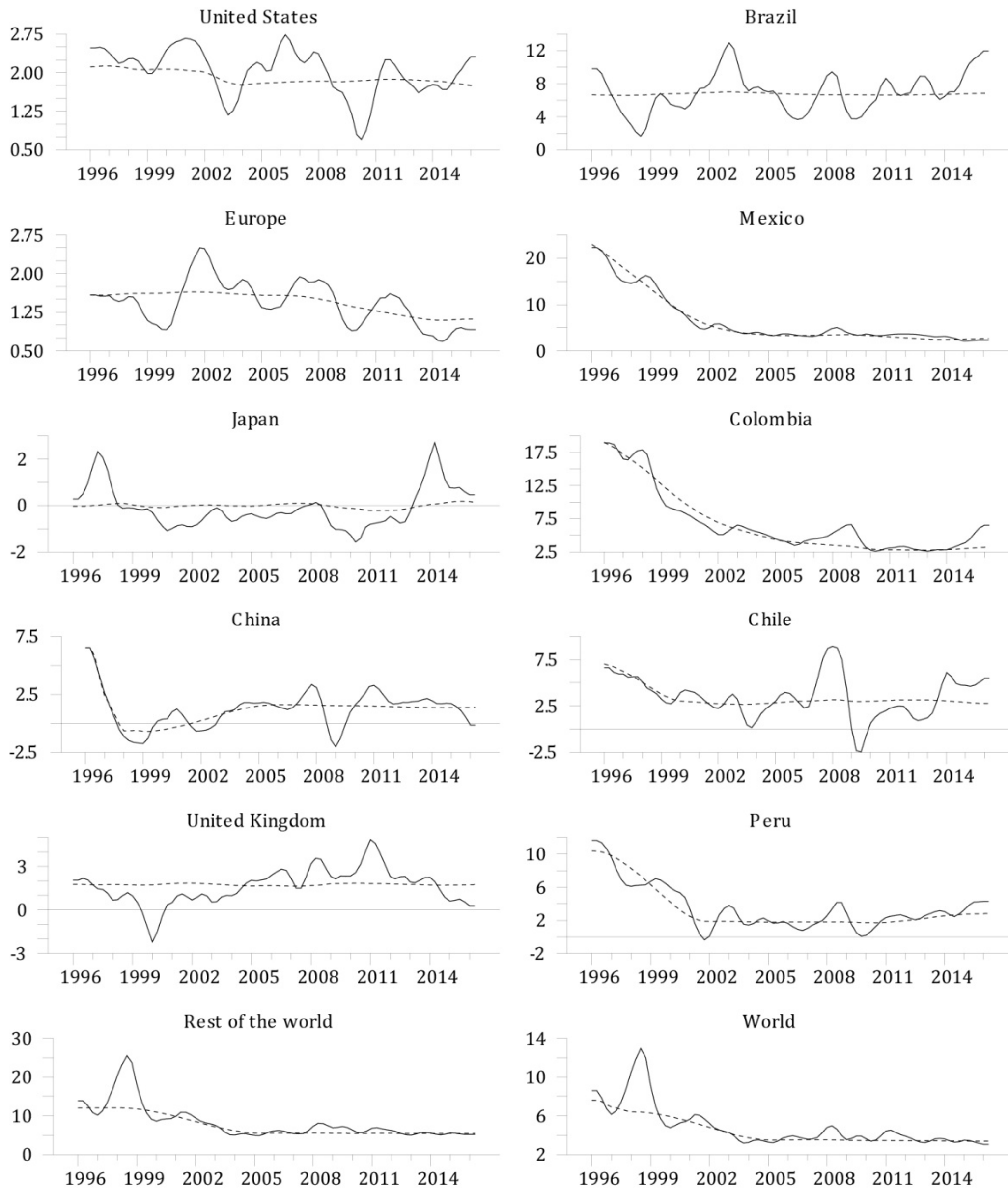

Figure 7. Systemic risk and global credit gaps
Historical decomposition into percent contributions from shocks

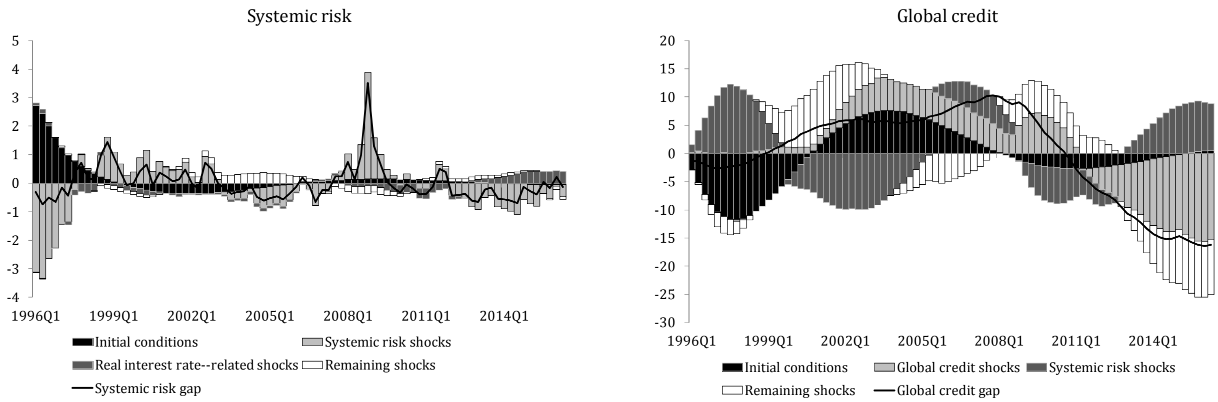

Figure 8. Risk premium gap: historical decomposition

Black bars: initial conditions; light gray bars: systemic risk shocks;
dark gray bars: country risk shocks; white bars: remaining shocks

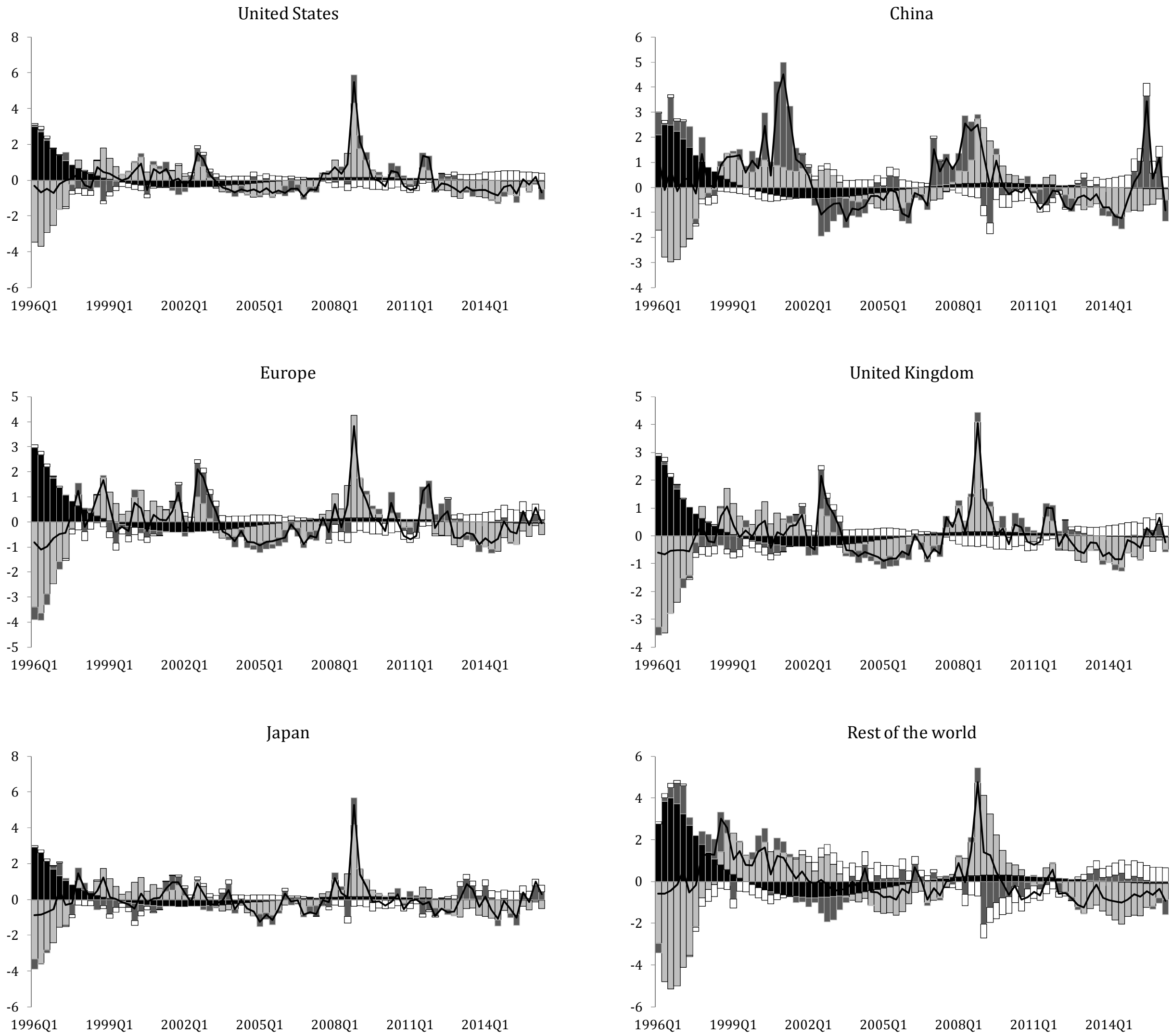

Figure 8. Risk premium gap: historical decomposition (continued)

Black bars: initial conditions; light gray bars: systemic risk shocks;
dark gray bars: country risk shocks; white bars: remaining shocks

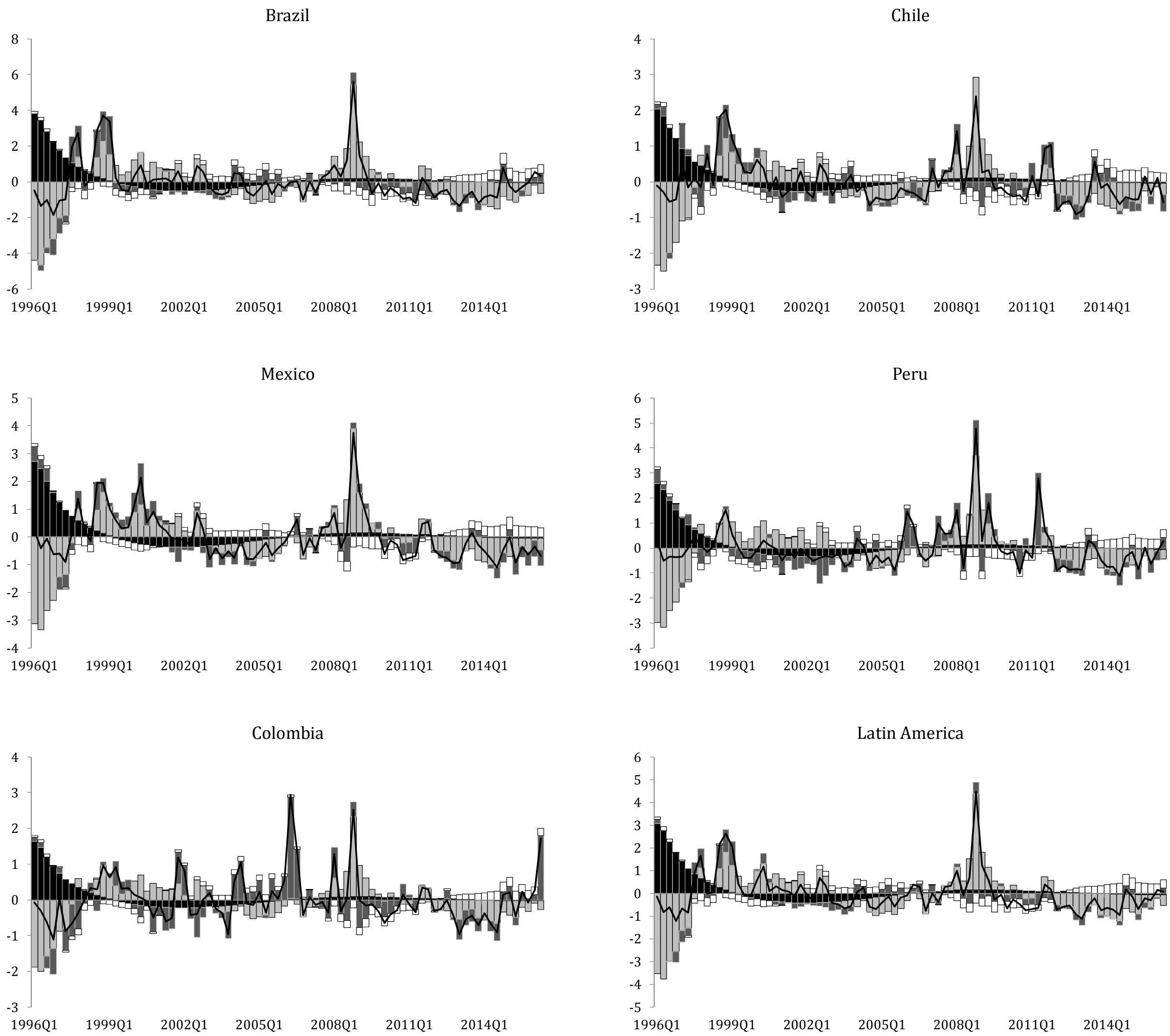

Figure 9. Country credit gap: historical decomposition

Black bars: initial conditions; light gray bars: global credit shocks; dark gray bars: country credit shocks; white bars: remaining shocks

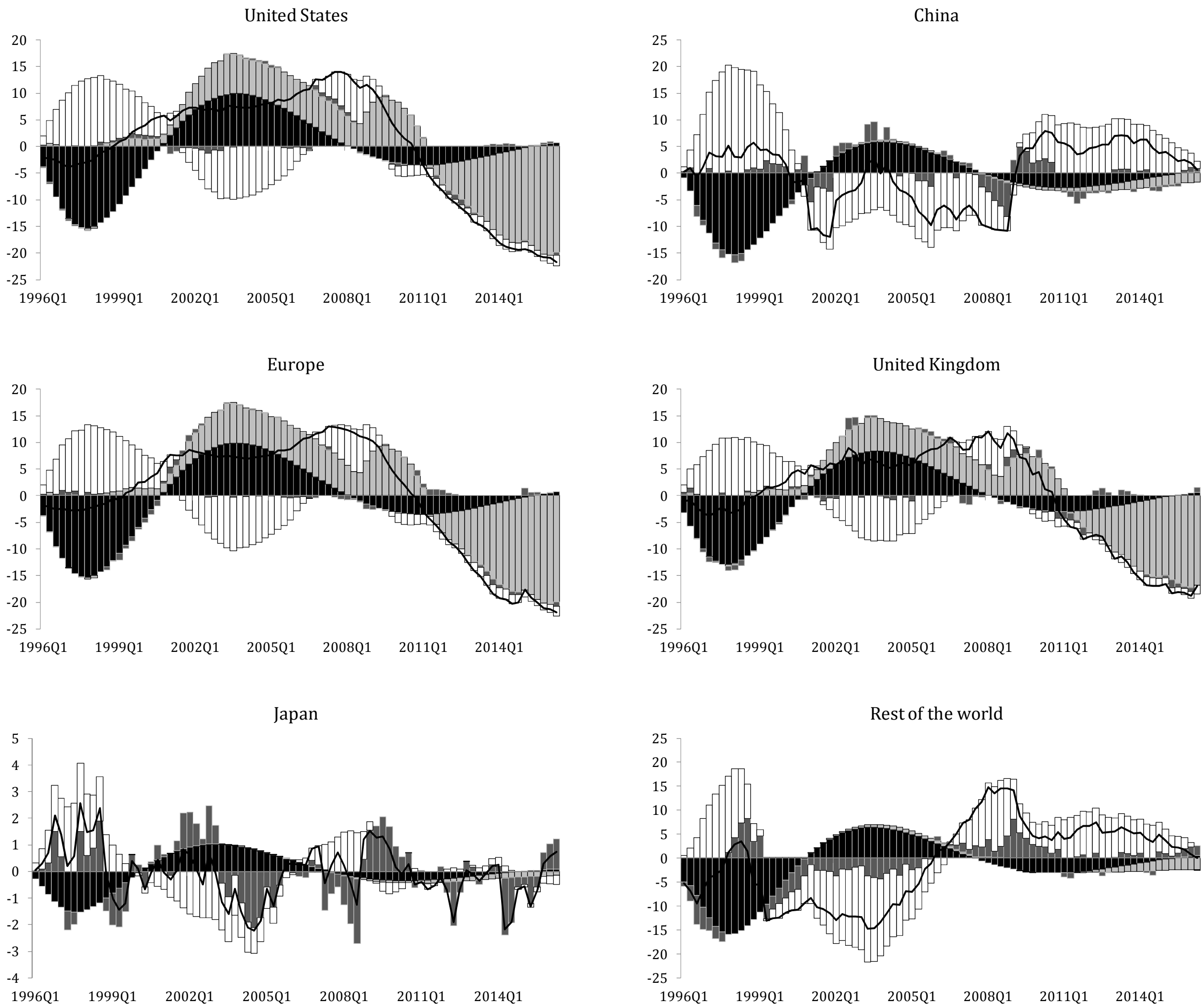

Figure 9. Country credit gap: historical decomposition (end)

Black bars: initial conditions; light gray bars: global credit shocks;
dark gray bars: country credit shocks; white bars: remaining shocks

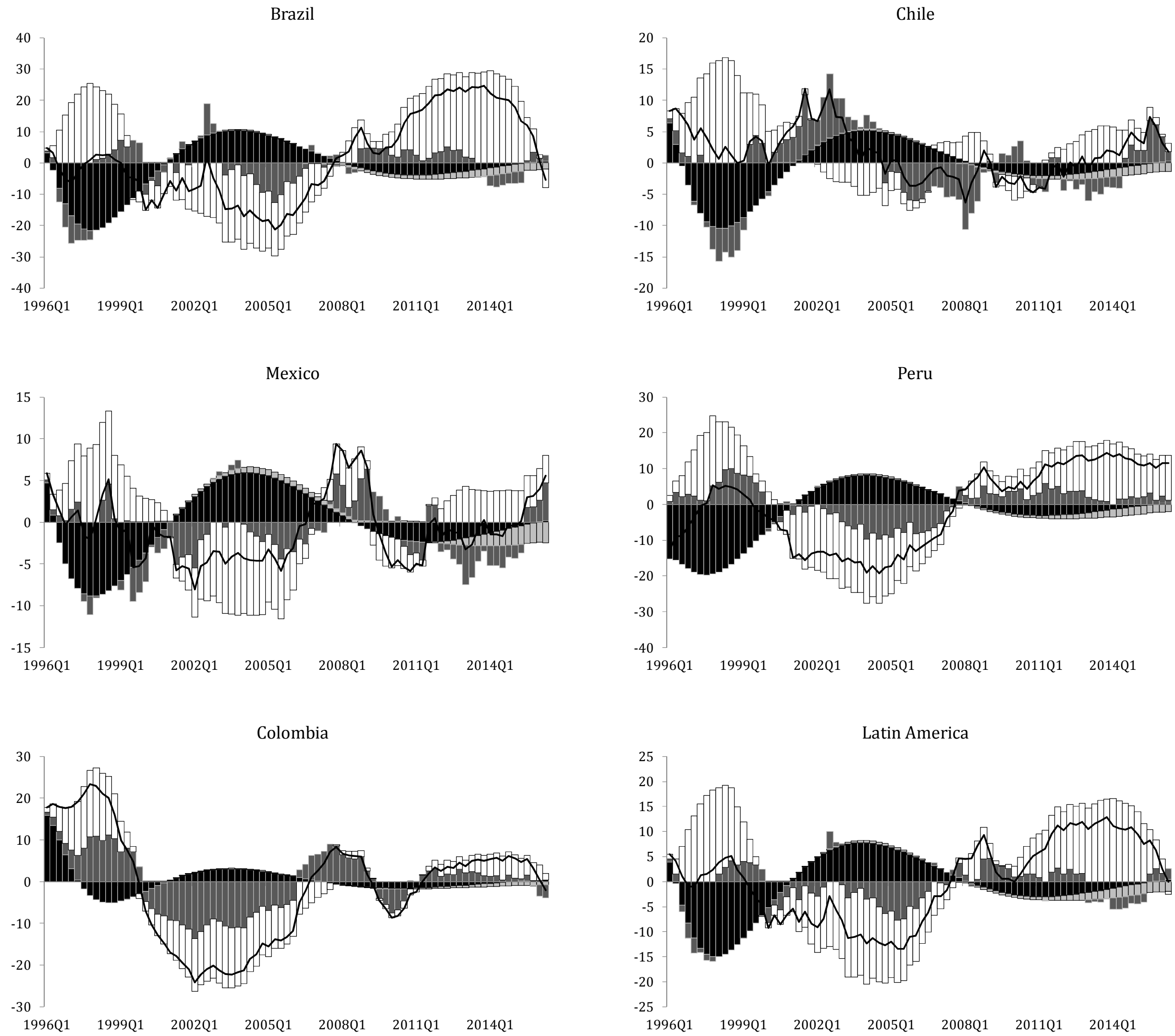

Figure 10. Output gaps: historical decomposition

Black bars: initial conditions; light gray bars: systemic risk shocks; dark gray bars: interest rate shocks; white bars: remaining shocks

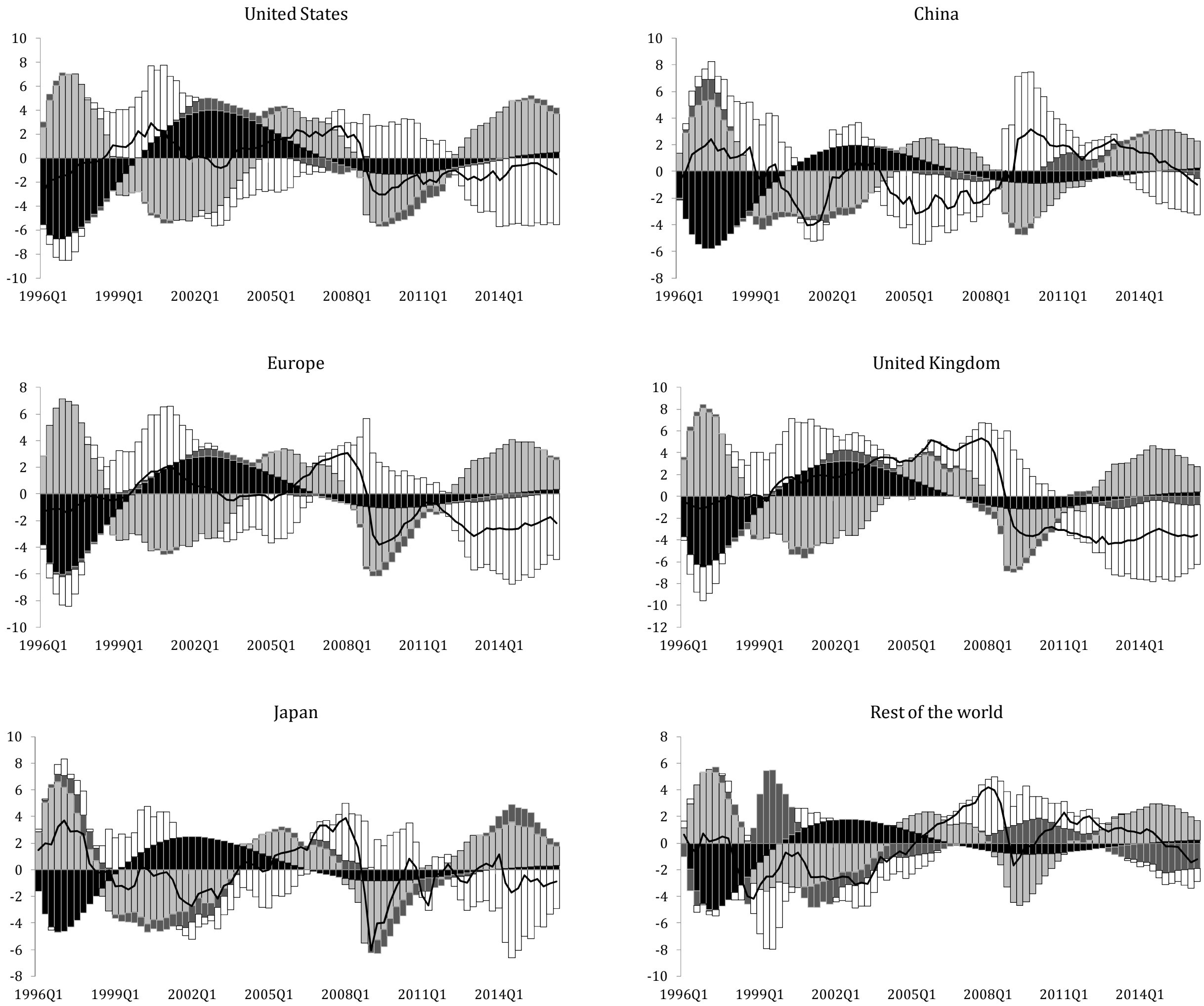

Figure 10. Output gaps: historical decomposition (end)

Black bars: initial conditions; light gray bars: systemic risk shocks;
dark gray bars: interest rate shocks; white bars: remaining shocks

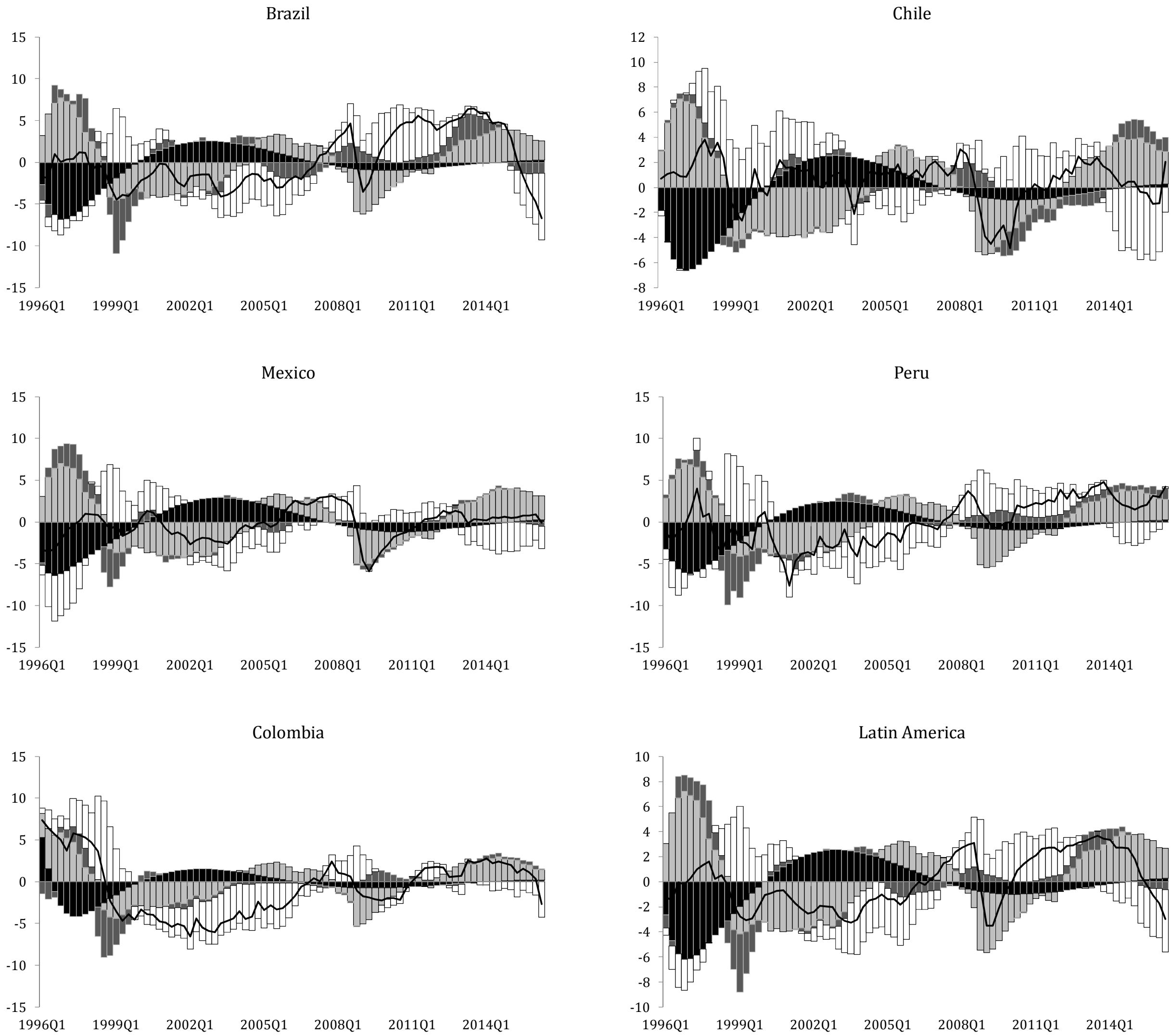

Figure 11. Systemic risk as a volatility factor

Percent of forecast error variance explained by systemic risk shocks
Solid line: inflation; dashed line: output growth; dotted line: policy interest rate