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Policy Analysis and Forecasting in the World Economy: A Panel Unobserved Components Approach

Francis Vitek

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Prepared by Francis Vitek[1]

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Abstract

This paper develops a structural macroeconometric model of the world economy, disaggregated into thirty five national economies. This panel unobserved components model features a monetary transmission mechanism, a fiscal transmission mechanism, and extensive macrofinancial linkages, both within and across economies. A variety of monetary policy analysis, fiscal policy analysis, spillover analysis, and forecasting applications of the estimated model are demonstrated, based on a Bayesian framework for conditioning on judgment.

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Author's E-Mail Address: fvitek@imf.org

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I. INTRODUCTION

The global financial crisis highlighted the potency of macrofinancial linkages, both within and across economies. As discussed in a recent survey paper on structural macroeconometric models used for policy analysis and forecasting by Roger and Vlcek (2012), much progress has since been made on incorporating macrofinancial linkages within economies, but little has been made across economies. The development of highly disaggregated structural macroeconometric models of the world economy featuring a monetary transmission mechanism, a fiscal transmission mechanism, and macrofinancial linkages along both dimensions is prerequisite to the effective integration of bilateral and multilateral surveillance at the International Monetary Fund.

The development of highly disaggregated structural macroeconometric models of the world economy is not without precedent. In a recent contribution, Dées, Pesaran, Smith and Smith (2010) develop a structural macroeconometric model of the world economy, consisting of a large number of interconnected multivariate linear rational expectations models of the monetary transmission mechanism in a large open economy. While these multivariate linear rational expectations models are driven by orthogonal shocks having structural interpretations, they feature neither a fiscal transmission mechanism nor macrofinancial linkages, and are estimated individually conditional on preliminary trend component estimates subject to small open economy restrictions, precluding the imposition of cross-economy equality restrictions on structural parameters. A related contribution is the global vector autoregressive model introduced by Pesaran, Schuermann and Weiner (2004), which consists of a large number of interconnected reduced form vector autoregressive models of the monetary transmission mechanism in a large open economy estimated individually subject to small open economy restrictions. While these vector autoregressive models generally do account for macrofinancial linkages, they are not driven by orthogonal shocks having structural interpretations, and tend not to incorporate a fiscal transmission mechanism.

This paper develops a structural macroeconometric model of the world economy, disaggregated into thirty five national economies. This panel unobserved components model features a monetary transmission mechanism, a fiscal transmission mechanism, and extensive macrofinancial linkages, both within and across economies. The advanced and emerging economies under consideration are Argentina, Australia, Austria, Belgium, Brazil, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom, and the United States. A variety of monetary policy analysis, fiscal policy analysis, spillover analysis, and forecasting applications of the estimated model are demonstrated. These include accounting for business cycle fluctuations, quantifying the monetary and fiscal transmission mechanisms, and generating conditional forecasts of inflation and output growth. They are based on a Bayesian framework for conditioning on judgment in estimation and forecasting.

The structural macroeconometric model of the world economy documented in this paper is the third in a series developed to facilitate multilaterally consistent policy analysis, spillover analysis, and forecasting. The panel unobserved components model of the monetary transmission mechanism documented in Vitek (2009) covers fifteen major advanced and emerging economies, while that documented in Vitek (2010) covers twenty. In an extension and refinement of this empirical framework, the panel unobserved components model documented in this paper also features a fiscal transmission mechanism. The design of this empirical framework is intended to strike a balance between theoretical coherence and empirical adequacy, given the large number of structurally diverse economies under consideration.

The organization of this paper is as follows. The next section describes a panel unobserved components model of the world economy. Estimation of this model is the subject of section three. Monetary and fiscal policy analysis within the framework of the estimated model is conducted in section four, while spillover analysis is undertaken in section five, and forecasting in section six. Finally, section seven offers conclusions and recommendations for further research.

II. The Panel Unobserved Components Model

Our panel unobserved components model of the world economy consists of multiple large open economies connected by trade, financial, and commodity price linkages. Within each economy, cyclical components are modeled as a multivariate linear rational expectations model of interconnected real, external, monetary, fiscal, and financial sectors derived from postulated behavioral relationships and standard accounting identities. These behavioral relationships approximately nest those associated with a variety of alternative structural macroeconomic models derived from microeconomic foundations, conferring robustness to model misspecification. In the interest of parsimony, cross-economy equality restrictions are imposed on the structural parameters of these behavioral relationships, the response coefficients of which vary across economies with their structural characteristics. Trend components are modeled as independent random walks, conferring robustness to intermittent structural breaks.

In what follows, $\hat{x}_{i,t}$ denotes the cyclical component of variable $x_{i,t}$, while $\bar{x}_{i,t}$ denotes the trend component of variable $x_{i,t}$. Cyclical and trend components are additively separable, that is $x_{i,t} = \hat{x}_{i,t} + \bar{x}_{i,t}$. Furthermore, $\mathrm{E}_t\, x_{i,t+s}$ denotes the rational expectation of variable $x_{i,t+s}$ associated with economy i, conditional on information available at time t. In addition, $x_{i,t}^{Z}$ denotes the trade weighted average of variable $x_{i,t}$ across the trading partners of economy i, given bilateral weights $w_{i,j}^{Z}$ based on exports for $Z = X$, imports for $Z = M$, and their average for $Z = T$. Similarly, $x_{i,t}^{Z}$ denotes the portfolio weighted average of domestic currency denominated variable $x_{i,t}$ across the investment destinations of economy i, given bilateral weights $w_{i,j}^{Z}$ based on debt for $Z = B$ and equity for $Z = S$. Moreover, x_t^Z denotes the weighted average of variable $x_{i,t}$ across all economies, given world weights w_i^Z based on money market capitalization for $Z = M$, bond market capitalization for $Z = B$, stock market capitalization for $Z = S$, and output for $Z = Y$. Finally, economy $i*$ issues the quotation currency for transactions in the foreign exchange market.

A. Cyclical Components

The cyclical component of output price inflation $\hat{\pi}_{i,t}^{Y}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of output according to domestic supply relationship,

$$\hat{\pi}_{i,t}^{Y} = \phi_{1,1}\hat{\pi}_{i,t-1}^{Y} + \phi_{1,2}\,\mathrm{E}_t\,\hat{\pi}_{i,t+1}^{Y} + \theta_{1,1}\ln\hat{Y}_{i,t} + \theta_{1,2}\frac{X_i}{Y_i}\sum_{z}\frac{X_i^{COM^z}}{X_i}\phi_1(L)\Delta\ln\frac{\hat{\mathcal{E}}_{i,i*,t}\hat{P}_t^{COM^z}}{\hat{P}_{i,t}^{Y}} + \nu_{i,t}^{\hat{P}^Y}, \quad (1)$$

where domestic supply shock $\nu_{i,t}^{\hat{P}^Y} = \rho_{\hat{P}^Y}\nu_{i,t-1}^{\hat{P}^Y} + \varepsilon_{i,t}^{\hat{P}^Y}$ with $\varepsilon_{i,t}^{\hat{P}^Y} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{P}^Y,i}^2)$. The cyclical component of output price inflation also depends on contemporaneous, past, and expected future changes in the cyclical components of the relative domestic currency denominated prices of energy and nonenergy commodity exports, where polynomial in the lag operator $\phi_1(L) = 1 - \phi_{1,1}L - \phi_{1,2}\,\mathrm{E}_t\,L^{-1}$. The response coefficients of this relationship vary across economies with their export openness, measured by the ratio of exports to output $\frac{X_i}{Y_i}$, as well as their commodity export intensities, measured by the ratios of commodity exports to exports $\frac{X_i^{COM^z}}{X_i}$.

The cyclical component of consumption price inflation $\hat{\pi}_{i,t}^{C}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of output according to supply relationship,

$$\begin{aligned}\hat{\pi}_{i,t}^{C} &= \phi_{1,1}\hat{\pi}_{i,t-1}^{C} + \phi_{1,2}\,\mathrm{E}_t\,\hat{\pi}_{i,t+1}^{C} + \theta_{1,1}\ln\hat{Y}_{i,t} \\ &\quad + \theta_{2,1}\frac{M_i}{D_i}\phi_1(L)\left[\left(1-\frac{M_i^{COM}}{M_i}\right)\Delta\ln\hat{\mathcal{T}}_{i,t} + \theta_{2,2}\sum_{z}\frac{M_i^{COM^z}}{M_i}\Delta\ln\frac{\hat{\mathcal{E}}_{i,i*,t}\hat{P}_t^{COM^z}}{\hat{P}_{i,t}^{Y}} + \nu_{i,t}^{\hat{P}^M}\right] + \nu_{i,t}^{\hat{P}^Y},\end{aligned} \quad (2)$$

where import supply shock $\nu_{i,t}^{\hat{P}^M} = \rho_{\hat{P}^M}\nu_{i,t-1}^{\hat{P}^M} + \varepsilon_{i,t}^{\hat{P}^M}$ with $\varepsilon_{i,t}^{\hat{P}^M} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{P}^M,i}^2)$. The cyclical component of consumption price inflation also depends on contemporaneous, past, and expected future changes in the cyclical component of the terms of trade and the relative domestic currency denominated prices of energy and nonenergy commodity imports. The response coefficients of this relationship vary across economies with their import openness, measured by the ratio of imports to domestic demand $\frac{M_i}{D_i}$, as well as their commodity import intensities, measured by the ratios of commodity imports to imports $\frac{M_i^{COM^z}}{M_i}$.

The cyclical component of output $\ln\hat{Y}_{i,t}$ follows a stationary first order autoregressive process driven by a monetary conditions index according to demand relationship,

$$\ln\hat{Y}_{i,t} = \phi_{3,1}\ln\hat{Y}_{i,t-1} + \left(1-\theta_{4,1}\frac{M_i}{D_i}\right)\left\{\frac{C_i}{Y_i}\left\{\theta_{3,1}\left(\hat{r}^{L,C}_{i,t} + \theta_{3,2}\ln\frac{\hat{P}^{STK,S}_{i,t}}{\hat{P}^{C}_{i,t}}\right)\right.\right.$$
$$\left.\left.+\theta_{3,3}\phi_3(L)\left[\ln\hat{Y}_{i,t} + \theta_{3,4}\frac{M_i}{D_i}\ln\hat{\mathcal{T}}_{i,t} + \theta_{3,5}\left(1-\frac{T_i}{P^Y_iY_i}\right)^{-1}\frac{\hat{T}_{i,t}}{P^Y_{i,t}Y_{i,t}}\right] + \nu^{\hat{C}}_{i,t}\right\} + \frac{G_i}{Y_i}\phi_3(L)\ln\hat{G}_{i,t}\right\} \tag{3}$$
$$+\phi_3(L)\left\{\theta_{4,1}\frac{X_i}{Y_i}(\ln\hat{D}^X_{i,t} + \nu^{\hat{X}}_{i,t}) + \theta_{4,2}\left\{\frac{X_i}{Y_i}\left[\left(1-\frac{M_i}{D_i}\right)\ln\hat{\mathcal{T}}_{i,t}\right]^X - \frac{M_i}{Y_i}\left(1-\frac{M_i}{D_i}\right)\ln\hat{\mathcal{T}}_{i,t}\right\}\right\},$$

where export demand shock $\nu^{\hat{X}}_{i,t} = \rho_{\hat{X}}\nu^{\hat{X}}_{i,t-1} + \varepsilon^{\hat{X}}_{i,t}$ with $\varepsilon^{\hat{X}}_{i,t} \sim \text{iid } \mathcal{N}(0,\sigma^2_{\hat{X},i})$. Reflecting the existence of international trade and financial linkages, this monetary conditions index is defined as a linear combination of a financial conditions index and the contemporaneous and past cyclical components of the terms of trade.[2] Reflecting the existence of credit constraints, the cyclical component of output also depends on the contemporaneous and past cyclical components of output, the terms of trade, and the ratio of tax revenues to nominal output. In addition, the cyclical component of output depends on the contemporaneous and past cyclical components of public domestic demand. Finally, the cyclical component of output depends on the contemporaneous and past cyclical components of export weighted foreign demand, where polynomial in the lag operator $\phi_3(L) = 1-\phi_{3,1}L$. The response coefficients of this relationship vary across economies with their trade openness, measured by the ratio of exports to output $\frac{X_i}{Y_i}$ or imports to output $\frac{M_i}{Y_i}$.

The cyclical component of domestic demand $\ln\hat{D}_{i,t}$ follows a stationary first order autoregressive process driven by a financial conditions index according to domestic demand relationship,

$$\ln\hat{D}_{i,t} = \phi_{3,1}\ln\hat{D}_{i,t-1} + \left(\frac{D_i}{Y_i}\right)^{-1}\left\{\frac{C_i}{Y_i}\left\{\theta_{3,1}\left(\hat{r}^{L,C}_{i,t} + \theta_{3,2}\ln\frac{\hat{P}^{STK,S}_{i,t}}{\hat{P}^{C}_{i,t}}\right)\right.\right.$$
$$\left.\left.+\theta_{3,3}\phi_3(L)\left[\ln\hat{Y}_{i,t} + \theta_{3,4}\frac{M_i}{D_i}\ln\hat{\mathcal{T}}_{i,t} + \theta_{3,5}\left(1-\frac{T_i}{P^Y_iY_i}\right)^{-1}\frac{\hat{T}_{i,t}}{P^Y_{i,t}Y_{i,t}}\right] + \nu^{\hat{C}}_{i,t}\right\} + \frac{G_i}{Y_i}\phi_3(L)\ln\hat{G}_{i,t}\right\}, \tag{4}$$

where private domestic demand shock $\nu^{\hat{C}}_{i,t} = \rho_{\hat{C}}\nu^{\hat{C}}_{i,t-1} + \varepsilon^{\hat{C}}_{i,t}$ with $\varepsilon^{\hat{C}}_{i,t} \sim \text{iid } \mathcal{N}(0,\sigma^2_{\hat{C},i})$. This financial conditions index is defined as a linear combination of the contemporaneous and past cyclical components of the long term consumption based real market interest rate and the real value of an internationally diversified equity portfolio. Reflecting the existence of

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[2] This monetary conditions index $\hat{\mathcal{I}}^{MCI}_{i,t}$ is defined as that subcomponent of the cyclical component of output driven by contemporaneous and past monetary and financial variables. It is generated recursively as $\hat{\mathcal{I}}^{MCI}_{i,t} = \phi_{3,1}\hat{\mathcal{I}}^{MCI}_{i,t-1} + \left[1-\theta_{3,3}\frac{C_i}{Y_i}\left(1-\theta_{4,1}\frac{M_i}{D_i}\right)\right]^{-1}\hat{I}^{MCI}_{i,t}$, where $\hat{I}^{MCI}_{i,t} = \hat{I}^{FCI}_{i,t} + \theta_{3,3}\theta_{3,4}\frac{C_i}{Y_i}\left(1-\theta_{4,1}\frac{M_i}{D_i}\right)\frac{M_i}{D_i}\phi_3(L)\ln\hat{\mathcal{T}}_{i,t}$ $+\theta_{4,2}\phi_3(L)\left\{\frac{X_i}{Y_i}\left[\left(1-\frac{M_i}{D_i}\right)\ln\hat{\mathcal{T}}_{i,t}\right]^X - \frac{M_i}{Y_i}\left[\left(1-\frac{M_i}{D_i}\right)\ln\hat{\mathcal{T}}_{i,t}\right]\right\}$. The corresponding financial conditions index $\hat{\mathcal{I}}^{FCI}_{i,t}$ is defined as that subcomponent of the cyclical component of output driven by contemporaneous and past financial variables. It is also generated recursively as $\hat{\mathcal{I}}^{FCI}_{i,t} = \phi_{3,1}\hat{\mathcal{I}}^{FCI}_{i,t-1} + \left[1-\theta_{3,3}\frac{C_i}{Y_i}\left(1-\theta_{4,1}\frac{M_i}{D_i}\right)\right]^{-1}\hat{I}^{FCI}_{i,t}$, where $\hat{I}^{FCI}_{i,t} = \theta_{3,1}\frac{C_i}{Y_i}\left(1-\theta_{4,1}\frac{M_i}{D_i}\right)\left(\hat{r}^{L,C}_{i,t} + \theta_{3,2}\ln\frac{\hat{P}^{STK,S}_{i,t}}{\hat{P}^{C}_{i,t}}\right)$.

credit constraints, the cyclical component of domestic demand also depends on the contemporaneous and past cyclical components of output, the terms of trade, and the ratio of tax revenues to nominal output. In addition, the cyclical component of domestic demand depends on the contemporaneous and past cyclical components of public domestic demand. The response coefficients of this relationship vary across economies with the size of their government, measured by the ratio of public domestic demand to output $\frac{G_i}{Y_i}$ or tax revenues to nominal output $\frac{T_i}{P_i^Y Y_i}$.

The cyclical component of the nominal policy interest rate $\hat{i}_{i,t}^P$ depends on a weighted average of its past and desired cyclical components according to monetary policy rule,

$$\hat{i}_{i,t}^P = \phi_{5,1}\hat{i}_{i,t-1}^P + (1-\phi_{5,1})(\theta_{5,1,j}\hat{\pi}_{i,t}^C + \theta_{5,2,j}\ln\hat{Y}_{i,t} + \theta_{5,3,j}\ln\hat{\mathcal{Q}}_{i,t}^T) + \varepsilon_{i,t}^{\hat{i}^P}, \tag{5}$$

where monetary policy shock $\varepsilon_{i,t}^{\hat{i}^P} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{i}^P,i}^2)$. Under a flexible inflation targeting regime $j=1$ and the desired cyclical component of the nominal policy interest rate responds to the contemporaneous cyclical components of consumption price inflation and output, while under a managed exchange rate regime $j=0$ and it also responds to the contemporaneous cyclical component of the trade weighted real effective exchange rate. For economies belonging to a currency union, the target variables entering into their common monetary policy rule are expressed as output weighted averages across union members. The cyclical component of the real policy interest rate $\hat{r}_{i,t}^{P,Z}$ satisfies $\hat{r}_{i,t}^{P,Z} = \hat{i}_{i,t}^P - \mathrm{E}_t\,\hat{\pi}_{i,t+1}^Z$, where $Z \in \{C,Y\}$.

The cyclical component of the spread between the short term nominal market interest rate $\hat{i}_{i,t}^S$ and the nominal policy interest rate follows a stationary first order autoregressive process driven by the contemporaneous cyclical component of the ratio of net foreign assets to nominal output according to money market relationship,

$$\hat{i}_{i,t}^S - \hat{i}_{i,t}^P = \phi_{6,1}(\hat{i}_{i,t-1}^S - \hat{i}_{i,t-1}^P) + (1-\phi_{6,1})\theta_{6,1}\frac{\hat{B}_{i,t+1}}{P_{i,t}^Y Y_{i,t}} + \lambda_{6,j}\nu_t^{\hat{i}^S,M} + (1-\lambda_{6,j}w_i^M)\nu_{i,t}^{\hat{i}^S}, \tag{6}$$

where credit risk premium shock $\nu_{i,t}^{\hat{i}^S} = \rho_{\hat{i}^S}\nu_{i,t-1}^{\hat{i}^S} + \varepsilon_{i,t}^{\hat{i}^S}$ with $\varepsilon_{i,t}^{\hat{i}^S} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{i}^S,i}^2)$. The intensity of international money market contagion varies across economies, with $j=0$ for advanced economies, $j=1$ for emerging economies with capital controls, and $j=2$ for emerging economies without capital controls. For economies belonging to a currency union, the ratio of net foreign assets to nominal output is expressed as an output weighted average across union members, scaled by the number of union members. The cyclical component of the short term real market interest rate $\hat{r}_{i,t}^{S,Z}$ satisfies $\hat{r}_{i,t}^{S,Z} = \hat{i}_{i,t}^S - \mathrm{E}_t\,\hat{\pi}_{i,t+1}^Z$.

The cyclical component of the long term nominal market interest rate $\hat{i}_{i,t}^L$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of the short term nominal market interest rate according to bond market relationship,

$$\hat{i}_{i,t}^L = \phi_{7,1}\hat{i}_{i,t-1}^L + \phi_{7,2}\,\mathrm{E}_t\,\hat{i}_{i,t+1}^L + \theta_{7,1}\hat{i}_{i,t}^S + \lambda_{7,j}\nu_t^{\hat{i}^L,B} + (1-\lambda_{7,j}w_i^B)\nu_{i,t}^{\hat{i}^L}, \tag{7}$$

where duration risk premium shock $\nu_{i,t}^{\hat{i}^L} = \rho_{\hat{i}^L}\nu_{i,t-1}^{\hat{i}^L} + \varepsilon_{i,t}^{\hat{i}^L}$ with $\varepsilon_{i,t}^{\hat{i}^L} \sim \text{iid } \mathcal{N}(0, \sigma_{\hat{i}^L,i}^2)$. The intensity of international bond market contagion varies across economies, with $j = 0$ for advanced economies, $j = 1$ for emerging economies with capital controls, and $j = 2$ for emerging economies without capital controls. The cyclical component of the long term real market interest rate $\hat{r}_{i,t}^{L,Z}$ satisfies the same bond market relationship, driven by the contemporaneous cyclical component of the corresponding short term real market interest rate.

The cyclical component of the relative price of equity $\ln \hat{P}_{i,t}^{STK}$ depends on a linear combination of its past and expected future cyclical components driven by the expected future cyclical components of output and the ratio of tax revenues to nominal output, as well as the contemporaneous cyclical component of the short term output based real market interest rate, according to stock market relationship,

$$\begin{aligned}\ln \frac{\hat{P}_{i,t}^{STK}}{\hat{P}_{i,t}^{Y}} &= \phi_{8,1} \ln \frac{\hat{P}_{i,t-1}^{STK}}{\hat{P}_{i,t-1}^{Y}} + \phi_{8,2} \, \mathrm{E}_t \ln \frac{\hat{P}_{i,t+1}^{STK}}{\hat{P}_{i,t+1}^{Y}} \\ &+ \theta_{8,1} \, \mathrm{E}_t \left[\ln \hat{Y}_{i,t+1} + \theta_{8,2} \left(1 - \frac{T_i}{P_i^Y Y_i} \right)^{-1} \frac{\hat{T}_{i,t+1}}{P_{i,t+1}^{Y} Y_{i,t+1}} \right] + \theta_{8,3} \hat{r}_{i,t}^{S,Y} + \lambda_{8,j} \nu_t^{\hat{P}^{STK},S} + (1 - \lambda_{8,j} w_i^S) \nu_{i,t}^{\hat{P}^{STK}},\end{aligned} \tag{8}$$

where equity risk premium shock $\nu_{i,t}^{\hat{P}^{STK}} = \rho_{\hat{P}^{STK}} \nu_{i,t-1}^{\hat{P}^{STK}} + \varepsilon_{i,t}^{\hat{P}^{STK}}$ with $\varepsilon_{i,t}^{\hat{P}^{STK}} \sim \text{iid } \mathcal{N}(0, \sigma_{\hat{P}^{STK},i}^2)$. The intensity of international stock market contagion varies across economies, with $j = 0$ for advanced economies, $j = 1$ for emerging economies with capital controls, and $j = 2$ for emerging economies without capital controls.

The cyclical component of the real bilateral exchange rate $\ln \hat{\mathcal{Q}}_{i,i^*,t}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of the short term output based real market interest rate differential according to foreign exchange market relationship,

$$\ln \hat{\mathcal{Q}}_{i,i^*,t} = \phi_{9,1} \ln \hat{\mathcal{Q}}_{i,i^*,t-1} + \phi_{9,2} \, \mathrm{E}_t \ln \hat{\mathcal{Q}}_{i,i^*,t+1} + \theta_{9,1,j} (\hat{r}_{i,t}^{S,Y} - \hat{r}_{i^*,t}^{S,Y}) + \nu_{i,t}^{\hat{\mathcal{E}}}, \tag{9}$$

where exchange rate risk premium shock $\nu_{i,t}^{\hat{\mathcal{E}}} = \rho_{\hat{\mathcal{E}}} \nu_{i,t-1}^{\hat{\mathcal{E}}} + \varepsilon_{i,t}^{\hat{\mathcal{E}}}$ with $\varepsilon_{i,t}^{\hat{\mathcal{E}}} \sim \text{iid } \mathcal{N}(0, \sigma_{\hat{\mathcal{E}},i}^2)$. The sensitivity of the real bilateral exchange rate to changes in the short term output based real market interest rate differential depends on capital controls, with $j = 1$ in their presence and $j = 0$ in their absence. For economies belonging to a currency union, the variables entering into their common foreign exchange market relationship are expressed as output weighted averages across union members. The cyclical component of the nominal bilateral exchange rate $\ln \hat{\mathcal{E}}_{i,i^*,t}$ satisfies $\ln \hat{\mathcal{Q}}_{i,i^*,t} = \ln \hat{\mathcal{E}}_{i,i^*,t} + \ln \hat{P}_{i^*,t}^{Y} - \ln \hat{P}_{i,t}^{Y}$.[3]

[3] It can be shown that the cyclical component of the nominal effective exchange rate $\ln \hat{\mathcal{E}}_{i,t}^{Z}$ satisfies $\ln \hat{\mathcal{E}}_{i,t}^{Z} = \ln \hat{\mathcal{E}}_{i,i^*,t} - \sum_{j=1}^{N} w_{i,j}^{Z} \ln \hat{\mathcal{E}}_{j,i^*,t}$, while the cyclical component of the real effective exchange rate $\ln \hat{\mathcal{Q}}_{i,t}^{Z}$ satisfies $\ln \hat{\mathcal{Q}}_{i,t}^{Z} = \ln \hat{\mathcal{Q}}_{i,i^*,t} - \sum_{j=1}^{N} w_{i,j}^{Z} \ln \hat{\mathcal{Q}}_{j,i^*,t}$, where N denotes the number of economies. Note that $\ln \hat{\mathcal{Q}}_{i,t}^{Z} = \ln \hat{\mathcal{E}}_{i,t}^{Z} + \ln \hat{P}_{i,t}^{Y,Z} - \ln \hat{P}_{i,t}^{Y}$.

The change in the cyclical component of the terms of trade $\ln\hat{\mathcal{T}}_{i,t}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of the deviation of the import weighted real effective exchange rate from the terms of trade according to terms of trade relationship,

$$\Delta\ln\hat{\mathcal{T}}_{i,t} = \phi_{10,1}\Delta\ln\hat{\mathcal{T}}_{i,t-1} + \phi_{10,2}\mathrm{E}_t\Delta\ln\hat{\mathcal{T}}_{i,t+1} + \theta_{10,1}\ln\frac{\hat{\mathcal{Q}}^M_{i,t}}{\hat{\mathcal{T}}_{i,t}} + \theta_{10,2}\phi_{10}(L)\hat{\pi}^Y_{i,t} + \nu^{\hat{\mathcal{T}}}_{i,t}, \tag{10}$$

where terms of trade shock $\nu^{\hat{\mathcal{T}}}_{i,t} = \rho_{\hat{\mathcal{T}}}\nu^{\hat{\mathcal{T}}}_{i,t-1} + \varepsilon^{\hat{\mathcal{T}}}_{i,t}$ with $\varepsilon^{\hat{\mathcal{T}}}_{i,t} \sim \text{iid } \mathcal{N}(0,\sigma^2_{\hat{\mathcal{T}},i})$. The change in the cyclical component of the terms of trade also depends on the contemporaneous, past, and expected future cyclical components of output price inflation, where polynomial in the lag operator $\phi_{10}(L) = 1 - \phi_{10,1}L - \phi_{10,2}\,\mathrm{E}_t\,L^{-1}$.

The cyclical component of public domestic demand $\ln\hat{G}_{i,t}$ depends on a weighted average of its past and desired cyclical components according to fiscal expenditure rule,

$$\ln\hat{G}_{i,t} = \phi_{11,1}\ln\hat{G}_{i,t-1} + (1-\phi_{11,1})\theta_{11,1}\left(\frac{G_i}{Y_i}\right)^{-1}\frac{\hat{B}^G_{i,t+1}}{P^Y_{i,t}Y_{i,t}} + \left(\frac{G_i}{Y_i}\right)^{-1}\varepsilon^{\hat{G}}_{i,t}, \tag{11}$$

where fiscal expenditure shock $\varepsilon^{\hat{G}}_{i,t} \sim \text{iid } \mathcal{N}(0,\sigma^2_{\hat{G},i})$. The desired cyclical component of public domestic demand responds to the contemporaneous cyclical component of the ratio of net government assets to nominal output.

The cyclical component of the ratio of tax revenues to nominal output $\frac{\hat{T}_{i,t}}{P^Y_{i,t}Y_{i,t}}$ depends on a weighted average of its past and desired cyclical components according to fiscal revenue rule,

$$\frac{\hat{T}_{i,t}}{P^Y_{i,t}Y_{i,t}} = \phi_{12,1}\frac{\hat{T}_{i,t-1}}{P^Y_{i,t-1}Y_{i,t-1}} + (1-\phi_{12,1})\theta_{12,1}\frac{\hat{B}^G_{i,t+1}}{P^Y_{i,t}Y_{i,t}} + \varepsilon^{\hat{T}}_{i,t}, \tag{12}$$

where fiscal revenue shock $\varepsilon^{\hat{T}}_{i,t} \sim \text{iid } \mathcal{N}(0,\sigma^2_{\hat{T},i})$. The desired cyclical component of the ratio of tax revenues to nominal output responds to the contemporaneous cyclical component of the ratio of net government assets to nominal output.

The cyclical component of the ratio of the fiscal balance to nominal output $\frac{FB_{i,t}}{P^Y_{i,t}Y_{i,t}}$ depends on the contemporaneous cyclical components of the short term nominal market interest rate and the ratio of the primary fiscal balance to nominal output according to government dynamic budget constraint:

$$\frac{FB_{i,t}}{P^Y_{i,t}Y_{i,t}} = \frac{B^{G,S}_i}{P^Y_iY_i}\hat{i}^S_{i,t} + \frac{PB_{i,t}}{P^Y_{i,t}Y_{i,t}}. \tag{13}$$

The cyclical component of the ratio of the primary fiscal balance to nominal output $\frac{PB_{i,t}}{P^Y_{i,t}Y_{i,t}}$ depends on the contemporaneous cyclical components of the ratios of tax revenues to nominal output and of public domestic demand to output, as well as the contemporaneous cyclical component of the terms of trade, according to:

$$\frac{PB_{i,t}}{P_{i,t}^{Y}Y_{i,t}}=\frac{\hat{T}_{i,t}}{P_{i,t}^{Y}Y_{i,t}}-\frac{G_i}{Y_i}\left(\ln\frac{\hat{G}_{i,t}}{\hat{Y}_{i,t}}+\frac{M_i}{D_i}\ln\hat{\mathcal{T}}_{i,t}\right). \tag{14}$$

The cyclical component of the ratio of net government assets to nominal output $\frac{\hat{B}_{i,t+1}^{G}}{P_{i,t}^{Y}Y_{i,t}}$ follows a stationary first order autoregressive process driven by the contemporaneous cyclical components of the growth rate of nominal output and the ratio of the fiscal balance to nominal output according to:

$$\frac{\hat{B}_{i,t+1}^{G}}{P_{i,t}^{Y}Y_{i,t}}=\frac{1}{1+g}\frac{\hat{B}_{i,t}^{G}}{P_{i,t-1}^{Y}Y_{i,t-1}}-\frac{B_i^G}{P_i^Y Y_i}\ln\frac{\hat{P}_{i,t}^{Y}\hat{Y}_{i,t}}{\hat{P}_{i,t-1}^{Y}\hat{Y}_{i,t-1}}+\frac{FB_{i,t}}{P_{i,t}^{Y}Y_{i,t}}. \tag{15}$$

The response coefficients of these relationships vary across economies with their public financial wealth, measured by the ratio of net government assets to nominal output $\frac{B_i^G}{P_i^Y Y_i}$, in particular of short maturity $\frac{B_i^{G,S}}{P_i^Y Y_i}$.

The cyclical component of the ratio of the current account balance to nominal output $\frac{CA_{i,t}}{P_{i,t}^{Y}Y_{i,t}}$ depends on the contemporaneous cyclical components of the short term nominal market interest rate and the ratio of the trade balance to nominal output according to national dynamic budget constraint:

$$\frac{CA_{i,t}}{P_{i,t}^{Y}Y_{i,t}}=\frac{B_i^S}{P_i^Y Y_i}\hat{i}_{i,t}^{S}+\frac{TB_{i,t}}{P_{i,t}^{Y}Y_{i,t}}. \tag{16}$$

The cyclical component of the ratio of the trade balance to nominal output $\frac{TB_{i,t}}{P_{i,t}^{Y}Y_{i,t}}$ depends on the contemporaneous cyclical component of the ratio of output to domestic demand and the terms of trade according to:

$$\frac{TB_{i,t}}{P_{i,t}^{Y}Y_{i,t}}=\frac{D_i}{Y_i}\ln\frac{\hat{Y}_{i,t}}{\hat{D}_{i,t}}-\frac{M_i}{Y_i}\ln\hat{\mathcal{T}}_{i,t}. \tag{17}$$

The cyclical component of the ratio of net foreign assets to nominal output $\frac{\hat{B}_{i,t+1}}{P_{i,t}^{Y}Y_{i,t}}$ follows a stationary first order autoregressive process driven by the contemporaneous cyclical components of the growth rate of nominal output and the ratio of the current account balance to nominal output according to:

$$\frac{\hat{B}_{i,t+1}}{P_{i,t}^{Y}Y_{i,t}}=\frac{1}{1+g}\frac{\hat{B}_{i,t}}{P_{i,t-1}^{Y}Y_{i,t-1}}-\frac{B_i}{P_i^Y Y_i}\ln\frac{\hat{P}_{i,t}^{Y}\hat{Y}_{i,t}}{\hat{P}_{i,t-1}^{Y}\hat{Y}_{i,t-1}}+\frac{CA_{i,t}}{P_{i,t}^{Y}Y_{i,t}}. \tag{18}$$

The response coefficients of these relationships vary across economies with their national financial wealth, measured by the ratio of net foreign assets to nominal output $\frac{B_i}{P_i^Y Y_i}$, in particular of short maturity $\frac{B_i^S}{P_i^Y Y_i}$.

The cyclical component of the relative price of commodities $\ln \hat{P}_t^{COM^z}$ depends on a linear combination of its past and expected future cyclical components driven by the contemporaneous cyclical component of world output according to commodity market relationship,

$$\ln \frac{\hat{P}_t^{COM^z}}{\hat{P}_{i^*,t}^Y} = \phi_{13,1} \ln \frac{\hat{P}_{t-1}^{COM^z}}{\hat{P}_{i^*,t-1}^Y} + \phi_{13,2} \,\mathrm{E}_t \ln \frac{\hat{P}_{t+1}^{COM^z}}{\hat{P}_{i^*,t+1}^Y} + \theta_{13,1,j} \ln \hat{Y}_{i,t}^Y + \nu_t^{\hat{P}^{COM^z}}, \tag{19}$$

where world commodity price shock $\nu_t^{\hat{P}^{COM^z}} = \rho_{\hat{P}^{COM}} \nu_{t-1}^{\hat{P}^{COM^z}} + \varepsilon_t^{\hat{P}^{COM^z}}$ with $\varepsilon_t^{\hat{P}^{COM^z}} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\hat{P}^{COM^z}})$. The response coefficients of this relationship vary across commodity markets $z \in \{e, n\}$, with $j = 1$ for energy commodities and $j = 0$ for nonenergy commodities. As an identifying restriction, all innovations are assumed to be independent, which combined with our distributional assumptions implies multivariate normality.

B. Trend Components

The changes in the trend components of the price of output $\ln \bar{P}_{i,t}^Y$, the price of consumption $\ln \bar{P}_{i,t}^C$, output $\ln \bar{Y}_{i,t}$, domestic demand $\ln \bar{D}_{i,t}$, public domestic demand $\ln \bar{G}_{i,t}$, and the price of commodities $\ln \bar{P}_t^{COM^z}$ follow random walks:

$$\Delta \ln \bar{P}_{i,t}^Y = \Delta \ln \bar{P}_{i,t-1}^Y + \varepsilon_{i,t}^{\bar{P}^Y}, \ \varepsilon_{i,t}^{\bar{P}^Y} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{P}^Y,i}), \tag{20}$$

$$\Delta \ln \bar{P}_{i,t}^C = \Delta \ln \bar{P}_{i,t-1}^C + \varepsilon_{i,t}^{\bar{P}^C}, \ \varepsilon_{i,t}^{\bar{P}^C} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{P}^C,i}), \tag{21}$$

$$\Delta \ln \bar{Y}_{i,t} = \Delta \ln \bar{Y}_{i,t-1} + \varepsilon_{i,t}^{\bar{Y}}, \ \varepsilon_{i,t}^{\bar{Y}} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{Y},i}), \tag{22}$$

$$\Delta \ln \bar{D}_{i,t} = \Delta \ln \bar{D}_{i,t-1} + \varepsilon_{i,t}^{\bar{D}}, \ \varepsilon_{i,t}^{\bar{D}} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{D},i}), \tag{23}$$

$$\Delta \ln \bar{G}_{i,t} = \Delta \ln \bar{G}_{i,t-1} + \varepsilon_{i,t}^{\bar{G}}, \ \varepsilon_{i,t}^{\bar{G}} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{G},i}), \tag{24}$$

$$\Delta \ln \bar{P}_t^{COM^z} = \Delta \ln \bar{P}_{t-1}^{COM^z} + \varepsilon_t^{\bar{P}^{COM^z}}, \ \varepsilon_t^{\bar{P}^{COM^z}} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{P}^{COM^z}}). \tag{25}$$

The trend component of the ratio of tax revenues to nominal output $\frac{\bar{T}_{i,t}}{P_{i,t}^Y Y_{i,t}}$ satisfies $\frac{\bar{T}_{i,t}}{P_{i,t}^Y Y_{i,t}} = \frac{T_i}{P_i^Y Y_i}$.

The changes in the trend components of the nominal policy interest rate $\bar{i}_{i,t}^P$, short term nominal market interest rate $\bar{i}_{i,t}^S$, and long term nominal market interest rate $\bar{i}_{i,t}^L$ also follow random walks:

$$\Delta \bar{i}_{i,t}^P = \Delta \bar{i}_{i,t-1}^P + \varepsilon_{i,t}^{\bar{i}^P}, \ \varepsilon_{i,t}^{\bar{i}^P} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{i}^P,i}), \tag{26}$$

$$\Delta \bar{i}_{i,t}^S = \Delta \bar{i}_{i,t-1}^S + \varepsilon_{i,t}^{\bar{i}^S}, \ \varepsilon_{i,t}^{\bar{i}^S} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{i}^S,i}), \tag{27}$$

$$\Delta \bar{i}_{i,t}^L = \Delta \bar{i}_{i,t-1}^L + \varepsilon_{i,t}^{\bar{i}^L}, \ \varepsilon_{i,t}^{\bar{i}^L} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{i}^L,i}). \tag{28}$$

The trend component of the real policy interest rate $\bar{r}^{P,Z}_{i,t}$ satisfies $\bar{r}^{P,Z}_{i,t} = \bar{i}^{P}_{i,t} - \mathrm{E}_t\, \bar{\pi}^{Z}_{i,t+1}$, the trend component of the short term real market interest rate $\bar{r}^{S,Z}_{i,t}$ satisfies $\bar{r}^{S,Z}_{i,t} = \bar{i}^{S}_{i,t} - \mathrm{E}_t\, \bar{\pi}^{Z}_{i,t+1}$, and the trend component of the long term real market interest rate $\bar{r}^{L,Z}_{i,t}$ satisfies $\bar{r}^{L,Z}_{i,t} = \bar{i}^{L}_{i,t} - \mathrm{E}_t\, \bar{\pi}^{Z}_{i,t+1}$.

The changes in the trend components of the price of equity $\ln \bar{P}^{STK}_{i,t}$ and the nominal bilateral exchange rate $\ln \bar{\mathcal{E}}_{i,i^*,t}$ also follow random walks:

$$\Delta \ln \bar{P}^{STK}_{i,t} = \Delta \ln \bar{P}^{STK}_{i,t-1} + \varepsilon^{\bar{P}^{STK}}_{i,t}, \;\; \varepsilon^{\bar{P}^{STK}}_{i,t} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{P}^{STK},i}), \tag{29}$$

$$\Delta \ln \bar{\mathcal{E}}_{i,i^*,t} = \Delta \ln \bar{\mathcal{E}}_{i,i^*,t-1} + \varepsilon^{\bar{\mathcal{E}}}_{i,t}, \;\; \varepsilon^{\bar{\mathcal{E}}}_{i,t} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\bar{\mathcal{E}},i}). \tag{30}$$

The trend component of the real bilateral exchange rate $\ln \bar{\mathcal{Q}}_{i,i^*,t}$ satisfies $\ln \bar{\mathcal{Q}}_{i,i^*,t} = \ln \bar{\mathcal{E}}_{i,i^*,t} + \ln \bar{P}^{Y}_{i^*,t} - \ln \bar{P}^{Y}_{i,t}$, and the trend component of the terms of trade $\ln \bar{\mathcal{T}}_{i,t}$ satisfies $\ln \bar{\mathcal{T}}_{i,t} = 0$.

The changes in the trend components of the ratios of the fiscal balance to nominal output $\frac{\overline{FB}_{i,t}}{P^Y_{i,t}Y_{i,t}}$ and the current account balance to nominal output $\frac{\overline{CA}_{i,t}}{P^Y_{i,t}Y_{i,t}}$ also follow random walks:

$$\Delta \frac{\overline{FB}_{i,t}}{P^Y_{i,t}Y_{i,t}} = \Delta \frac{\overline{FB}_{i,t-1}}{P^Y_{i,t-1}Y_{i,t-1}} + \varepsilon^{\overline{FB}}_{i,t}, \;\; \varepsilon^{\overline{FB}}_{i,t} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\overline{FB},i}), \tag{31}$$

$$\Delta \frac{\overline{CA}_{i,t}}{P^Y_{i,t}Y_{i,t}} = \Delta \frac{\overline{CA}_{i,t-1}}{P^Y_{i,t-1}Y_{i,t-1}} + \varepsilon^{\overline{CA}}_{i,t}, \;\; \varepsilon^{\overline{CA}}_{i,t} \sim \text{iid } \mathcal{N}(0, \sigma^2_{\overline{CA},i}). \tag{32}$$

The trend component of the ratio of the primary fiscal balance to nominal output $\frac{\overline{PB}_{i,t}}{P^Y_{i,t}Y_{i,t}}$ satisfies $\frac{\overline{PB}_{i,t}}{P^Y_{i,t}Y_{i,t}} = \frac{T_i}{Y_i} - \frac{G_i}{Y_i}$, and the trend component of the ratio of net government assets to nominal output $\frac{\bar{B}^G_{i,t+1}}{P^Y_{i,t}Y_{i,t}}$ satisfies $\frac{\bar{B}^G_{i,t+1}}{P^Y_{i,t}Y_{i,t}} = \frac{B^G_i}{P^Y_i Y_i}$. The trend component of the ratio of the trade balance to nominal output $\frac{\overline{TB}_{i,t}}{P^Y_{i,t}Y_{i,t}}$ satisfies $\frac{\overline{TB}_{i,t}}{P^Y_{i,t}Y_{i,t}} = \frac{X_i}{Y_i} - \frac{M_i}{Y_i}$, and the trend component of the ratio of net foreign assets to nominal output $\frac{\bar{B}_{i,t+1}}{P^Y_{i,t}Y_{i,t}}$ satisfies $\frac{\bar{B}_{i,t+1}}{P^Y_{i,t}Y_{i,t}} = \frac{B_i}{P^Y_i Y_i}$. As an identifying restriction, all innovations are assumed to be independent.

III. Estimation

The traditional econometric interpretation of this panel unobserved components model of the world economy regards it as a representation of the joint probability distribution of the data. We employ a Bayesian estimation procedure which respects this traditional econometric interpretation while conditioning on prior information concerning the common values of structural parameters across economies, and judgment concerning the paths of trend components. In addition to mitigating potential model misspecification and identification problems, exploiting this additional information may be expected to yield efficiency gains in estimation.

A. Estimation Procedure

Let $\boldsymbol{x}_t$ denote a vector stochastic process consisting of the levels of $N_{\boldsymbol{x}}$ nonpredetermined endogenous variables, of which $N_{\boldsymbol{y}}$ are observed. The cyclical components of this vector stochastic process satisfy second order stochastic linear difference equation

$$\boldsymbol{A}_0\hat{\boldsymbol{x}}_t = \boldsymbol{A}_1\hat{\boldsymbol{x}}_{t-1} + \boldsymbol{A}_2\mathrm{E}_t\hat{\boldsymbol{x}}_{t+1} + \boldsymbol{A}_3\hat{\boldsymbol{v}}_t, \tag{33}$$

where vector stochastic process $\hat{\boldsymbol{v}}_t$ consists of the cyclical components of $N_{\boldsymbol{v}}$ exogenous variables. This vector stochastic process satisfies stationary first order stochastic linear difference equation

$$\hat{\boldsymbol{v}}_t = \boldsymbol{B}_1\hat{\boldsymbol{v}}_{t-1} + \boldsymbol{\varepsilon}_{1,t}, \tag{34}$$

where $\boldsymbol{\varepsilon}_{1,t} \sim \text{iid } \mathcal{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_1)$. If there exists a unique stationary solution to this multivariate linear rational expectations model, then it may be expressed as:

$$\hat{\boldsymbol{x}}_t = \boldsymbol{C}_1\hat{\boldsymbol{x}}_{t-1} + \boldsymbol{C}_2\hat{\boldsymbol{v}}_t. \tag{35}$$

This unique stationary solution is calculated with the procedure due to Klein (2000).

The trend components of vector stochastic process $\boldsymbol{x}_t$ satisfy first order stochastic linear difference equation

$$\boldsymbol{D}_0\bar{\boldsymbol{x}}_t = \boldsymbol{D}_1\boldsymbol{u}_t + \boldsymbol{D}_2\bar{\boldsymbol{x}}_{t-1} + \boldsymbol{\varepsilon}_{2,t}, \tag{36}$$

where $\boldsymbol{\varepsilon}_{2,t} \sim \text{iid } \mathcal{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_2)$. Vector stochastic process $\boldsymbol{u}_t$ consists of the levels of $N_{\boldsymbol{u}}$ common stochastic trends, and satisfies nonstationary first order stochastic linear difference equation

$$\boldsymbol{u}_t = \boldsymbol{u}_{t-1} + \boldsymbol{\varepsilon}_{3,t}, \tag{37}$$

where $\boldsymbol{\varepsilon}_{3,t} \sim \text{iid } \mathcal{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_3)$. Cyclical and trend components are additively separable, that is $\boldsymbol{x}_t = \hat{\boldsymbol{x}}_t + \bar{\boldsymbol{x}}_t$.

Let $\boldsymbol{y}_t$ denote a vector stochastic process consisting of the levels of $N_{\boldsymbol{y}}$ observed nonpredetermined endogenous variables. Also, let $\boldsymbol{z}_t$ denote a vector stochastic process consisting of the levels of $N_{\boldsymbol{x}} - N_{\boldsymbol{y}}$ unobserved nonpredetermined endogenous variables, the cyclical components of $N_{\boldsymbol{x}}$ nonpredetermined endogenous variables, the trend components of $N_{\boldsymbol{x}}$ nonpredetermined endogenous variables, the cyclical components of $N_{\boldsymbol{v}}$ exogenous variables, and the levels of $N_{\boldsymbol{u}}$ common stochastic trends. Given unique stationary solution (35), these vector stochastic processes have linear state space representation

$$\boldsymbol{y}_t = \boldsymbol{F}_1\boldsymbol{z}_t, \tag{38}$$

$$\boldsymbol{z}_t = \boldsymbol{G}_1\boldsymbol{z}_{t-1} + \boldsymbol{G}_2\boldsymbol{\varepsilon}_{4,t}, \tag{39}$$

where $\boldsymbol{\varepsilon}_{4,t} \sim \text{iid } \mathcal{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_4)$ and $\boldsymbol{z}_0 \sim \mathcal{N}(\boldsymbol{z}_{0|0}, \boldsymbol{P}_{0|0})$. Let $\boldsymbol{w}_t$ denote a vector stochastic process consisting of alternative estimates or forecasts of $N_{\boldsymbol{w}}$ linearly independent linear combinations of unobserved state variables. Following Vitek (2009), suppose that this vector stochastic process satisfies

$$\boldsymbol{w}_t = \boldsymbol{H}_1 \boldsymbol{z}_t + \boldsymbol{\varepsilon}_{5,t}, \tag{40}$$

where $\boldsymbol{\varepsilon}_{5,t} \sim \text{iid } \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}_{5,t})$. Conditional on known parameter values, this signal equation imposes judgment on linear combinations of unobserved state variables in the form of a set of stochastic restrictions of time dependent tightness. The signal and state innovation vectors are assumed to be independent, while the initial state vector is assumed to be independent from the signal and state innovation vectors, which combined with our distributional assumptions implies multivariate normality.

Conditional on the parameters associated with these signal and state equations, estimates of unobserved state vector $\boldsymbol{z}_t$ and its mean squared error matrix $\boldsymbol{P}_t$ may be calculated with the filter due to Kalman (1960) or the smoother associated with de Jong (1989). Given initial conditions $\boldsymbol{z}_{0|0}$ and $\boldsymbol{P}_{0|0}$, estimates conditional on information available at time $t-1$ satisfy prediction equations:

$$\boldsymbol{z}_{t|t-1} = \boldsymbol{G}_1 \boldsymbol{z}_{t-1|t-1}, \tag{41}$$

$$\boldsymbol{P}_{t|t-1} = \boldsymbol{G}_1 \boldsymbol{P}_{t-1|t-1} \boldsymbol{G}_1^\top + \boldsymbol{G}_2 \boldsymbol{\Sigma}_4 \boldsymbol{G}_2^\top, \tag{42}$$

$$\boldsymbol{y}_{t|t-1} = \boldsymbol{F}_1 \boldsymbol{z}_{t|t-1}, \tag{43}$$

$$\boldsymbol{Q}_{t|t-1} = \boldsymbol{F}_1 \boldsymbol{P}_{t|t-1} \boldsymbol{F}_1^\top, \tag{44}$$

$$\boldsymbol{w}_{t|t-1} = \boldsymbol{H}_1 \boldsymbol{z}_{t|t-1}, \tag{45}$$

$$\boldsymbol{R}_{t|t-1} = \boldsymbol{H}_1 \boldsymbol{P}_{t|t-1} \boldsymbol{H}_1^\top + \boldsymbol{\Sigma}_{5,t}. \tag{46}$$

Given these predictions, under the assumption of multivariate normally distributed signal and state innovation vectors, together with conditionally contemporaneously uncorrelated signal vectors, estimates conditional on information available at time t, and judgment concerning the paths of linear combinations of state variables through time t, satisfy Bayesian updating equations

$$\boldsymbol{z}_{t|t} = \boldsymbol{z}_{t|t-1} + \boldsymbol{K}_{y_t}(\boldsymbol{y}_t - \boldsymbol{y}_{t|t-1}) + \boldsymbol{K}_{w_t}(\boldsymbol{w}_t - \boldsymbol{w}_{t|t-1}), \tag{47}$$

$$\boldsymbol{P}_{t|t} = \boldsymbol{P}_{t|t-1} - \boldsymbol{K}_{y_t} \boldsymbol{F}_1 \boldsymbol{P}_{t|t-1} - \boldsymbol{K}_{w_t} \boldsymbol{H}_1 \boldsymbol{P}_{t|t-1}, \tag{48}$$

where $\boldsymbol{K}_{y_t} = \boldsymbol{P}_{t|t-1} \boldsymbol{F}_1^\top \boldsymbol{Q}_{t|t-1}^{-1}$ and $\boldsymbol{K}_{w_t} = \boldsymbol{P}_{t|t-1} \boldsymbol{H}_1^\top \boldsymbol{R}_{t|t-1}^{-1}$. Given terminal conditions $\hat{\boldsymbol{z}}_{T+1|T} = \mathbf{0}$ and $\hat{\boldsymbol{P}}_{T+1|T} = \mathbf{0}$, estimates conditional on information available at time T, and judgment concerning the paths of linear combinations of state variables through time T, satisfy computationally efficient Bayesian smoothing equations

$$\hat{\boldsymbol{z}}_{t|T} = \boldsymbol{J}_t^\top \hat{\boldsymbol{z}}_{t+1|T} + \boldsymbol{F}_1^\top \boldsymbol{Q}_{t|t-1}^{-1}(\boldsymbol{y}_t - \boldsymbol{y}_{t|t-1}) + \boldsymbol{H}_1^\top \boldsymbol{R}_{t|t-1}^{-1}(\boldsymbol{w}_t - \boldsymbol{w}_{t|t-1}), \tag{49}$$

$$\boldsymbol{z}_{t|T} = \boldsymbol{z}_{t|t-1} + \boldsymbol{P}_{t|t-1} \hat{\boldsymbol{z}}_{t|T}, \tag{50}$$

$$\hat{\boldsymbol{P}}_{t|T} = \boldsymbol{J}_t^\top \hat{\boldsymbol{P}}_{t+1|T} \boldsymbol{J}_t - \boldsymbol{F}_1^\top \boldsymbol{Q}_{t|t-1}^{-1} \boldsymbol{F}_1 - \boldsymbol{H}_1^\top \boldsymbol{R}_{t|t-1}^{-1} \boldsymbol{H}_1, \tag{51}$$

$$\boldsymbol{P}_{t|T} = \boldsymbol{P}_{t|t-1} + \boldsymbol{P}_{t|t-1}\hat{\boldsymbol{P}}_{t|T}\boldsymbol{P}_{t|t-1}, \tag{52}$$

where $\boldsymbol{J}_t = \boldsymbol{G}_1\left[\boldsymbol{I}_K - \boldsymbol{P}_{t|t-1}(\boldsymbol{F}_1^{\top}\boldsymbol{Q}_{t|t-1}^{-1}\boldsymbol{F}_1 + \boldsymbol{H}_1^{\top}\boldsymbol{R}_{t|t-1}^{-1}\boldsymbol{H}_1)\right]$. Under our distributional assumptions, recursive forward evaluation of equations (41) through (48), followed by recursive backward evaluation of equations (49) and (51), yields mean squared error optimal conditional estimates of the unobserved state vector.

Let $\boldsymbol{\theta} \in \boldsymbol{\Theta} \subset \mathbb{R}^K$ denote a K dimensional vector containing the parameters associated with the signal and state equations of this linear state space model. The Bayesian estimator of this parameter vector has posterior density function

$$f(\boldsymbol{\theta} \mid \mathcal{I}_T) \propto f(\mathcal{I}_T \mid \boldsymbol{\theta}) f(\boldsymbol{\theta}), \tag{53}$$

where $\mathcal{I}_t = \{\{\boldsymbol{y}_s\}_{s=1}^t, \{\boldsymbol{w}_s\}_{s=1}^t\}$. Under the assumption of multivariate normally distributed signal and state innovation vectors, together with conditionally contemporaneously uncorrelated signal vectors, conditional density function $f(\mathcal{I}_T \mid \boldsymbol{\theta})$ satisfies:

$$f(\mathcal{I}_T \mid \boldsymbol{\theta}) = \prod_{t=1}^{T} f(\boldsymbol{y}_t \mid \mathcal{I}_{t-1}, \boldsymbol{\theta}) \cdot \prod_{t=1}^{T} f(\boldsymbol{w}_t \mid \mathcal{I}_{t-1}, \boldsymbol{\theta}). \tag{54}$$

Under our distributional assumptions, conditional density functions $f(\boldsymbol{y}_t \mid \mathcal{I}_{t-1}, \boldsymbol{\theta})$ and $f(\boldsymbol{w}_t \mid \mathcal{I}_{t-1}, \boldsymbol{\theta})$ satisfy:

$$f(\boldsymbol{y}_t \mid \mathcal{I}_{t-1}, \boldsymbol{\theta}) = (2\pi)^{-\frac{N_y}{2}} \mid \boldsymbol{Q}_{t|t-1} \mid^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}(\boldsymbol{y}_t - \boldsymbol{y}_{t|t-1})^{\top} \boldsymbol{Q}_{t|t-1}^{-1}(\boldsymbol{y}_t - \boldsymbol{y}_{t|t-1})\right\}, \tag{55}$$

$$f(\boldsymbol{w}_t \mid \mathcal{I}_{t-1}, \boldsymbol{\theta}) = (2\pi)^{-\frac{N_w}{2}} \mid \boldsymbol{R}_{t|t-1} \mid^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}(\boldsymbol{w}_t - \boldsymbol{w}_{t|t-1})^{\top} \boldsymbol{R}_{t|t-1}^{-1}(\boldsymbol{w}_t - \boldsymbol{w}_{t|t-1})\right\}. \tag{56}$$

Prior information concerning parameter vector $\boldsymbol{\theta}$ is summarized by a multivariate normal prior distribution having mean vector $\boldsymbol{\theta}_1$ and covariance matrix $\boldsymbol{\Omega}$:

$$f(\boldsymbol{\theta}) = (2\pi)^{-\frac{K}{2}} \mid \boldsymbol{\Omega} \mid^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}(\boldsymbol{\theta} - \boldsymbol{\theta}_1)^{\top} \boldsymbol{\Omega}^{-1}(\boldsymbol{\theta} - \boldsymbol{\theta}_1)\right\}. \tag{57}$$

Independent priors are represented by a diagonal covariance matrix, under which diffuse priors are represented by infinite variances.

Inference on the parameters is based on an asymptotic normal approximation to the posterior distribution around its mode. Under regularity conditions stated in Geweke (2005), posterior mode $\hat{\boldsymbol{\theta}}_T$ satisfies

$$\sqrt{T}(\hat{\boldsymbol{\theta}}_T - \boldsymbol{\theta}_0) \xrightarrow{d} \mathcal{N}(\boldsymbol{0}, -\boldsymbol{\mathcal{H}}_0^{-1}), \tag{58}$$

where $\boldsymbol{\theta}_0 \in \boldsymbol{\Theta}$ denotes the pseudo-true parameter vector. Following Engle and Watson (1981), Hessian $\boldsymbol{\mathcal{H}}_0$ is estimated by:

$$\hat{\mathcal{H}}_T = -\frac{1}{T}\sum_{t=1}^{T}\left[\nabla_\theta \boldsymbol{y}_{t|t-1}^\mathsf{T}\boldsymbol{Q}_{t|t-1}^{-1}\nabla_\theta \boldsymbol{y}_{t|t-1} + \frac{1}{2}\nabla_\theta \boldsymbol{Q}_{t|t-1}^\mathsf{T}(\boldsymbol{Q}_{t|t-1}^{-1}\otimes\boldsymbol{Q}_{t|t-1}^{-1})\nabla_\theta \boldsymbol{Q}_{t|t-1}\right] \\ -\frac{1}{T}\sum_{t=1}^{T}\left[\nabla_\theta \boldsymbol{w}_{t|t-1}^\mathsf{T}\boldsymbol{R}_{t|t-1}^{-1}\nabla_\theta \boldsymbol{w}_{t|t-1} + \frac{1}{2}\nabla_\theta \boldsymbol{R}_{t|t-1}^\mathsf{T}(\boldsymbol{R}_{t|t-1}^{-1}\otimes\boldsymbol{R}_{t|t-1}^{-1})\nabla_\theta \boldsymbol{R}_{t|t-1}\right] - \frac{1}{T}\boldsymbol{\Omega}^{-1}. \tag{59}$$

This estimator of the Hessian depends only on first derivatives and is negative semidefinite.

B. Estimation Results

Joint estimation of the parameters and unobserved components of our panel unobserved components model of the world economy is based on the levels of a total of four hundred one endogenous variables observed for thirty five economies over the sample period 1999Q1 through 2011Q3. The economies under consideration are Argentina, Australia, Austria, Belgium, Brazil, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom, and the United States. The observed endogenous variables under consideration are the price of output, the price of consumption, the quantity of output, the quantity of domestic demand, the nominal policy interest rate, the short term nominal market interest rate, the long term nominal market interest rate, the price of equity, the nominal bilateral exchange rate, the quantity of public domestic demand, the ratio of the fiscal balance to nominal output, the ratio of the current account balance to nominal output, and the prices of energy and nonenergy commodities. For a detailed description of this data set, please refer to Appendix A.

Parameters

The set of parameters associated with our panel unobserved components model is partitioned into two subsets. Those parameters associated with the conditional mean function are estimated conditional on informative independent priors, while those parameters associated exclusively with the conditional variance function are estimated conditional on diffuse priors.

The marginal prior distributions of those parameters associated with the conditional mean function are centered within the range of estimates reported in the existing empirical literature, where available. The conduct of monetary policy is represented by a flexible inflation targeting regime in all economies except for Argentina, China, the Czech Republic, Denmark, India, Indonesia, Russia, Saudi Arabia and Thailand, where it is represented by a managed exchange rate regime, consistent with IMF (2006). Capital controls apply in China, India, and Saudi Arabia. The quotation currency for transactions in the foreign exchange market is issued by the United States. Great ratios and bilateral trade and equity portfolio weights entering into the conditional mean function are calibrated to match their observed values in 2005. All world weights and bilateral trade and portfolio weights are normalized to sum to one.

Judgment concerning the paths of trend components is generated by passing the levels of all observed endogenous variables through the filter described in Hodrick and Prescott (1997). Stochastic restrictions on the trend components of all observed endogenous variables are derived from these preliminary estimates, with a time varying innovation covariance matrix set equal to that obtained from unrestricted estimation, rescaled by a factor of 2^2. Initial conditions for the cyclical components of exogenous variables are given by their unconditional means and variances, while the initial values of all other state variables are treated as parameters, and are calibrated to match functions of initial realizations of the levels of observed endogenous variables, or preliminary estimates of their trend components calculated with the filter associated with Hodrick and Prescott (1997).

The posterior mode is calculated by numerically maximizing the logarithm of the posterior density kernel with a modified steepest ascent algorithm. To avoid finding a local as opposed to global maximum, starting values for structural parameters are generated with a customized implementation of the differential evolution algorithm proposed by Storn and Price (1997). Parameter estimation results pertaining to the sample period 1999Q3 through 2011Q3 are reported in Table 1 of Appendix B. The sufficient condition for the existence of a unique stationary rational expectations equilibrium stated in Klein (2000) is satisfied in a neighborhood around the posterior mode, while our estimator of the Hessian is not nearly singular at the posterior mode, suggesting that the linear state space representation of our panel unobserved components model is locally identified.

The posterior modes of most structural parameters are close to their prior means, reflecting the imposition of tight priors to preserve empirically plausible impulse response dynamics. Nevertheless, the data are quite informative regarding some of these structural parameters, as evidenced by substantial updates from prior to posterior. The estimated variances of innovations driving variation in cyclical components are all well within the range of estimates reported in the existing empirical literature, after accounting for data rescaling. The estimated variances of innovations driving variation in trend components vary considerably across economies and observed endogenous variables.

Unobserved Components

Within the framework of our estimated panel unobserved components model, the output gap and the monetary conditions gap are indicators of inflationary or disinflationary pressure, while the monetary conditions gap is also an indicator of business cycle fluctuations. Smoothed estimates of the output gap are plotted in Figure 1 and Figure 2 of Appendix B, while smoothed estimates of the monetary conditions gap are also plotted in Figure 2 of Appendix B. These estimates are conditional on past, present, and future information.

A decomposition of our output gap estimates into contributions from domestic demand and net exports indicates that the gradual global synchronized accumulation of excess demand pressure which occurred during the build up to the global financial crisis was primarily driven by the excessive expansion of private domestic demand in most economies. During this period of widening global current account imbalances, the excessive expansion of net exports was also a major contributor to the accumulation of excess demand pressure in major surplus economies such as China, Germany, and Japan. The global financial crisis triggered the rapid global synchronized unwinding of this excess demand pressure, and resulted in the accumulation of substantial excess supply pressure in many economies. During this episode of narrowing global current account imbalances, collapses in private domestic demand in major deficit economies such as France, the United Kingdom, and the United States coincided with collapses in net exports in major surplus economies.

A decomposition of our output gap estimates into contributions from monetary conditions and real conditions reveals that the gradual global synchronized accumulation of excess demand pressure which occurred during the build up to the global financial crisis was accompanied by loose financial conditions in many economies, notably France, Germany, and the United States. During the global financial crisis, monetary and financial conditions abruptly tightened in these and many other economies.

IV. Monetary and Fiscal Policy Analysis

We analyze the interaction between business cycle dynamics in the world economy, and the systematic and unsystematic components of monetary and fiscal policy, within the framework of our estimated panel unobserved components model. In particular, we quantify dynamic interrelationships among key instrument, indicator, and target variables with simulated unconditional correlations and estimated impulse response functions. We also identify the structural determinants of these instrument, indicator, and target variables with estimated forecast error variance decompositions and historical decompositions.

A. Simulated Unconditional Correlations

Simulated unconditional correlations measure intertemporal comovement between endogenous variables driven by all structural shocks, on average over the business cycle. The simulated unconditional correlations between consumption price inflation, the output gap, and the monetary conditions gap are plotted in Figure 3 of Appendix B.

Our simulated unconditional correlations confirm that the output gap and the monetary conditions gap are both leading indicators of inflationary or disinflationary pressure. However, the usefulness of these indicators for predicting deviations of inflation from its implicit target rate varies across economies and horizons. These deviations are relatively unpredictable in economies with flexible inflation targeting regimes, particularly relatively small and open ones such as Australia, Canada, New Zealand, Norway, Sweden, and the United Kingdom. They are generally slightly more predictable in economies with managed exchange rate regimes, reflecting their lower degree of monetary policy autonomy. In contrast, they tend to be relatively predictable within the Euro Area, the member economies of which lack monetary policy autonomy. Reflecting lags in the monetary transmission mechanism, the output gap is generally slightly more useful for predicting inflation at short horizons, while the monetary conditions gap tends to be slightly more useful at long horizons.

Simulated unconditional correlations also verify that the monetary conditions gap is a leading indicator of business cycle fluctuations. The monetary conditions gap is generally more useful for predicting the output gap in economies with high dependence on private domestic demand. Conversely, it tends to be less useful for predicting the output gap in relatively open economies, due to their high dependence on foreign demand, and in economies with relatively large governments, reflecting their high dependence on public domestic demand.

B. Impulse Response Functions

Impulse response functions measure the dynamic effects of selected structural shocks on endogenous variables. The estimated impulse responses of consumption price inflation, output, domestic demand, the nominal policy interest rate, the real effective exchange rate, the ratio of the fiscal balance to nominal output, and the ratio of the current account balance to nominal output to a variety of structural shocks are plotted in Figure 4 through Figure 13 of Appendix B. The structural shocks under consideration are domestic supply shocks, domestic private demand shocks, domestic monetary policy shocks, domestic credit risk premium shocks, domestic duration risk premium shocks, domestic equity risk premium shocks, domestic fiscal expenditure shocks, domestic fiscal revenue shocks, world energy commodity price shocks, and world nonenergy commodity price shocks.

In response to a domestic supply shock which generates a persistent increase in inflation, there arises a persistent hump shaped contraction of output. Facing a monetary policy tradeoff, the central bank raises the nominal policy interest rate to control inflation, and the currency generally appreciates in real effective terms. The fiscal balance tends to deteriorate due to the fall in output, while the current account balance generally improves reflecting the generally larger fall in domestic demand. In response to a domestic private demand shock which generates a persistent hump shaped expansion of output, there generally arises a persistent hump shaped increase in inflation. Not facing a monetary policy tradeoff, the central bank tends to raise the nominal policy interest rate to stabilize inflation and output, and the currency appreciates in real effective terms. The fiscal balance improves due to the rise in output, while the current account balance deteriorates reflecting the larger rise in domestic demand.

In response to a domestic monetary policy shock which generates a persistent increase in the nominal policy interest rate, the currency appreciates in real effective terms. Reflecting the interest rate and exchange rate channels of monetary transmission, interacted with an international financial accelerator mechanism, there arises a persistent hump shaped contraction of output, accompanied by a persistent decrease in inflation. In particular, in response to a one percentage point increase in the nominal policy interest rate, the peak contraction of output averages 0.5 percent across economies within a range of 0.2 to 0.7 percent, while the peak decrease in inflation averages 0.3 percentage points within a range of 0.1 to 0.4 percentage points. The fiscal balance deteriorates due to the fall in output, while the current account balance generally improves reflecting the generally larger fall in domestic demand.

In response to a domestic credit risk premium shock which generates a persistent increase in the short term nominal market interest rate, the currency generally appreciates in real effective terms, and there arises a persistent hump shaped contraction of output, accompanied by a persistent decrease in inflation. The central bank tends to cut the nominal policy interest rate to stabilize inflation and output, but the fiscal balance deteriorates due to the fall in output, while the current account balance generally improves reflecting the generally larger fall in domestic demand. In response to a domestic duration risk premium shock which generates a persistent increase in the long term nominal market interest rate, there arises a persistent hump shaped contraction of output, generally accompanied by a persistent hump shaped decrease in inflation. The central bank tends to cut the nominal policy interest rate to stabilize inflation and output, and the currency depreciates in real effective terms. The fiscal balance deteriorates due to the fall in output, while the current account balance improves reflecting the larger fall in domestic demand. In response to a domestic equity risk premium shock which generates a persistent increase in the price of equity, there arises a persistent hump shaped expansion of output, generally accompanied by a persistent hump shaped increase in inflation. The central bank tends to raise the nominal policy interest rate to stabilize inflation and output, and the currency appreciates in real effective terms. The fiscal balance generally improves due to the rise in output, while the current account balance deteriorates reflecting the larger rise in domestic demand.

In response to a domestic fiscal expenditure shock which generates a persistent deterioration in the fiscal balance, there arises a persistent expansion of output, generally accompanied by a persistent hump shaped increase in inflation. In particular, in response to a one percentage point decrease in the ratio of the fiscal balance to nominal output, the peak expansion of output averages 1.0 percent within a range of 0.2 to 1.7 percent, and tends to decrease across economies with their trade openness. The central bank generally raises the nominal policy interest rate to stabilize inflation and output, and the currency appreciates in real effective terms. The current account balance deteriorates, reflecting the larger rise in domestic demand than in output. In response to a domestic fiscal revenue shock which generates a persistent improvement in the fiscal balance, there arises a persistent contraction of output, generally accompanied by a persistent hump shaped decrease in inflation. In particular, in response to a one percentage point increase in the ratio of the fiscal balance to nominal output, the peak contraction of output averages 0.6 percent within a range of 0.1 to 1.0 percent, and tends to decrease across economies with their trade openness. The central bank generally cuts the nominal policy interest rate to stabilize inflation and output, and the currency depreciates in real effective terms. The current account balance improves, reflecting the larger fall in domestic demand than in output.

In response to a world energy or nonenergy commodity price shock which generates a persistent increase in the price of energy or nonenergy commodities, inflation generally increases, and the central bank tends to raise the nominal policy interest rate. For net exporters of energy or nonenergy commodities, the currency generally appreciates in real effective terms, generally inducing a persistent terms of trade driven expansion of domestic demand mitigated by monetary policy tightening, which eventually translates into a persistent expansion of output in spite of terms of trade driven expenditure switching. The fiscal balance tends to improve, while the current account balance may improve or deteriorate. For net importers of energy or nonenergy commodities, the currency generally depreciates in real effective terms, generally inducing a persistent terms of trade driven contraction of domestic demand amplified by monetary policy tightening, which immediately translates into a persistent contraction of output in spite of terms of trade driven expenditure switching. The fiscal balance tends to deteriorate, while the current account balance may deteriorate or improve.

C. Forecast Error Variance Decompositions

Forecast error variance decompositions measure the contributions of mutually exclusive sets of structural shocks to unpredictable variation in endogenous variables at different horizons, on average over the business cycle. The estimated forecast error variance decompositions of consumption price inflation, output, domestic demand, the nominal policy interest rate, the real effective exchange rate, the ratio of the fiscal balance to nominal output, and the ratio of the current account balance to nominal output are plotted in Figure 14 through Figure 20 of Appendix B. The sets of structural shocks under consideration are domestic supply shocks, foreign supply shocks, domestic demand shocks, foreign demand shocks, world monetary policy shocks, world fiscal policy shocks, world risk premium shocks, and world terms of trade shocks.

Our estimated forecast error variance decompositions indicate that unpredictable variation in inflation is primarily driven by domestic and foreign supply shocks, and to a lesser extent world monetary policy shocks, at all horizons. The contribution of domestic supply shocks relative to foreign supply shocks is generally decreasing across economies with their trade openness and increasing with their monetary policy autonomy. In contrast, unpredictable variation in output tends to be primarily attributable to domestic and foreign demand shocks, together with world risk premium shocks, at high frequencies. The contribution of domestic demand shocks relative to foreign demand shocks is generally decreasing across economies with their trade openness. Nevertheless, domestic and foreign supply shocks, together with world monetary policy shocks, are major contributors to unpredictable output fluctuations at low frequencies. Estimated forecast error variance decompositions of domestic demand reveal a similar pattern, with the exception that domestic demand shocks are larger contributors to unpredictable variation at all frequencies, while foreign demand shocks are smaller contributors. In addition, world fiscal policy shocks tend to be significant contributors to unpredictable domestic demand fluctuations at high frequencies.

Estimated forecast error variance decompositions indicate that unpredictable variation in the nominal policy interest rate is primarily driven by world monetary policy shocks at short horizons. However, domestic and foreign supply shocks are also major contributors to unpredictable variation at long horizons, where the relative contribution of domestic supply shocks is generally decreasing across economies with their trade openness and increasing with their monetary policy autonomy. Estimated forecast error variance decompositions of the real effective exchange rate attribute most unpredictable high frequency variation to world monetary policy and risk premium shocks. Nevertheless, domestic and foreign supply shocks are also major contributors to unpredictable real effective exchange rate fluctuations at low frequencies.

Our estimated forecast error variance decompositions reveal that unpredictable variation in the fiscal balance is primarily driven by world monetary and fiscal policy shocks, and to a lesser extent domestic and foreign demand shocks, at short horizons. However, domestic and foreign supply shocks, and to a lesser extent domestic and foreign demand shocks, are also major contributors to unpredictable variation at long horizons. Estimated forecast error variance decompositions of the current account balance attribute most unpredictable high frequency variation to domestic and foreign demand shocks, together with world monetary policy shocks for economies with high net foreign asset or debt positions. The contribution of domestic demand shocks relative to foreign demand shocks tends to be decreasing across economies with their trade openness. Nevertheless, domestic and foreign supply shocks are also major contributors to unpredictable current account balance fluctuations at low frequencies.

D. Historical Decompositions

Historical decompositions measure the time varying contributions of mutually exclusive sets of structural shocks to the realizations of endogenous variables. The estimated historical decompositions of consumption price inflation, output growth, the ratio of the fiscal balance to nominal output, and the ratio of the current account balance to nominal output are plotted in Figure 21 through Figure 24 of Appendix B. The sets of structural shocks under consideration are domestic supply shocks, foreign supply shocks, domestic demand shocks, foreign demand shocks, world monetary policy shocks, world fiscal policy shocks, world risk premium shocks, and world terms of trade shocks.

Our estimated historical decompositions of inflation attribute deviations from implicit targets primarily to economy specific combinations of domestic and foreign supply and demand shocks, together with world risk premium and terms of trade shocks. Implicit inflation targets have generally stabilized at relatively low levels in advanced economies, particularly those with well established flexible inflation targeting regimes such as Australia, Canada, New Zealand, Norway, Sweden, and the United Kingdom. Estimated historical decompositions of output growth attribute business cycle dynamics around relatively stable potential output growth rates primarily to economy specific combinations of domestic and foreign demand shocks, together with world fiscal policy and risk premium shocks. Business cycle fluctuations in major deficit economies such as Spain and the United States have been primarily driven by domestic demand shocks, whereas those in major surplus economies such as China and Germany have been primarily driven by foreign demand shocks. In both groups of economies, these business cycle fluctuations have usually been amplified by world risk premium shocks and mitigated by world fiscal policy shocks. Potential output growth rates have generally stabilized at relatively low levels in advanced economies, and at relatively high levels in emerging economies.

Estimated historical decompositions of the fiscal balance attribute fluctuations around structural balances primarily to world fiscal policy shocks, together with economy specific combinations of domestic and foreign demand shocks. These fluctuations have usually been amplified by world risk premium shocks, reflecting the effects of discretionary fiscal policy on nominal market interest rates. Structural fiscal balances have generally deteriorated recently, particularly in advanced economies. Our estimated historical decompositions of the current account balance attribute fluctuations around structural balances primarily to economy specific combinations of domestic and foreign demand shocks. These contributions have been broadly balanced in major surplus and deficit economies, with the notable exception of Spain where domestic demand shocks have dominated, and China where foreign demand shocks have dominated.

During the build up to the global financial crisis, positive domestic and foreign demand shocks contributed to the gradual accumulation of excess demand pressure throughout the world economy, generally amplified by world risk premium shocks. This synchronized global expansion was reflected in a synchronized global rise in inflation, usually amplified by world terms of trade shocks. During the global financial crisis, economy specific combinations of negative domestic and foreign demand shocks, amplified and accelerated by world risk premium shocks, rapidly eliminated this excess demand pressure, generally supplanting it with excess supply pressure to varying degrees. This synchronized global recession was mitigated by unsystematic monetary and fiscal policy interventions, with the latter contributing to large deteriorations in fiscal balances. It was reflected in a synchronized global fall in inflation, usually amplified by world terms of trade shocks. Since the global financial crisis, economy specific combinations of positive domestic and foreign demand shocks, generally amplified by world risk premium shocks, have gradually reduced this excess supply pressure. This synchronized global recovery has been decelerated by world fiscal policy shocks, which have contributed to moderate to large improvements in fiscal balances.

V. SPILLOVER ANALYSIS

Within the framework of our estimated panel unobserved components model, the dynamic effects of macroeconomic and financial shocks are transmitted throughout the world economy via trade, financial and commodity price linkages, necessitating monetary and fiscal policy responses to spillovers. Macroeconomic shocks are transmitted via direct financial linkages, while financial shocks are also transmitted via indirect financial linkages representing contagion effects.

We analyze spillovers from macroeconomic and financial shocks in systemic economies to the rest of the world with simulated conditional betas and estimated impulse response functions. The systemic economies under consideration are China, the Euro Area, Japan, the United Kingdom, and the United States, consistent with IMF (2011). The macroeconomic shocks under consideration are supply shocks, private demand shocks, monetary policy shocks, fiscal expenditure shocks, and fiscal revenue shocks. The financial shocks under consideration are credit risk premium shocks, duration risk premium shocks, and equity risk premium shocks.

A. Simulated Conditional Betas

Simulated conditional betas measure contemporaneous comovement between endogenous variables driven by selected structural shocks, on average over the business cycle. They are ordinary least squares estimates of slope coefficients in bivariate regressions of endogenous variables on contemporaneous endogenous variables, averaged across a large number of simulated paths for the world economy. The simulated betas of the output gap with respect to the contemporaneous output gap in systemic economies, conditional on macroeconomic or financial shocks in each of these systemic economies, are plotted in Figure 25 of Appendix B. They measure causality as opposed to correlation, because they abstract from structural shocks associated with other economies.

On average over the business cycle, output spillovers from systemic economies to the rest of the world in our estimated panel unobserved components model are primarily generated by macroeconomic shocks, which contribute more to business cycle fluctuations than financial shocks. This implies weak international business cycle comovement beyond close trading partners. However, during episodes of financial stress in systemic economies, such as during the global financial crisis, international business cycle comovement is more uniformly strong due to the prevalence of financial shocks, which propagate via elevated contagion effects.

Output spillovers generated by macroeconomic shocks are generally small but concentrated in our estimated panel unobserved components model. The pattern of international business cycle comovement driven by macroeconomic shocks primarily reflects bilateral trade relationships, and therefore exhibits gravity. That is, output spillovers generated by macroeconomic shocks tend to be concentrated among geographically close trading partners, which generally have strong bilateral trade relationships due in part to transportation costs. However, this pattern is diluted by supply shocks, which are primarily transmitted internationally via terms of trade shifts, unlike other macroeconomic shocks which are primarily transmitted internationally via domestic demand shifts.

Output spillovers generated by financial shocks are generally large and diffuse in our estimated panel unobserved components model. The pattern of international business cycle comovement driven by financial shocks transcends bilateral portfolio investment relationships, which tend to be weak reflecting home bias. Output spillovers generated by financial shocks are primarily transmitted via international comovement in financial asset prices. Given that bilateral trade relationships are generally weak beyond close trading partners, accounting for strong international comovement in financial asset prices requires strong international comovement in risk premia. The intensity of these contagion effects varies across source and recipient economies. They are uniquely strong from the United States, reflecting the depth of its money, bond and stock markets. They are strong to emerging economies with open capital accounts, moderate to advanced economies, and weak to emerging economies with closed capital accounts.

B. Impulse Response Functions

Peak impulse response functions measure the maximum effects of selected structural shocks on endogenous variables. The estimated peak impulse responses of consumption price inflation, output, the real effective exchange rate, the ratio of the fiscal balance to nominal output, and the ratio of the current account balance to nominal output to a variety of structural shocks are plotted in Figure 26 through Figure 33 of Appendix B. The structural shocks under consideration are foreign supply shocks, foreign private demand shocks, foreign monetary policy shocks, foreign credit risk premium shocks, foreign duration risk premium shocks, foreign equity risk premium shocks, foreign fiscal expenditure shocks, and foreign fiscal revenue shocks.

In response to a supply shock which generates an increase in inflation and contraction of output in a systemic economy, the currencies of recipient economies generally depreciate in real effective terms. The effects on inflation and output in recipient economies are diverse, as are the effects on their fiscal and current account balances. In response to a private demand shock which generates an increase in inflation and expansion of output in a systemic economy, there generally arise foreign demand driven increases in inflation and expansions of output in recipient economies, accompanied by depreciations of their currencies in real effective terms. As a result, their fiscal and current account balances tend to improve.

In response to a monetary policy shock which generates an increase in the nominal policy interest rate in a systemic economy, the currencies of recipient economies generally depreciate in real effective terms. There tend to arise terms of trade driven increases in inflation and foreign demand driven contractions of output in recipient economies, while their fiscal and current account balances generally deteriorate.

In response to a credit risk premium shock which generates an increase in the short term nominal market interest rate in a systemic economy, the short term nominal market interest rates of recipient economies also generally increase, reflecting international money market contagion effects. As a result, there tend to arise decreases in inflation and contractions of output in recipient economies, accompanied by deteriorations of their fiscal and current account balances. In response to a duration risk premium shock which generates an increase in the long term nominal market interest rate in a systemic economy, the long term nominal market interest rates of recipient economies also generally increase, reflecting international bond market contagion effects. As a result, there tend to arise decreases in inflation and contractions of output in recipient economies, accompanied by deteriorations of their fiscal and current account balances. In response to an equity risk premium shock which generates an increase in the price of equity in a systemic economy, the prices of equity in recipient economies also generally increase, reflecting international stock market contagion effects. As a result, there tend to arise increases in inflation and expansions of output in recipient economies, accompanied by improvements in their fiscal and current account balances.

In response to a fiscal expenditure shock which generates a deterioration in the fiscal balance in a systemic economy, there generally arise foreign demand driven increases in inflation and expansions of output in recipient economies, accompanied by depreciations of their currencies in real effective terms. As a result, their fiscal and current account balances tend to improve. In response to a fiscal revenue shock which generates an improvement in the fiscal balance in a systemic economy, there generally arise foreign demand driven decreases in inflation and contractions of output in recipient economies, accompanied by appreciations of their currencies in real effective terms. As a result, their fiscal and current account balances tend to deteriorate.

It should be noted that the economies of Greece and Portugal, and to a lesser degree that of Spain, are nearly dynamically unstable in our estimated panel unobserved components model. To elaborate, in response to selected foreign shocks, notably foreign supply shocks which cause large shifts in their terms of trade, these economies undergo disruptive internal adjustments, in the form of large shifts in domestic demand, to maintain external debt sustainability. This reflects their membership of a currency union in which low weights are attached to cyclical stabilization of their target variables in the setting of monetary policy, combined with their low trade openness and high net foreign debt positions. In contrast, the other economies in the Euro Area which have recently been subjected to severe financial stress, namely Ireland and Italy, are not nearly dynamically unstable in the model, due in part to their low net foreign debt positions.

VI. FORECASTING

The world economy is complex, and any structural macroeconometric model of it is necessarily misspecified to some extent, while any forecasts generated by such a model are necessarily based on an incomplete information set. To mitigate these problems while respecting monetary and fiscal policy relevant constraints, we employ a Bayesian forecasting procedure which combines restricted forecasts generated with our estimated panel unobserved components model with judgment.

A. Forecasting Procedure

Consider the linear state space model consisting of signal equations (38) and (40), and state equation (39). Given initial conditions $\boldsymbol{z}_{T|T}$ and $\boldsymbol{P}_{T|T}$, dynamic out of sample forecasts at horizon h conditional on information available at time T, and judgment concerning the paths of linear combinations of state variables through time $T+h-1$, satisfy prediction equations:

$$\boldsymbol{z}_{T+h|T+h-1} = \boldsymbol{G}_1 \boldsymbol{z}_{T+h-1|T+h-1}, \tag{60}$$

$$\boldsymbol{P}_{T+h|T+h-1} = \boldsymbol{G}_1 \boldsymbol{P}_{T+h-1|T+h-1} \boldsymbol{G}_1^{\top} + \boldsymbol{G}_2 \boldsymbol{\Sigma}_4 \boldsymbol{G}_2^{\top}, \tag{61}$$

$$\boldsymbol{y}_{T+h|T+h-1} = \boldsymbol{F}_1 \boldsymbol{z}_{T+h|T+h-1}, \tag{62}$$

$$\boldsymbol{Q}_{T+h|T+h-1} = \boldsymbol{F}_1 \boldsymbol{P}_{T+h|T+h-1} \boldsymbol{F}_1^{\top}, \tag{63}$$

$$\boldsymbol{w}_{T+h|T+h-1} = \boldsymbol{H}_1 \boldsymbol{z}_{T+h|T+h-1}, \tag{64}$$

$$\boldsymbol{R}_{T+h|T+h-1} = \boldsymbol{H}_1 \boldsymbol{P}_{T+h|T+h-1} \boldsymbol{H}_1^{\top} + \boldsymbol{\Sigma}_{5,T+h}. \tag{65}$$

Given these predictions, under the assumption of multivariate normally distributed signal and state innovation vectors, dynamic out of sample forecasts at horizon h conditional on information available at time T, and judgment concerning the paths of linear combinations of state variables through time $T+h$, satisfy Bayesian updating equations

$$\boldsymbol{z}_{T+h|T+h} = \boldsymbol{z}_{T+h|T+h-1} + \boldsymbol{K}_{\boldsymbol{w}_{T+h}} (\boldsymbol{w}_{T+h} - \boldsymbol{w}_{T+h|T+h-1}), \tag{66}$$

$$\boldsymbol{P}_{T+h|T+h} = \boldsymbol{P}_{T+h|T+h-1} - \boldsymbol{K}_{\boldsymbol{w}_{T+h}} \boldsymbol{H}_1 \boldsymbol{P}_{T+h|T+h-1}, \tag{67}$$

$$\boldsymbol{y}_{T+h|T+h} = \boldsymbol{F}_1 \boldsymbol{z}_{T+h|T+h}, \tag{68}$$

$$\boldsymbol{Q}_{T+h|T+h} = \boldsymbol{F}_1 \boldsymbol{P}_{T+h|T+h} \boldsymbol{F}_1^{\top}, \tag{69}$$

where $\boldsymbol{K}_{\boldsymbol{w}_{T+h}} = \boldsymbol{P}_{T+h|T+h-1} \boldsymbol{H}_1^{\top} \boldsymbol{R}_{T+h|T+h-1}^{-1}$. Given terminal forecasts $\hat{\boldsymbol{z}}_{T+H+1|T+H} = \boldsymbol{0}$ and $\hat{\boldsymbol{P}}_{T+H+1|T+H} = \boldsymbol{0}$, dynamic out of sample forecasts at horizon h conditional on information available at time T, and judgment concerning the paths of linear combinations of state variables through time $T+H$, satisfy computationally efficient Bayesian smoothing equations

$$\hat{\boldsymbol{z}}_{T+h|T+H} = \boldsymbol{J}_{T+h}^{\top} \hat{\boldsymbol{z}}_{T+h+1|T+H} + \boldsymbol{H}_1^{\top} \boldsymbol{R}_{T+h|T+h-1}^{-1} (\boldsymbol{w}_{T+h} - \boldsymbol{w}_{T+h|T+h-1}), \tag{70}$$

$$\boldsymbol{z}_{T+h|T+H} = \boldsymbol{z}_{T+h|T+h-1} + \boldsymbol{P}_{T+h|T+h-1}\hat{\boldsymbol{z}}_{T+h|T+H}, \tag{71}$$

$$\hat{\boldsymbol{P}}_{T+h|T+H} = \boldsymbol{J}_{T+h}^{\top}\hat{\boldsymbol{P}}_{T+h+1|T+H}\boldsymbol{J}_{T+h} - \boldsymbol{H}_1^{\top}\boldsymbol{R}_{T+h|T+h-1}^{-1}\boldsymbol{H}_1, \tag{72}$$

$$\boldsymbol{P}_{T+h|T+H} = \boldsymbol{P}_{T+h|T+h-1} + \boldsymbol{P}_{T+h|T+h-1}\hat{\boldsymbol{P}}_{T+h|T+H}\boldsymbol{P}_{T+h|T+h-1}, \tag{73}$$

$$\boldsymbol{y}_{T+h|T+H} = \boldsymbol{F}_1\boldsymbol{z}_{T+h|T+H}, \tag{74}$$

$$\boldsymbol{Q}_{T+h|T+H} = \boldsymbol{F}_1\boldsymbol{P}_{T+h|T+H}\boldsymbol{F}_1^{\top}, \tag{75}$$

where $\boldsymbol{J}_{T+h} = \boldsymbol{G}_1(\boldsymbol{I}_K - \boldsymbol{P}_{T+h|T+h-1}\boldsymbol{H}_1^{\top}\boldsymbol{R}_{T+h|T+h-1}^{-1}\boldsymbol{H}_1)$. Under our distributional assumptions, recursive forward evaluation of equations (60) through (69), followed by recursive backward evaluation of equations (70) through (75), yields mean squared error optimal conditional forecasts.

B. Forecasting Results

We analyze the predictive accuracy of our panel unobserved components model for consumption price inflation and output growth with sequential unconditional forecasts in sample. We then generate conditional forecasts of these variables out of sample with Bayesian updating, and analyze the revisions to unconditional forecasts resulting from imposing judgment on them with conditional forecast decompositions. The results of this forecasting exercise are plotted in Figure 34 through Figure 39.

Sequential Unconditional Forecasts

Sequential unconditional forecasts of inflation and output growth indicate that our panel unobserved components model is capable of predicting business cycle turning points. Indeed, our sequential unconditional forecasts of output growth suggest that a synchronized global moderation was overdue by the time of the global financial crisis. However, the model generally underpredicted the severity of this synchronized global recession, while overpredicting its disinflationary impact. While the model forecast the subsequent synchronized global recovery, it systematically underpredicted its sluggishness in economies undergoing balance sheet deleveraging such as Spain, the United Kingdom and the United States, due in part to violation of the zero lower bound constraint on the nominal policy interest rate.

Conditional Forecasts

We generate forecasts of inflation and output growth conditional on monetary and fiscal policy relevant constraints, and judgment concerning the paths of these variables. These combined forecasts are recursive weighted averages of restricted forecasts generated with our panel unobserved components model, and judgmental forecasts produced by the International Monetary Fund. To facilitate comparability with the World Economic Outlook of January 2012, the restricted forecasts are generated subject to constant real effective exchange rates, and common assumptions concerning the paths of energy and nonenergy commodity prices. They are also generated subject to the zero lower bound constraint on the nominal policy interest rate in the Euro Area, Japan, the United Kingdom, and the United States. The weight assigned to these restricted forecasts is decreasing in the objective uncertainty surrounding them, measured by their time varying forecast error covariance matrix, and is increasing in the subjective uncertainty associated with the judgmental forecasts, represented by the same forecast error covariance matrix, rescaled by a factor of 2^2.

The combined forecasts of inflation and output growth generally lie between the restricted forecasts and the judgmental forecasts, while the restricted forecasts tend to lie slightly below the unrestricted forecasts. These alternative forecasts generally have similar profiles, and point towards a temporary moderation of the synchronized global recovery. But the restricted forecasts tend to be more optimistic with regards to output growth prospects than the World Economic Outlook.

Conditional Forecast Decompositions

Our conditional forecast decompositions measure the contributions of different structural shocks to revisions to the unrestricted forecasts of inflation and output growth given the deterministic restrictions imposed in generating the restricted forecasts, and to these restricted forecasts given the stochastic restrictions imposed in representing the judgmental forecasts. These conditional forecast decompositions are estimated by the difference between unconditional forecast decompositions of the combined and unrestricted forecasts, which in turn are estimated by out of sample extensions of unconditional historical decompositions.

The effects on the unrestricted forecasts of inflation and output growth of conditioning on constant real effective exchange rates, given paths for energy and nonenergy commodity prices, and the zero lower bound constraint on the nominal policy interest rate are primarily measured by contributions from world risk premium shocks, world terms of trade shocks, and world monetary policy shocks, respectively. While imposing the zero lower bound constraint on the nominal policy interest rate is generally disinflationary and contractionary, the effects of imposing the other deterministic restrictions are of variable sign. The effects on the restricted forecasts of conditioning on judgment concerning the paths of inflation and output growth are primarily measured by contributions from domestic supply shocks and domestic private demand shocks. While domestic supply shocks of variable sign tend to account for most of the persistent discrepancies between the restricted and judgmental forecasts, negative domestic private demand shocks account for much in economies undergoing balance sheet deleveraging, with substantial spillovers to close trading partners.

VII. Conclusion

This paper develops a structural macroeconometric model of the world economy, disaggregated into thirty five national economies. A variety of monetary policy analysis, fiscal policy analysis, spillover analysis, and forecasting applications of the estimated model are demonstrated. These include accounting for business cycle fluctuations, quantifying the monetary and fiscal transmission mechanisms, and generating conditional forecasts of inflation and output growth. They are based on a Bayesian framework for conditioning on judgment in estimation and forecasting.

This panel unobserved components model consolidates much existing theoretical and empirical knowledge concerning business cycle dynamics in the world economy, provides a framework for a progressive research strategy, and suggests explanations for its own deficiencies. In particular, the structural interpretations of some of the orthogonal shocks driving variation in cyclical components are ambiguous, and strengthening the microeconomic foundations of the model remains an objective for future research. In addition, a more sophisticated procedure for generating judgment concerning the paths of trend components which accounts for structural breaks associated with financial crises seems warranted.

Appendix A. Description of the Data Set

Estimation is based on quarterly data on several macroeconomic and financial market variables for thirty five economies over the sample period 1999Q1 through 2011Q3. The economies under consideration are Argentina, Australia, Austria, Belgium, Brazil, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Greece, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom, and the United States. Where available, this data was obtained from the GDS and WEO databases compiled by the International Monetary Fund. Otherwise, it was extracted from the IFS database compiled by the International Monetary Fund, or the CEIC database produced by Internet Securities Incorporated, or the EMED database produced by Emerging Markets Economic Data Limited.

The macroeconomic variables under consideration are the price of output, the price of consumption, the quantity of output, the quantity of domestic demand, the quantity of public domestic demand, the ratio of the fiscal balance to nominal output, the ratio of the current account balance to nominal output, and the prices of energy and nonenergy commodities. The price of output is measured by the seasonally adjusted gross domestic product price deflator, while the price of consumption is proxied by the seasonally adjusted consumer price index. The quantity of output is measured by seasonally adjusted real gross domestic product, while the quantity of domestic demand is measured by the sum of seasonally adjusted real consumption and investment expenditures, and the quantity of public domestic demand is measured by the sum of quadratically interpolated annual real consumption and investment expenditures of the general government. The fiscal balance is measured by the quadratically interpolated annual overall fiscal balance of the general government, while the current account balance is measured by the quadratically interpolated annual current account balance. The prices of energy and nonenergy commodities are proxied by broad commodity price indexes denominated in United States dollars.

The financial market variables under consideration are the nominal policy interest rate, the short term nominal market interest rate, the long term nominal market interest rate, the price of equity, and the nominal bilateral exchange rate. The nominal policy interest rate is measured by the central bank discount rate, expressed as a period average. The short term nominal market interest rate is measured by a three month money market rate, expressed as a period average. The long term nominal market interest rate is measured by the ten year government bond yield where available, and a ten year commercial bank lending rate otherwise, expressed as a period average. The price of equity is proxied by a broad stock price index denominated in domestic currency units. The nominal bilateral exchange rate is measured by the domestic currency price of one United States dollar expressed as a period average.

Calibration is based on annual data obtained from databases compiled by the International Monetary Fund where available, and from the Bank for International Settlements or the World Bank Group otherwise. Great ratios are derived from the WEO and WDI databases. Bilateral trade weights are derived from the DOTS database. Portfolio weights are derived from the CPIS, BIS, and WDI databases.

Appendix B. Tables and Figures

Table 1. Parameter Estimation Results

	Prior		Posterior Mode																																		
	Mean	SE	WLD	ARG	AUS	AUT	BEL	BRA	CAN	CHN	CZE	DNK	FIN	FRA	DEU	GRC	IND	IDN	IRL	ITA	JPN	KOR	MEX	NLD	NZL	NOR	POL	PRT	RUS	SAU	ZAF	ESP	SWE	CHE	THA	TUR	GBR	USA
$\phi_{1,1}$	0.4900	4.9e–3	0.4897	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{1,2}$	0.4900	4.9e–3	0.4859	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{1,1}$	0.0075	7.5e–4	0.0077	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{1,2}$	0.3500	3.5e–2	0.3580	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{2,1}$	0.5000	5.0e–2	0.4879	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{2,2}$	0.3500	3.5e–2	0.3703	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{3,1}$	0.8500	8.5e–3	0.8467	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,1}$	-0.7500	7.5e–2	-0.7528	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,2}$	-0.0150	1.5e–3	-0.0156	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,3}$	0.5000	5.0e–2	0.5233	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,4}$	-2.2500	2.3e–2	-2.2445	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3,5}$	-1.0000	1.0e–1	-1.0683	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{4,1}$	1.0000	1.0e–1	1.0463	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{4,2}$	-1.2500	1.3e–1	-1.2686	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{5,1}$	0.8500	8.5e–3	0.8498	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{5,1,0}$	1.2500	1.3e–1	...	1.2902	...	...	...	...	...	1.2902	1.2902	1.2902	...	...	...	...	1.2902	1.2902	...	...	...	...	...	...	...	...	...	...	1.2902	1.2902	...	...	...	...	1.2902	...	...	...
$\theta_{5,1,1}$	1.5000	1.5e–1	...	...	1.5194	1.5194	1.5194	1.5194	1.5194	...	...	...	1.5194	1.5194	1.5194	1.5194	...	...	1.5194	1.5194	1.5194	1.5194	1.5194	1.5194	1.5194	1.5194	1.5194	1.5194	...	...	1.5194	1.5194	1.5194	1.5194	...	1.5194	1.5194	1.5194
$\theta_{5,2,0}$	0.1250	1.3e–2	...	0.1318	...	...	...	...	...	0.1318	0.1318	0.1318	...	...	...	...	0.1318	0.1318	...	...	...	...	...	...	...	...	...	...	0.1318	0.1318	...	...	...	...	0.1318	...	...	...
$\theta_{5,2,1}$	0.1250	1.3e–2	...	...	0.1216	0.1216	0.1216	0.1216	0.1216	...	...	...	0.1216	0.1216	0.1216	0.1216	...	...	0.1216	0.1216	0.1216	0.1216	0.1216	0.1216	0.1216	0.1216	0.1216	0.1216	...	...	0.1216	0.1216	0.1216	0.1216	...	0.1216	0.1216	0.1216
$\theta_{5,3,0}$	0.0375	3.8e–3	...	0.0362	...	...	...	...	...	0.0362	0.0362	0.0362	...	...	...	...	0.0362	0.0362	...	...	...	...	...	...	...	...	...	...	0.0362	0.0362	...	...	...	...	0.0362	...	...	...
$\phi_{6,1}$	0.2500	2.5e–3	0.2502	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{6,1}$	-0.0025	2.5e–4	-0.0025	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{6,0}$	1.0000	1.0e–1	...	...	0.9699	0.9699	0.9699	...	0.9699	...	...	0.9699	0.9699	0.9699	0.9699	0.9699	...	...	0.9699	0.9699	0.9699	...	...	0.9699	0.9699	0.9699	...	0.9699	...	...	...	0.9699	0.9699	0.9699	...	...	0.9699	0.9699
$\lambda_{6,1}$	0.5000	5.0e–2	...	...	...	...	...	...	...	0.4989	...	...	...	...	...	...	0.4989	...	...	...	...	...	...	...	...	...	...	...	...	0.4989	...	...	...	...	...	...	...	...
$\lambda_{6,2}$	1.5000	1.5e–1	...	1.5544	...	...	...	1.5544	...	...	1.5544	...	...	...	...	...	...	1.5544	...	...	...	1.5544	1.5544	...	...	...	1.5544	...	1.5544	...	1.5544	...	...	...	1.5544	1.5544	...	...
$\phi_{7,1}$	0.2400	2.4e–3	0.2415	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{7,2}$	0.7400	7.4e–3	0.7409	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{7,1}$	0.1500	1.5e–2	0.1532	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{7,0}$	1.0000	1.0e–1	...	...	1.0372	1.0372	1.0372	...	1.0372	...	...	1.0372	1.0372	1.0372	1.0372	1.0372	...	...	1.0372	1.0372	1.0372	...	...	1.0372	1.0372	1.0372	...	1.0372	...	...	...	1.0372	1.0372	1.0372	...	...	1.0372	1.0372
$\lambda_{7,1}$	0.5000	5.0e–2	...	...	...	...	...	...	...	0.4895	...	...	...	...	...	...	0.4895	...	...	...	...	...	...	...	...	...	...	...	...	0.4895	...	...	...	...	...	...	...	...
$\lambda_{7,2}$	1.5000	1.5e–1	...	1.4786	...	...	...	1.4786	...	...	1.4786	...	...	...	...	...	...	1.4786	...	...	...	1.4786	1.4786	...	...	...	1.4786	...	1.4786	...	1.4786	...	...	...	1.4786	1.4786	...	...
$\phi_{8,1}$	0.2400	2.4e–3	0.2398	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{8,2}$	0.7400	7.4e–3	0.7401	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8,1}$	1.0000	1.0e–1	1.0336	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8,2}$	-1.0000	1.0e–1	-0.9876	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8,3}$	-1.0000	1.0e–1	-1.0017	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{8,0}$	1.2500	1.3e–1	...	...	1.2955	1.2955	1.2955	...	1.2955	...	...	1.2955	1.2955	1.2955	1.2955	1.2955	...	...	1.2955	1.2955	1.2955	...	...	1.2955	1.2955	1.2955	...	1.2955	...	...	...	1.2955	1.2955	1.2955	...	...	1.2955	1.2955
$\lambda_{8,1}$	0.6250	6.3e–2	...	...	...	...	...	...	...	0.6405	...	...	...	...	...	...	0.6405	...	...	...	...	...	...	...	...	...	...	...	...	0.6405	...	...	...	...	...	...	...	...
$\lambda_{8,2}$	1.8750	1.9e–1	...	1.9597	...	...	...	1.9597	...	...	1.9597	...	...	...	...	...	...	1.9597	...	...	...	1.9597	1.9597	...	...	...	1.9597	...	1.9597	...	1.9597	...	...	...	1.9597	1.9597	...	...
$\phi_{9,1}$	0.2400	2.4e–3	0.2391	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{9,2}$	0.7400	7.4e–3	0.7394	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{9,1,0}$	-1.0000	1.0e–1	...	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	...	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	...	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	...	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609	-0.9609
$\theta_{9,1,1}$	-0.2500	2.5e–2	...	...	...	...	...	...	...	-0.2683	...	...	...	...	...	...	-0.2683	...	...	...	...	...	...	...	...	...	...	...	...	-0.2683	...	...	...	...	...	...	...	...
$\phi_{10,1}$	0.2400	2.4e–3	0.2394	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{10,2}$	0.7400	7.4e–3	0.7402	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{10,1}$	0.0750	7.5e–3	0.0702	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{10,2}$	-0.0500	5.0e–3	-0.0488	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{11,1}$	0.8500	8.5e–3	0.8486	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{11,1}$	0.0100	1.0e–3	0.0097	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{12,1}$	0.8500	8.5e–3	0.8489	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{12,1}$	-0.0100	1.0e–3	-0.0103	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{13,1}$	0.2400	2.4e–3	0.2409	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{13,2}$	0.7400	7.4e–3	0.7409	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{13,1,0}$	0.7500	7.5e–2	0.7259	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

	Prior		Posterior Mode																																		
	Mean	SE	WLD	ARG	AUS	AUT	BEL	BRA	CAN	CHN	CZE	DNK	FIN	FRA	DEU	GRC	IND	IDN	IRL	ITA	JPN	KOR	MEX	NLD	NZL	NOR	POL	PRT	RUS	SAU	ZAF	ESP	SWE	CHE	THA	TUR	GBR	USA
$\theta_{13,1,1}$	1.5000	1.5e–1	1.5123	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{D}^Y}$	0.2500	2.5e–2	0.2497	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{D}^M}$	0.7500	7.5e–2	0.7406	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{C}}$	0.2500	2.5e–2	0.2452	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{V}}$	0.7500	7.5e–2	0.7621	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{\imath}^S}$	0.5000	5.0e–2	0.4603	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{\imath}^L}$	0.2500	2.5e–2	0.2472	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{D}^{STK}}$	0.2500	2.5e–2	0.2612	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{c}}$	0.5000	5.0e–2	0.5051	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{\tau}}$	0.5000	5.0e–2	0.5165	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{D}^{COM}}$	0.5000	5.0e–2	0.4917	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\hat{D}^Y,i}$	...	∞	...	2.0e–1	1.6e–1	1.4e–1	1.3e–1	1.8e–1	1.4e–1	1.5e–1	1.6e–1	1.5e–1	1.4e–1	1.3e–1	1.4e–1	1.3e–1	1.4e–1	1.6e–1	1.6e–1	1.4e–1	1.5e–1	1.6e–1	1.6e–1	1.4e–1	1.7e–1	1.6e–1	1.6e–1	1.4e–1	1.8e–1	1.9e–1	1.8e–1	1.4e–1	1.6e–1	1.5e–1	1.5e–1	1.9e–1	1.5e–1	2.1e–1
$\sigma^2_{\hat{D}^M,i}$	...	∞	...	7.5e+0	6.7e+0	5.8e+0	4.8e+0	8.8e+0	5.7e+0	6.1e+0	5.5e+0	5.9e+0	5.9e+0	5.3e+0	5.6e+0	6.0e+0	6.7e+0	6.0e+0	5.5e+0	6.1e+0	7.6e+0	6.4e+0	6.8e+0	4.9e+0	6.8e+0	6.6e+0	6.2e+0	5.7e+0	7.6e+0	7.5e+0	7.3e+0	5.4e+0	5.9e+0	5.5e+0	5.6e+0	7.6e+0	6.0e+0	9.7e+0
$\sigma^2_{\hat{C},i}$	...	∞	...	1.1e+0	1.0e+0	1.1e+0	9.6e–1	1.0e+0	1.1e+0	1.0e+0	1.2e+0	1.1e+0	1.3e+0	8.9e–1	1.0e+0	1.1e+0	1.2e+0	1.2e+0	1.2e+0	9.1e–1	9.6e–1	1.1e+0	1.0e+0	1.0e+0	1.1e+0	1.3e+0	1.0e+0	1.0e+0	1.2e+0	1.3e+0	1.1e+0	9.3e–1	1.1e+0	1.2e+0	1.4e+0	1.2e+0	9.4e–1	9.5e–1
$\sigma^2_{\hat{V},i}$	...	∞	...	1.1e+0	8.6e–1	7.8e–1	7.0e–1	9.6e–1	8.0e–1	7.9e–1	7.9e–1	7.6e–1	7.7e–1	7.3e–1	7.7e–1	9.9e–1	9.3e–1	9.3e–1	8.7e–1	7.8e–1	9.5e–1	8.2e–1	9.1e–1	6.9e–1	9.3e–1	9.3e–1	8.4e–1	8.6e–1	9.0e–1	1.0e+0	8.3e–1	8.2e–1	8.1e–1	8.0e–1	8.7e–1	1.1e+0	7.8e–1	1.2e+0
$\sigma^2_{\hat{\imath}^P,i}$	...	∞	...	9.2e–1	4.5e–1	...	...	4.9e–1	4.3e–1	4.2e–1	4.5e–1	4.2e–1	...	...	4.0e–1	...	4.0e–1	4.9e–1	...	...	4.2e–1	4.6e–1	4.5e–1	...	4.7e–1	4.8e–1	4.7e–1	...	5.1e–1	5.3e–1	5.1e–1	...	4.5e–1	3.9e–1	4.2e–1	5.1e–1	4.6e–1	5.6e–1
$\sigma^2_{\hat{\imath}^S,i}$	...	∞	...	5.5e–2	2.3e–2	2.4e–2	2.3e–2	2.7e–2	2.0e–2	2.1e–2	2.2e–2	2.2e–2	2.5e–2	2.3e–2	2.4e–2	2.4e–2	2.0e–2	2.3e–2	2.6e–2	2.3e–2	2.7e–2	2.3e–2	2.2e–2	2.3e–2	2.5e–2	2.5e–2	2.2e–2	2.4e–2	2.8e–2	2.2e–2	2.3e–2	2.2e–2	2.2e–2	2.8e–2	2.5e–2	3.1e–2	2.2e–2	2.6e–2
$\sigma^2_{\hat{\imath}^L,i}$	...	∞	...	1.2e–1	8.1e–2	7.9e–2	6.7e–2	8.9e–2	8.1e–2	7.2e–2	8.7e–2	8.1e–2	8.3e–2	7.7e–2	7.8e–2	7.6e–2	7.3e–2	8.8e–2	7.3e–2	8.2e–2	7.7e–2	8.4e–2	7.8e–2	7.0e–2	8.3e–2	8.8e–2	8.7e–2	9.9e–2	8.8e–2	9.0e–2	9.5e–2	9.0e–2	8.5e–2	7.9e–2	7.9e–2	9.5e–2	8.4e–2	9.7e–2
$\sigma^2_{\hat{D}^{STK},i}$	...	∞	...	2.9e+2	2.0e+2	2.1e+2	1.8e+2	2.2e+2	1.8e+2	1.9e+2	2.0e+2	2.0e+2	2.1e+2	2.0e+2	2.0e+2	2.1e+2	2.0e+2	2.1e+2	1.9e+2	2.1e+2	1.9e+2	2.1e+2	1.9e+2	1.8e+2	2.0e+2	2.0e+2	2.0e+2	2.6e+2	2.2e+2	2.1e+2	2.3e+2	2.4e+2	2.0e+2	1.9e+2	2.0e+2	2.4e+2	2.0e+2	2.4e+2
$\sigma^2_{\hat{c},i}$	...	∞	...	3.0e+0	2.2e+0	...	...	2.2e+0	2.1e+0	1.7e+0	2.2e+0	2.2e+0	...	...	2.1e+0	...	1.8e+0	2.3e+0	...	...	2.1e+0	2.2e+0	2.3e+0	...	2.2e+0	2.1e+0	2.2e+0	...	2.1e+0	1.7e+0	2.3e+0	...	2.2e+0	2.2e+0	2.2e+0	2.4e+0	2.1e+0	...
$\sigma^2_{\hat{\tau},i}$	...	∞	...	3.1e–2	1.7e–2	1.9e–2	1.8e–2	2.1e–2	2.1e–2	1.8e–2	1.8e–2	1.8e–2	1.9e–2	1.5e–2	1.7e–2	1.9e–2	1.9e–2	2.0e–2	2.1e–2	1.6e–2	1.7e–2	1.7e–2	2.0e–2	1.8e–2	1.7e–2	2.1e–2	1.7e–2	1.8e–2	1.9e–2	2.0e–2	1.6e–2	1.7e–2	1.7e–2	1.9e–2	2.2e–2	2.2e–2	1.5e–2	2.0e–2
$\sigma^2_{\hat{C},i}$	...	∞	...	6.6e–2	5.7e–2	5.4e–2	5.0e–2	6.1e–2	5.4e–2	6.1e–2	6.8e–2	5.5e–2	5.1e–2	4.7e–2	4.7e–2	6.4e–2	5.9e–2	6.4e–2	5.5e–2	5.3e–2	4.8e–2	5.5e–2	5.7e–2	5.6e–2	5.9e–2	6.6e–2	5.4e–2	6.0e–2	6.7e–2	7.4e–2	5.5e–2	5.2e–2	5.2e–2	4.3e–2	5.8e–2	6.4e–2	5.1e–2	4.7e–2
$\sigma^2_{\hat{T},i}$	...	∞	...	1.5e–1	1.2e–1	1.2e–1	1.1e–1	1.3e–1	1.1e–1	1.3e–1	1.4e–1	1.1e–1	1.2e–1	1.1e–1	1.2e–1	1.2e–1	1.3e–1	1.3e–1	1.6e–1	1.0e–1	1.1e–1	1.2e–1	1.2e–1	1.1e–1	1.3e–1	1.2e–1	1.1e–1	1.1e–1	1.5e–1	1.6e–1	1.1e–1	1.1e–1	1.1e–1	1.1e–1	1.4e–1	1.3e–1	1.1e–1	1.2e–1
$\sigma^2_{\hat{D}^{COM^e}}$	...	∞	2.9e+1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\hat{D}^{COM^n}}$	...	∞	5.2e+0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\bar{D}^Y,i}$	...	∞	...	1.1e–4	1.5e–5	4.3e–6	1.8e–6	8.4e–5	1.8e–5	8.5e–5	1.6e–5	2.2e–6	2.7e–5	5.8e–6	7.7e–7	1.0e–5	1.1e–4	2.2e–4	3.2e–4	8.7e–6	2.5e–6	2.9e–5	2.6e–5	3.7e–5	4.1e–6	1.2e–4	1.3e–5	2.4e–5	3.0e–4	7.4e–4	3.6e–5	8.3e–5	8.2e–6	1.3e–5	5.7e–5	5.7e–3	7.3e–6	1.9e–5
$\sigma^2_{\bar{D}^C,i}$	...	∞	...	1.5e–4	5.6e–6	7.2e–7	2.3e–6	1.8e–4	4.4e–6	5.9e–5	1.6e–5	5.4e–6	2.8e–5	2.4e–6	3.4e–6	9.7e–7	2.7e–4	8.7e–5	8.2e–5	2.2e–6	9.3e–6	1.9e–6	3.6e–5	3.1e–5	2.9e–6	1.2e–5	8.7e–5	2.9e–5	2.9e–4	3.3e–4	8.3e–5	1.4e–5	5.9e–6	1.5e–6	5.2e–5	6.7e–3	2.3e–5	1.1e–5
$\sigma^2_{\bar{V},i}$	...	∞	...	9.9e–4	1.4e–5	3.1e–5	2.0e–5	3.1e–5	3.9e–5	8.4e–5	2.2e–4	8.7e–5	1.2e–4	2.8e–5	1.5e–5	3.8e–4	9.8e–5	1.5e–5	4.6e–4	4.6e–5	5.1e–5	3.0e–5	6.4e–5	3.1e–5	8.6e–5	4.6e–5	7.0e–5	1.2e–5	2.8e–4	4.3e–5	7.7e–5	1.3e–4	7.1e–5	3.0e–5	8.9e–5	2.8e–4	1.1e–4	6.8e–5
$\sigma^2_{\bar{D},i}$	...	∞	...	1.7e–3	5.7e–5	2.0e–5	3.0e–5	1.3e–4	5.6e–5	4.5e–5	1.5e–4	2.2e–4	8.4e–5	3.1e–5	1.7e–5	4.6e–4	2.0e–4	2.2e–5	1.2e–3	4.4e–5	2.8e–5	6.1e–5	9.3e–5	3.2e–5	2.7e–4	2.4e–4	2.8e–4	3.2e–5	4.1e–4	4.3e–4	2.0e–4	3.7e–4	3.2e–5	1.9e–6	2.1e–4	5.2e–4	1.8e–4	1.2e–4
$\sigma^2_{\bar{\imath}^P,i}$	...	∞	...	8.4e–4	3.8e–7	...	...	2.5e–6	8.5e–7	2.0e–7	8.5e–7	5.9e–7	...	...	4.7e–7	...	4.6e–7	3.2e–6	...	...	2.2e–8	2.3e–7	8.6e–6	...	2.0e–6	1.1e–6	4.9e–6	...	3.2e–5	2.2e–6	1.8e–6	...	2.1e–7	4.4e–7	6.4e–7	7.4e–5	1.3e–6	2.7e–6
$\sigma^2_{\bar{\imath}^S,i}$	...	∞	...	4.0e–5	4.4e–7	6.1e–7	4.2e–7	2.4e–6	7.4e–7	1.1e–7	1.2e–6	9.5e–7	6.1e–7	4.2e–7	6.2e–7	6.1e–7	1.1e–6	3.8e–6	6.2e–7	4.7e–7	5.7e–8	6.0e–7	9.3e–6	6.1e–7	2.1e–6	1.4e–6	6.0e–6	6.1e–7	5.5e–5	2.9e–6	1.3e–6	6.1e–7	2.1e–7	6.1e–7	6.0e–7	5.3e–5	1.6e–6	2.2e–6
$\sigma^2_{\bar{\imath}^L,i}$	...	∞	...	2.2e–6	4.3e–8	1.1e–7	1.1e–7	4.0e–7	1.1e–8	2.7e–7	8.6e–7	7.5e–8	9.4e–8	7.1e–8	5.8e–8	3.4e–6	1.9e–6	3.5e–7	1.4e–6	1.6e–7	6.5e–8	8.9e–7	4.7e–6	7.9e–8	2.2e–8	1.9e–7	1.1e–6	1.1e–6	7.9e–5	1.5e–5	9.2e–7	2.4e–7	4.3e–8	6.4e–8	1.2e–7	3.6e–5	5.5e–8	1.5e–7
$\sigma^2_{\bar{D}^{STK},i}$	...	∞	...	2.1e–2	3.4e–3	2.4e–2	9.8e–3	8.2e–3	2.8e–3	2.3e–2	1.7e–2	4.2e–3	8.8e–3	4.4e–3	7.6e–3	3.9e–2	1.1e–2	1.4e–2	2.2e–2	6.6e–3	9.3e–3	3.0e–3	7.7e–3	4.1e–3	4.5e–3	1.0e–2	9.5e–3	6.7e–3	1.7e–2	2.7e–2	2.5e–3	7.5e–3	6.7e–3	4.5e–3	5.2e–3	4.8e–3	2.6e–3	2.5e–3
$\sigma^2_{\bar{c},i}$	...	∞	...	7.5e–3	6.6e–4	...	...	5.4e–3	4.9e–4	2.1e–4	1.0e–3	1.1e–3	...	...	1.1e–3	...	2.9e–4	1.2e–4	...	...	5.0e–4	1.2e–3	8.4e–5	...	1.5e–3	6.5e–4	1.5e–3	...	1.1e–3	2.2e–8	2.1e–3	...	9.8e–4	1.7e–4	4.4e–4	1.3e–2	1.5e–3	...
$\sigma^2_{\bar{C},i}$	...	∞	...	4.4e–3	1.7e–5	8.9e–5	2.4e–6	2.1e–4	5.3e–5	7.5e–5	1.9e–4	3.4e–6	4.0e–5	1.3e–5	9.5e–5	3.7e–4	8.5e–4	5.1e–4	3.0e–4	6.7e–5	6.1e–5	2.2e–5	1.1e–4	3.8e–5	1.7e–4	1.5e–4	1.1e–4	2.8e–5	5.3e–4	3.0e–4	3.9e–5	1.1e–4	2.1e–5	8.7e–5	5.5e–4	5.5e–4	1.5e–4	3.1e–5
$\sigma^2_{\overline{EB},i}$	...	∞	...	1.2e–4	3.9e–5	6.4e–6	8.3e–6	2.4e–6	4.5e–5	1.4e–5	4.6e–5	1.2e–4	2.8e–5	1.4e–5	3.6e–5	1.9e–5	5.8e–5	9.5e–6	4.0e–4	7.6e–6	6.8e–5	1.1e–5	1.8e–5	4.7e–5	8.1e–5	1.1e–4	4.0e–5	1.4e–5	1.8e–4	8.7e–4	4.6e–5	1.3e–4	3.4e–5	1.5e–5	5.5e–5	1.8e–4	2.0e–5	5.2e–5
$\sigma^2_{\overline{CA},i}$	...	∞	...	9.8e–5	2.9e–5	6.6e–6	4.7e–6	5.4e–5	1.3e–5	9.6e–5	2.3e–5	1.5e–5	1.1e–5	2.6e–7	2.9e–5	7.9e–5	1.4e–5	1.4e–5	6.0e–5	3.0e–7	5.5e–6	5.8e–6	3.3e–6	4.7e–5	9.3e–5	3.1e–5	3.5e–5	3.5e–5	1.5e–5	7.3e–4	6.7e–5	8.6e–5	1.5e–5	8.6e–5	1.2e–4	1.7e–5	1.5e–6	1.3e–5
$\sigma^2_{\bar{D}^{COM^e}}$	...	∞	2.6e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\bar{D}^{COM^n}}$	...	∞	7.9e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Note: All priors are normally distributed, while all posteriors are asymptotically normally distributed. All observed endogenous variables are rescaled by a factor of 100.

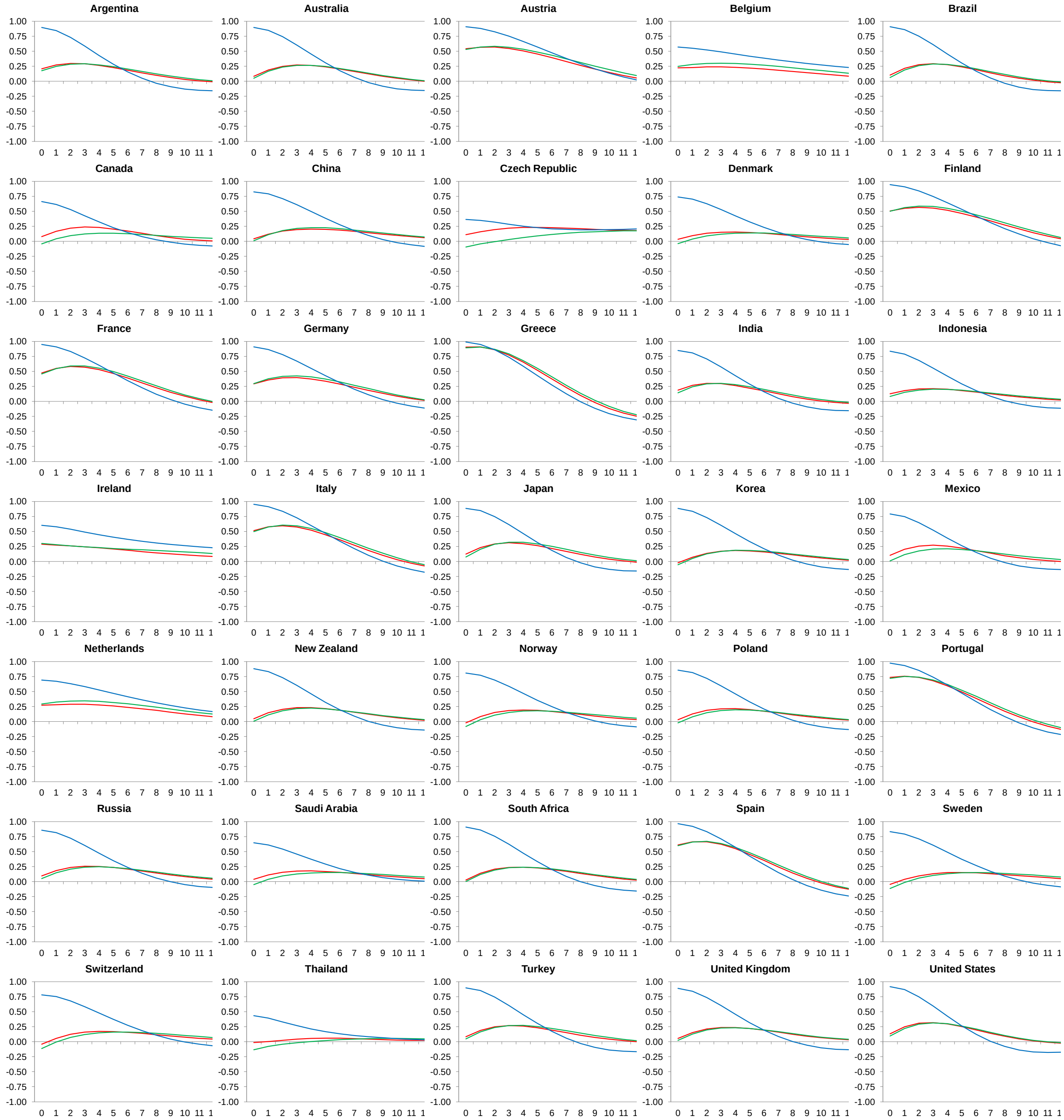
Figure 1. Output Gap Estimates, Decomposition by Source of Demand

Note: Decomposes smoothed estimates of the output gap ■ into contributions from domestic demand ■ and net exports ■. Smoothed estimates of the contribution from domestic demand ■ are decomposed into contributions from private domestic demand ■ and public domestic demand ■.

Figure 2. Output Gap Estimates, Decomposition by Source of Stimulus

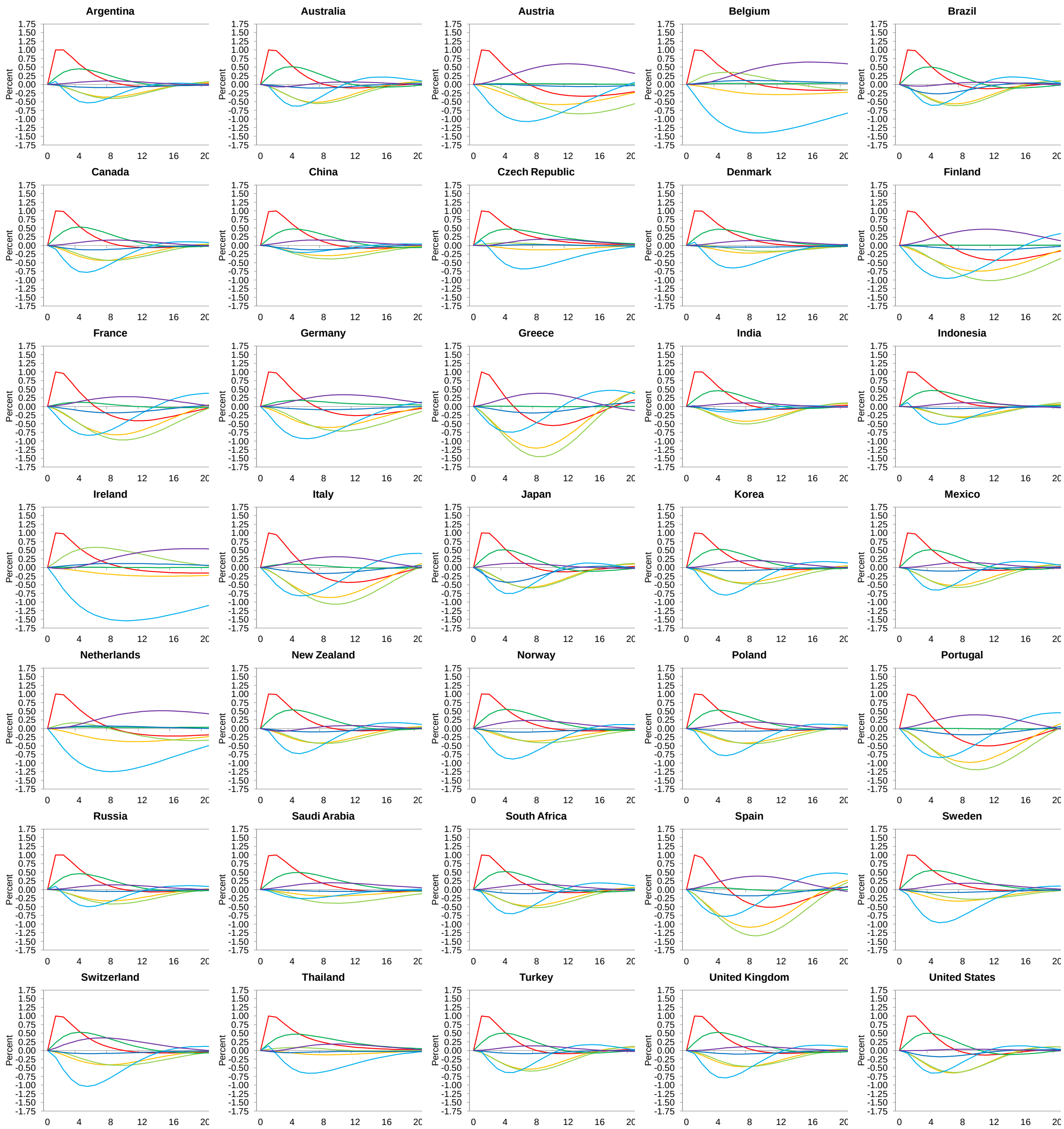
Note: Decomposes smoothed estimates of the output gap ■ into contributions from monetary conditions ■ and real conditions ■. Smoothed estimates of the monetary conditions gap ■ are decomposed into contributions from financial conditions ■ and the terms of trade ■.

Figure 3. Simulated Unconditional Correlations



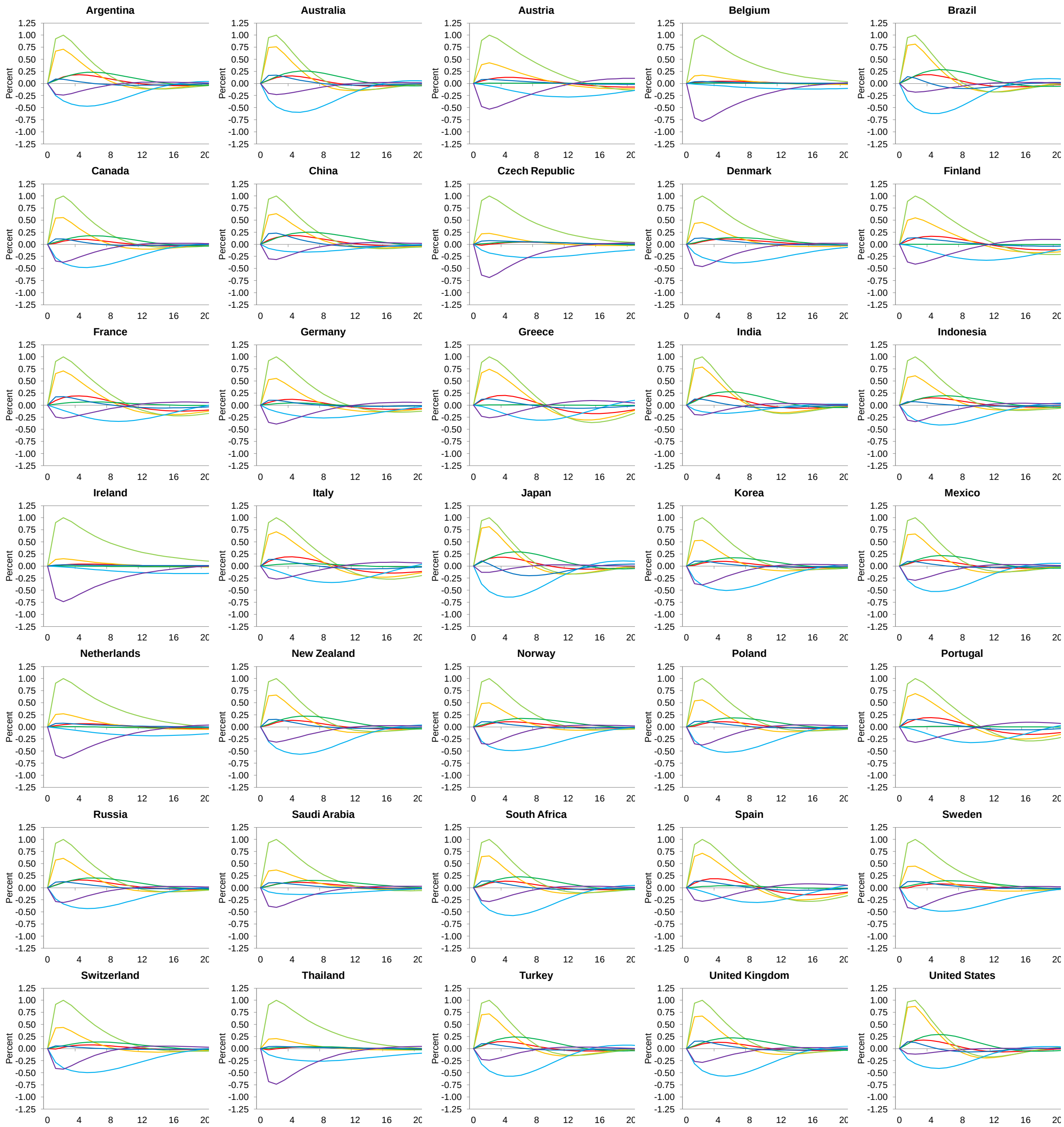
Note: Depicts the correlations of consumption price inflation with the lagged output gap ■, of consumption price inflation with the lagged monetary conditions gap ■, and of the output gap with the lagged monetary conditions gap ■. These correlations are calculated with a Monte Carlo simulation with 999 replications for *2T* periods, discarding the first *T* simulated observations to eliminate dependence on initial conditions, where *T* denotes the observed sample size.

Figure 4. Impulse Responses to a Domestic Supply Shock



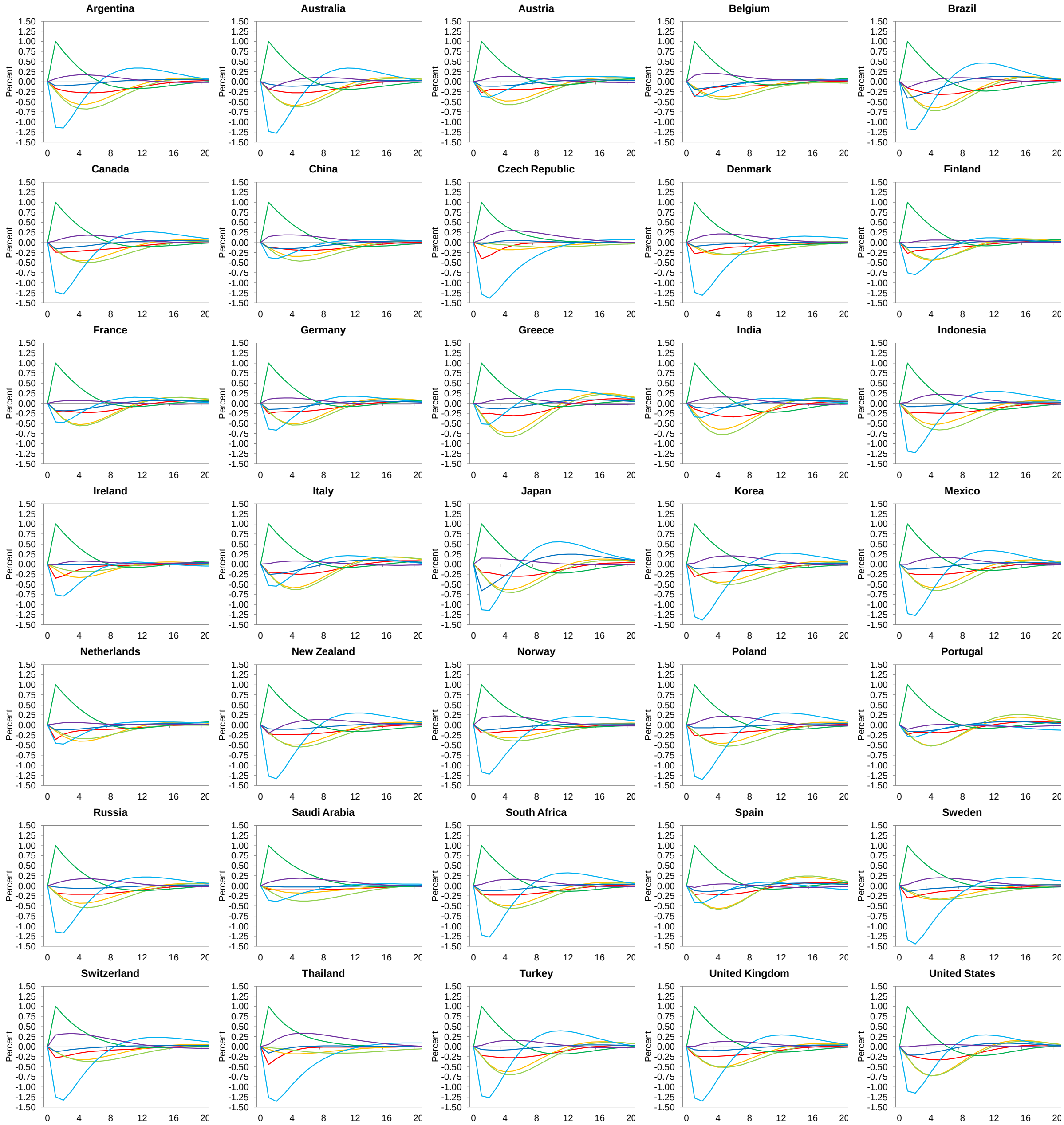
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic supply shocks which raise consumption price inflation by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 5. Impulse Responses to a Domestic Private Demand Shock



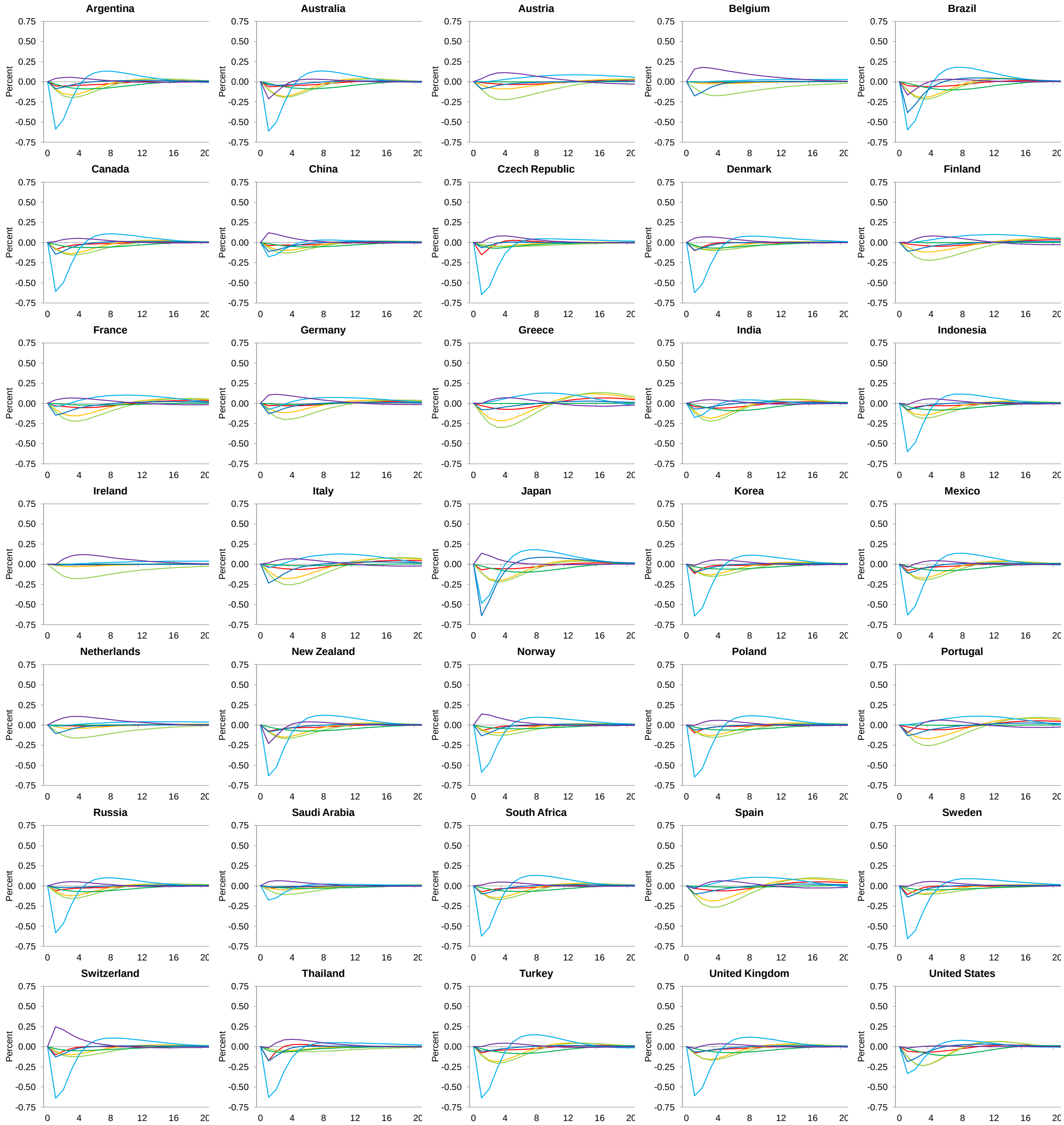
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to private domestic demand shocks which raise domestic demand by one percent. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 6. Impulse Responses to a Domestic Monetary Policy Shock



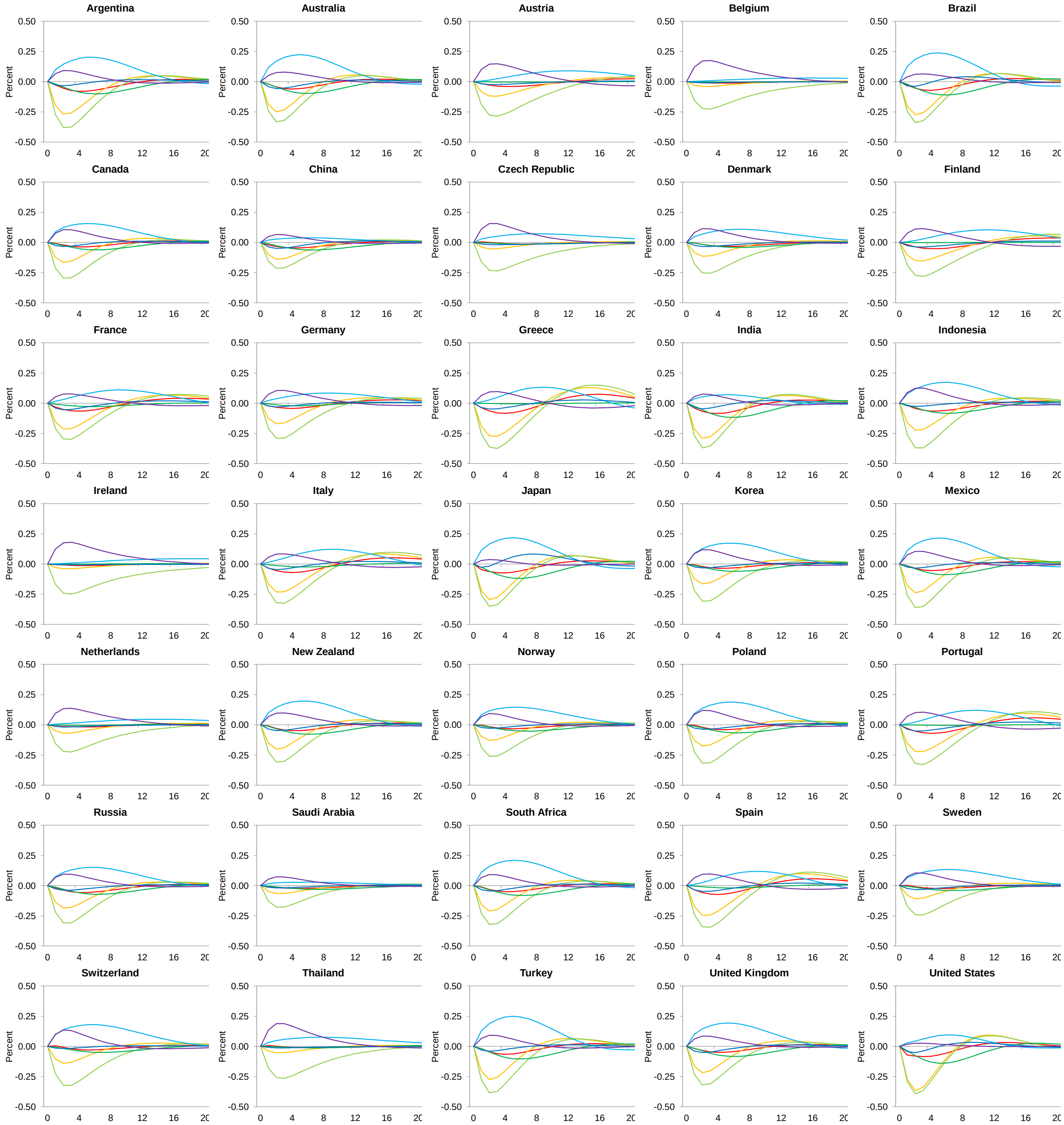
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic monetary policy shocks which raise the nominal policy interest rate by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 7. Impulse Responses to a Domestic Credit Risk Premium Shock



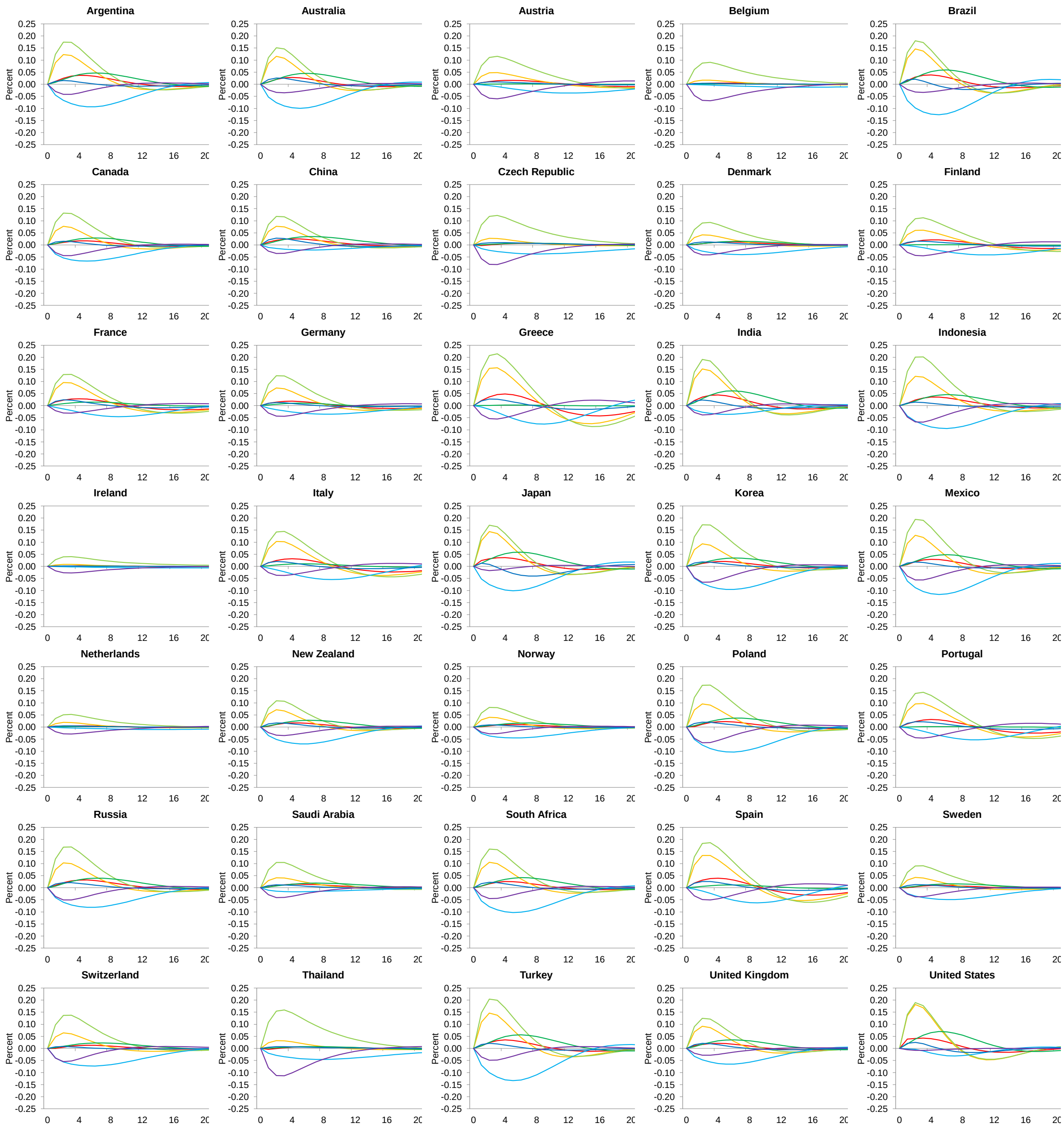
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic credit risk premium shocks which raise the short term nominal market interest rate by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 8. Impulse Responses to a Domestic Duration Risk Premium Shock



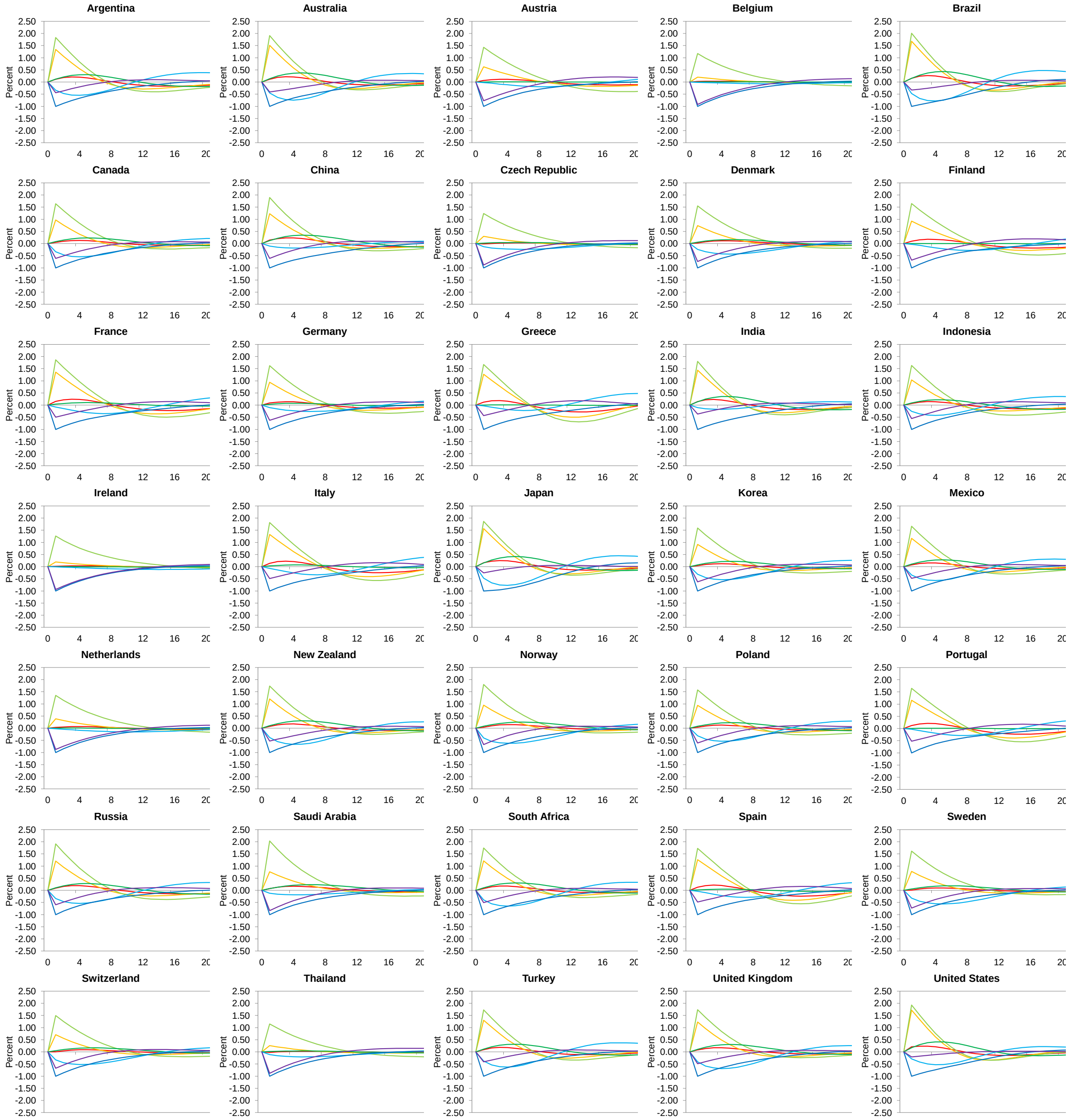
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic duration risk premium shocks which raise the long term nominal market interest rate by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 9. Impulse Responses to a Domestic Equity Risk Premium Shock



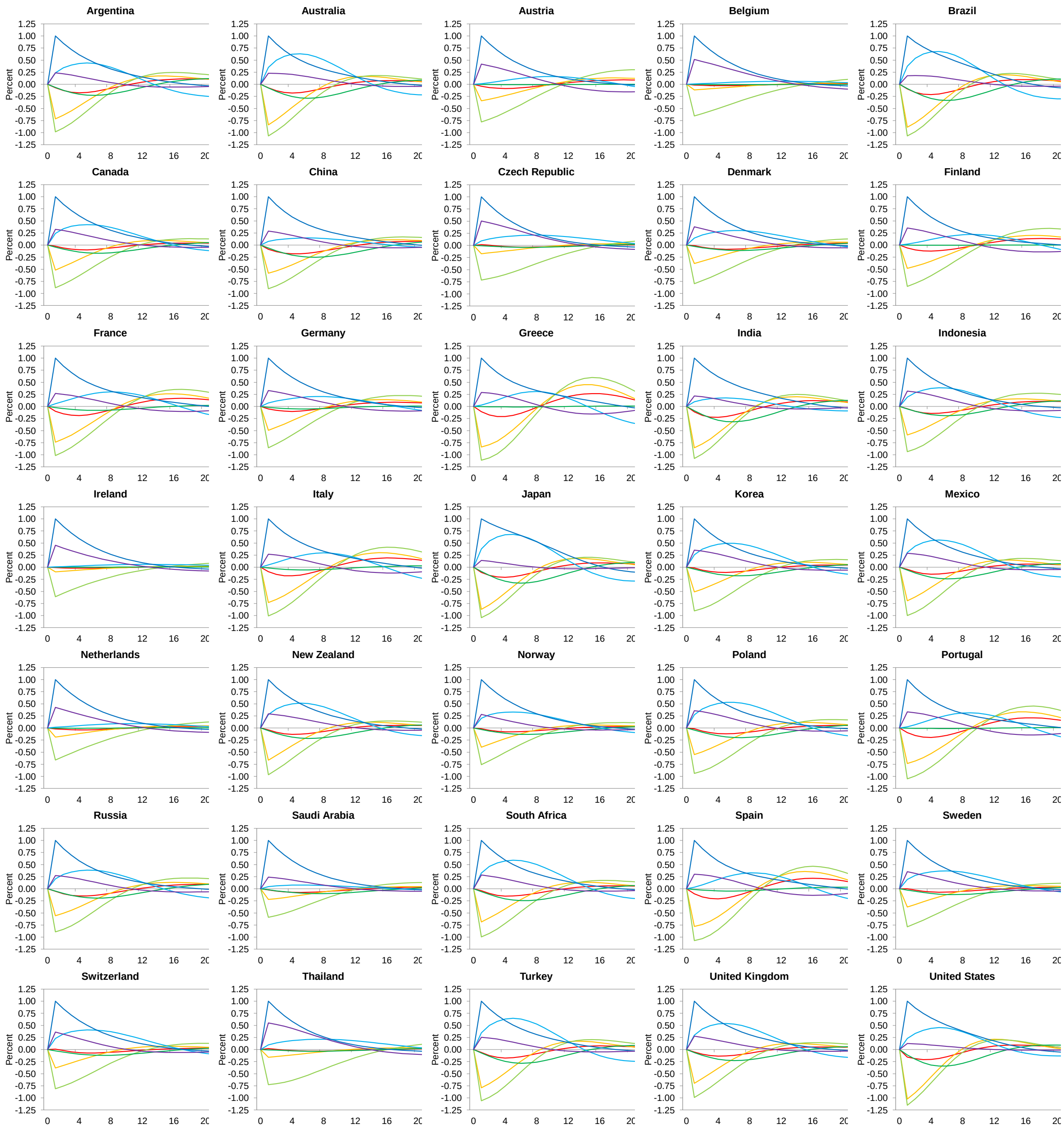
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic equity risk premium shocks which raise the price of equity by ten percent. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 10. Impulse Responses to a Domestic Fiscal Expenditure Shock



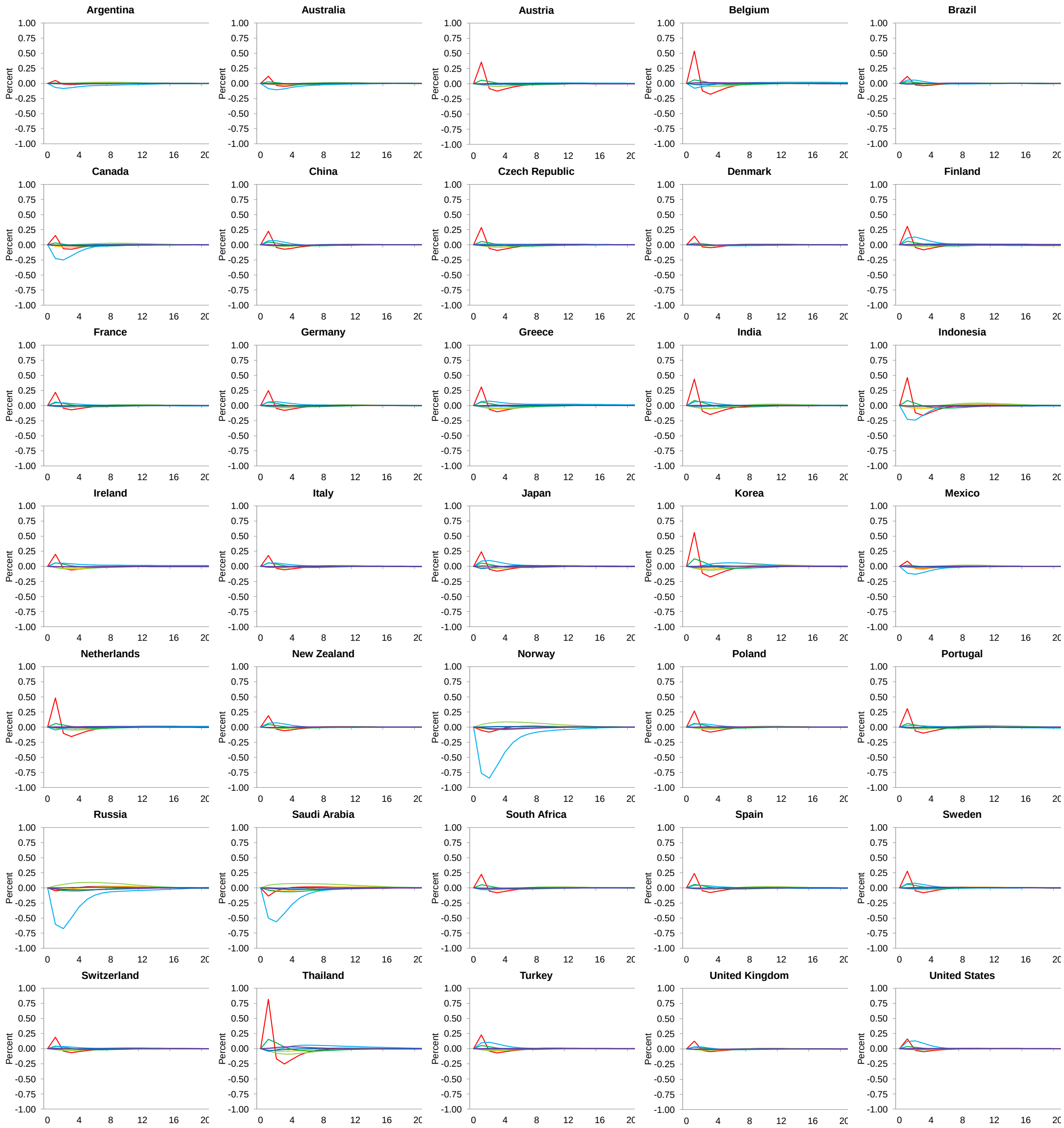
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic fiscal expenditure shocks which reduce the ratio of the fiscal balance to nominal output by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 11. Impulse Responses to a Domestic Fiscal Revenue Shock



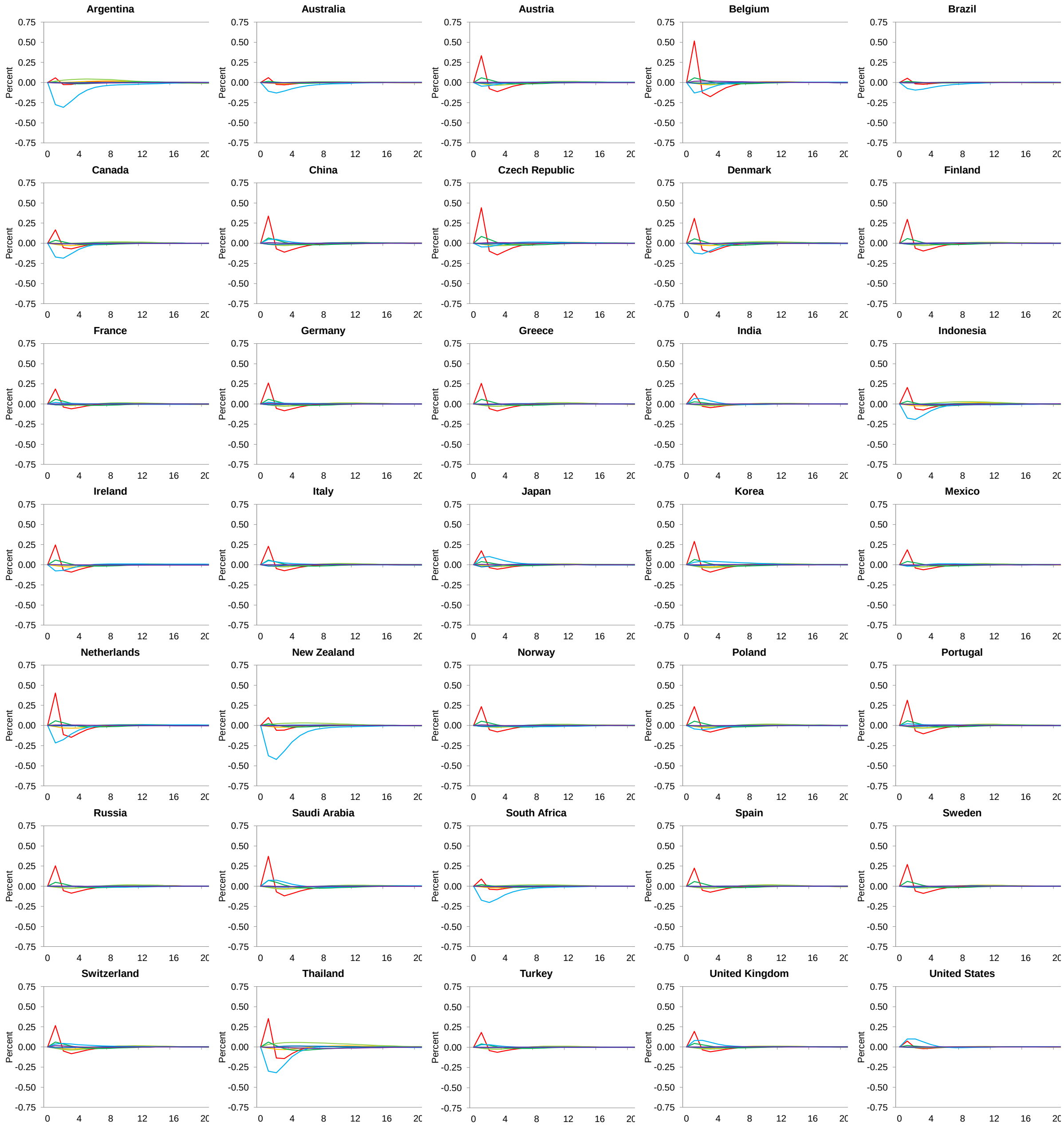
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic fiscal revenue shocks which raise the ratio of the fiscal balance to nominal output by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 12. Impulse Responses to a World Energy Commodity Price Shock



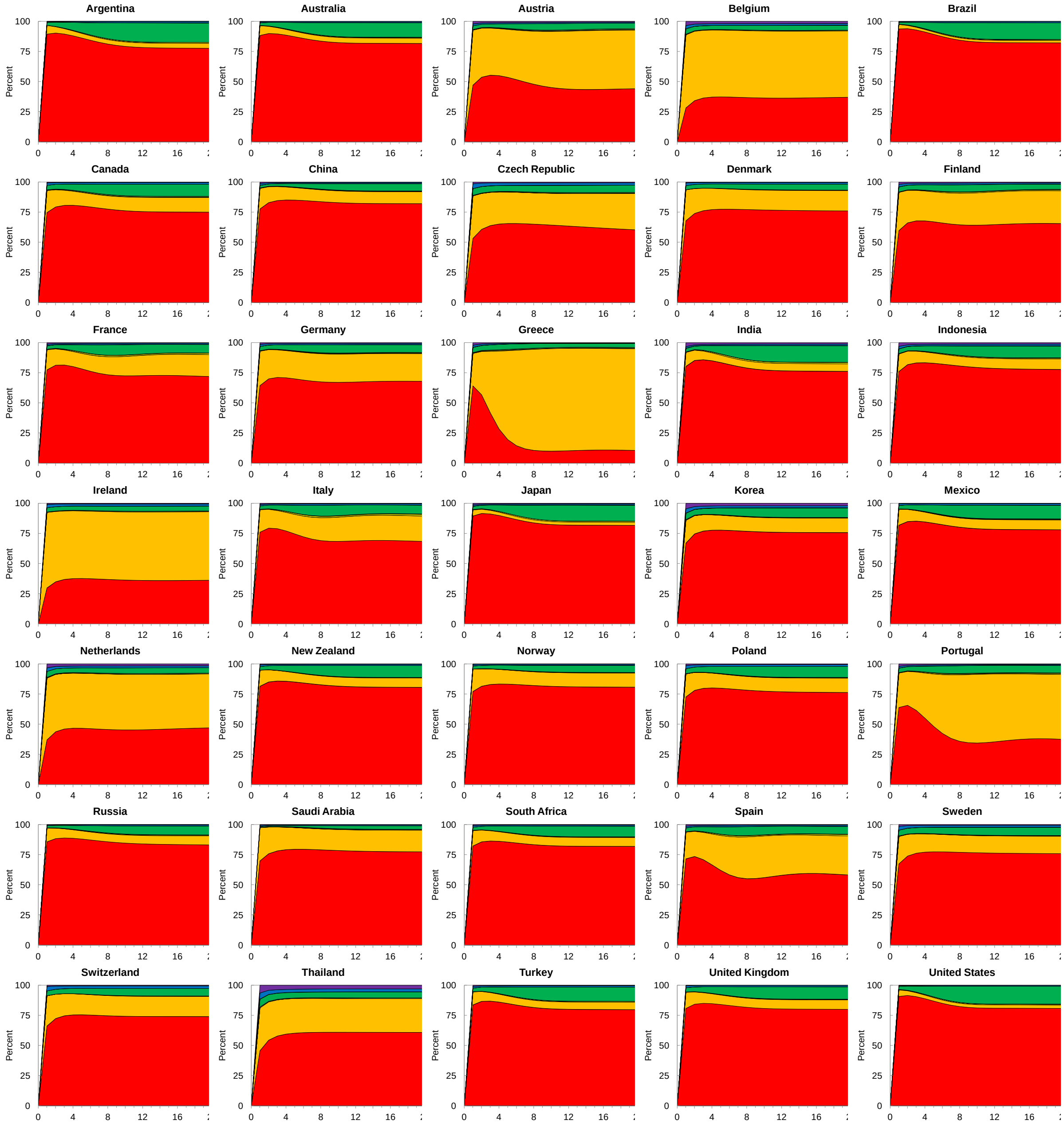
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to a world energy commodity price shock which raises the price of energy commodities by ten percent. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 13. Impulse Responses to a World Nonenergy Commodity Price Shock



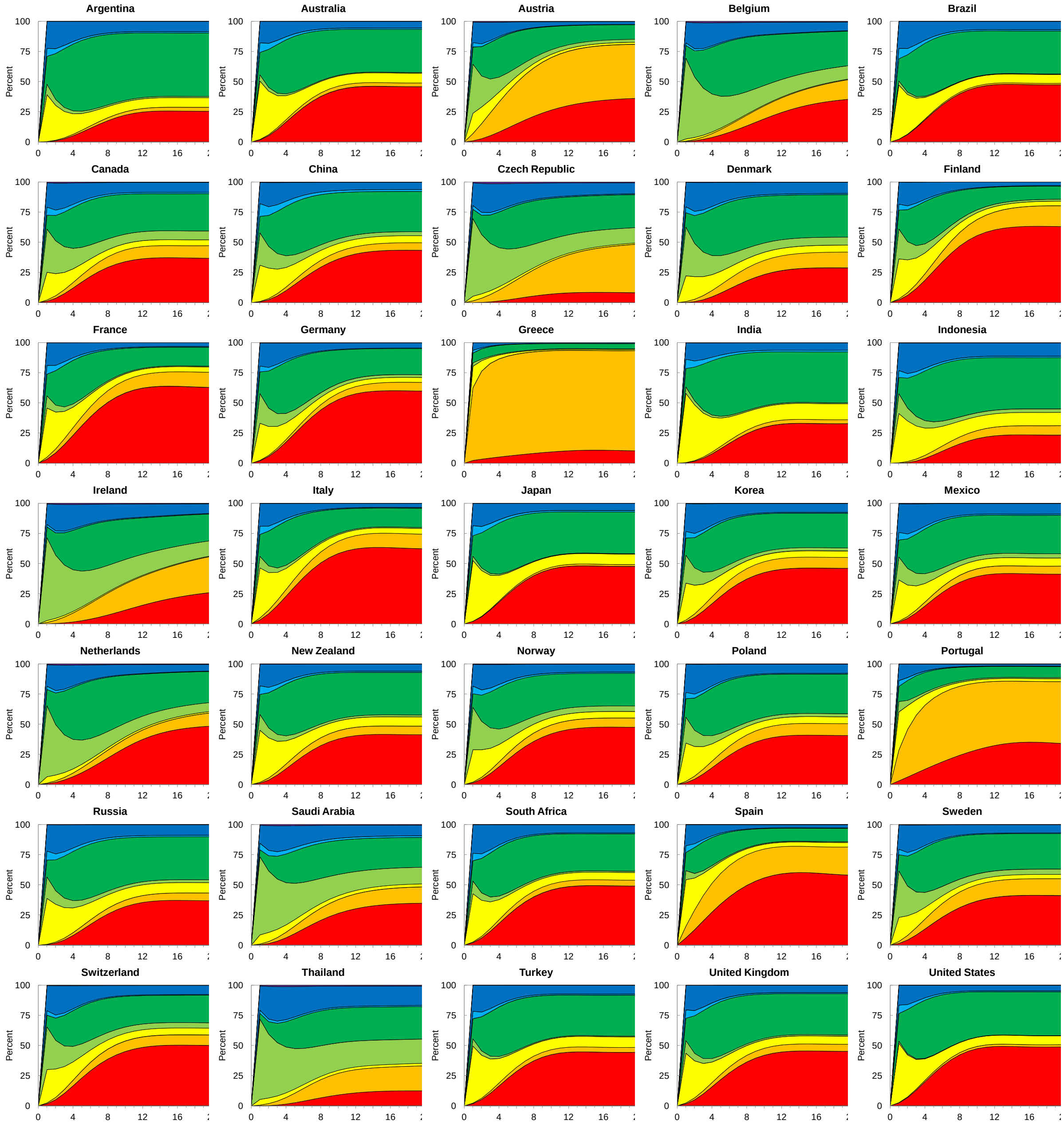
Note: Depicts the impulse responses of consumption price inflation ■, output ■, domestic demand ■, the nominal policy interest rate ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to a world nonenergy commodity price shock which raises the price of nonenergy commodities by ten percent. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 14. Forecast Error Variance Decompositions of Consumption Price Inflation



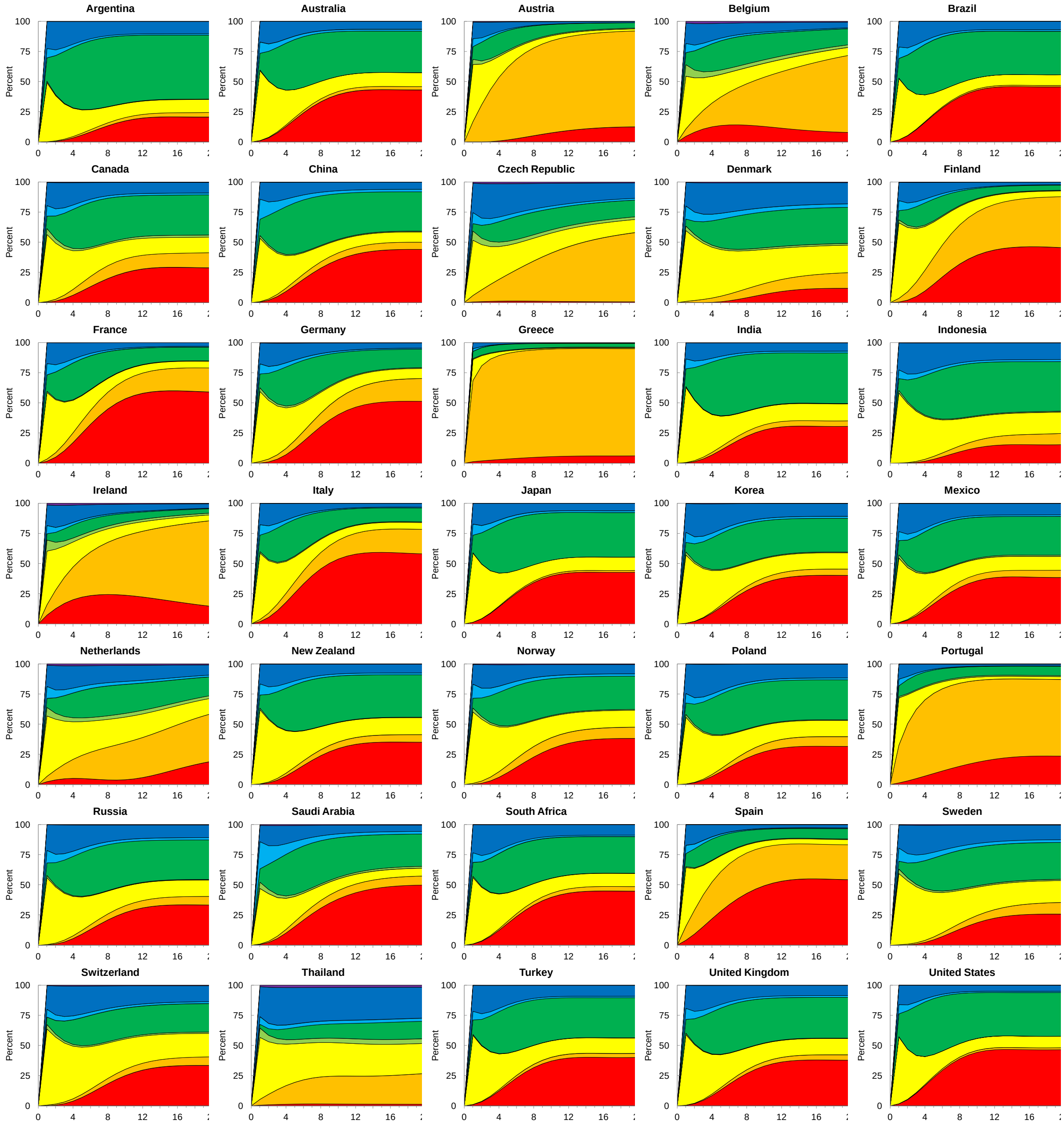
Note: Decomposes the horizon dependent forecast error variance of consumption price inflation into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 15. Forecast Error Variance Decompositions of Output



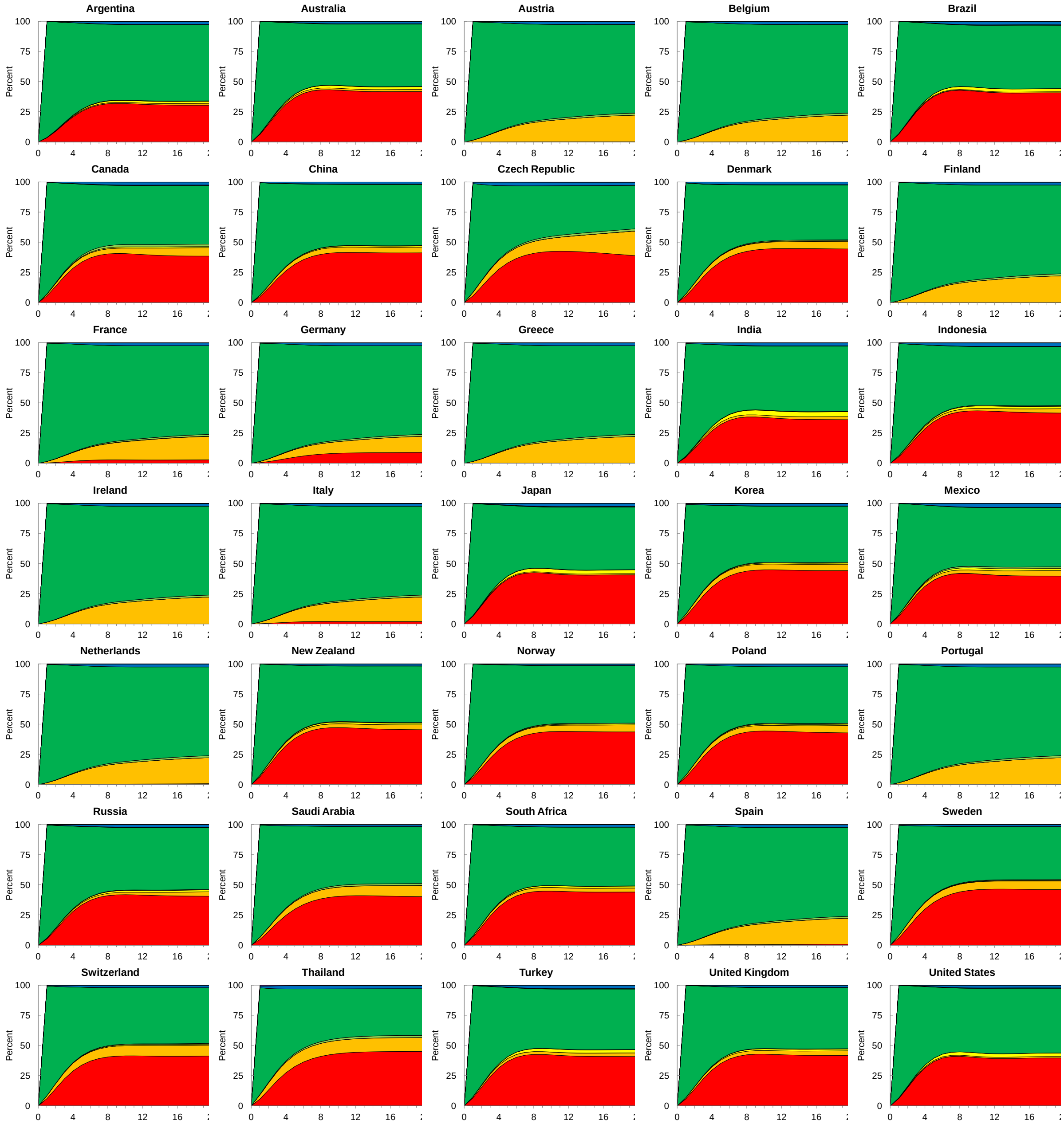
Note: Decomposes the horizon dependent forecast error variance of output into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 16. Forecast Error Variance Decompositions of Domestic Demand



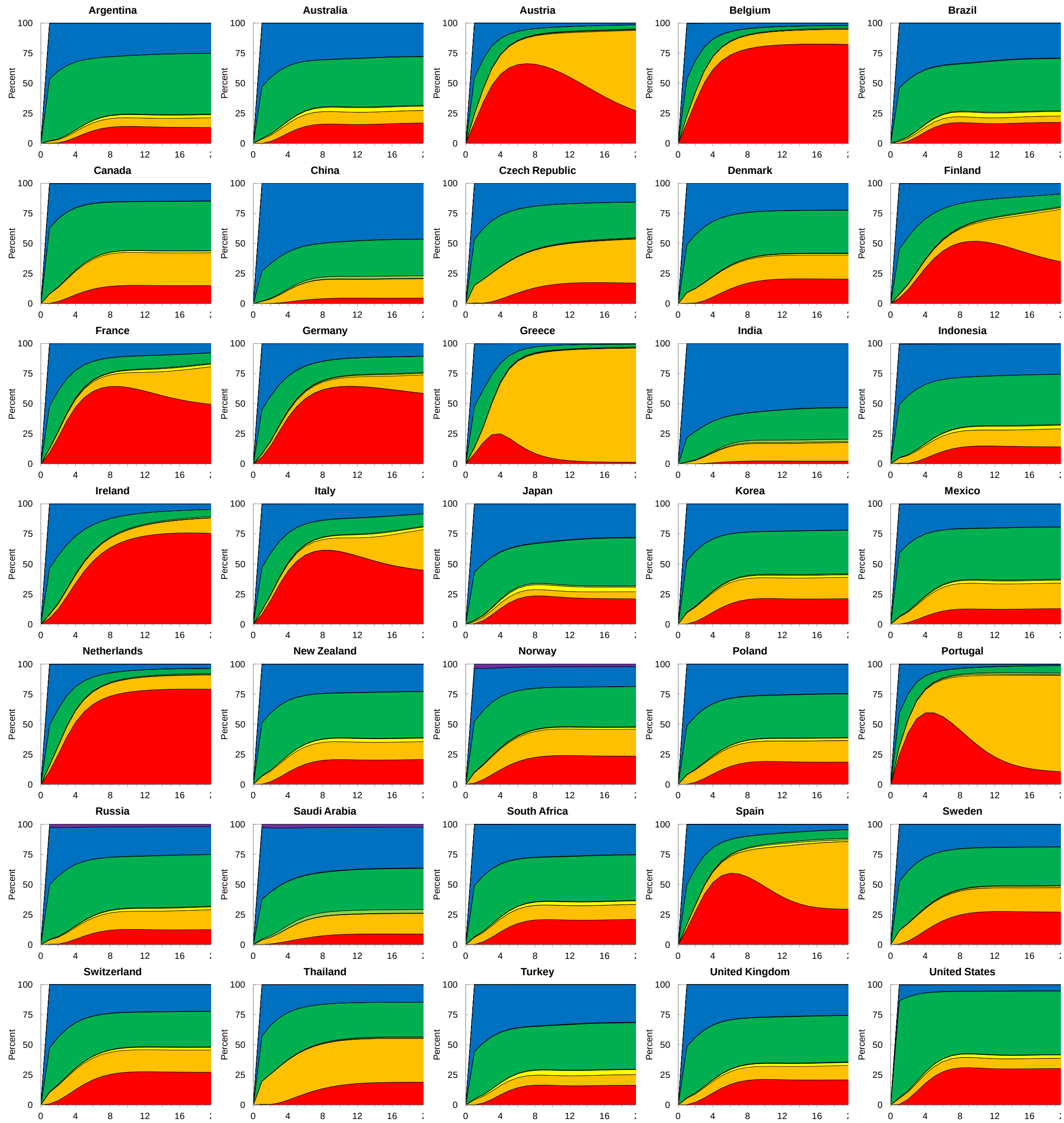
Note: Decomposes the horizon dependent forecast error variance of domestic demand into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 17. Forecast Error Variance Decompositions of the Nominal Policy Interest Rate



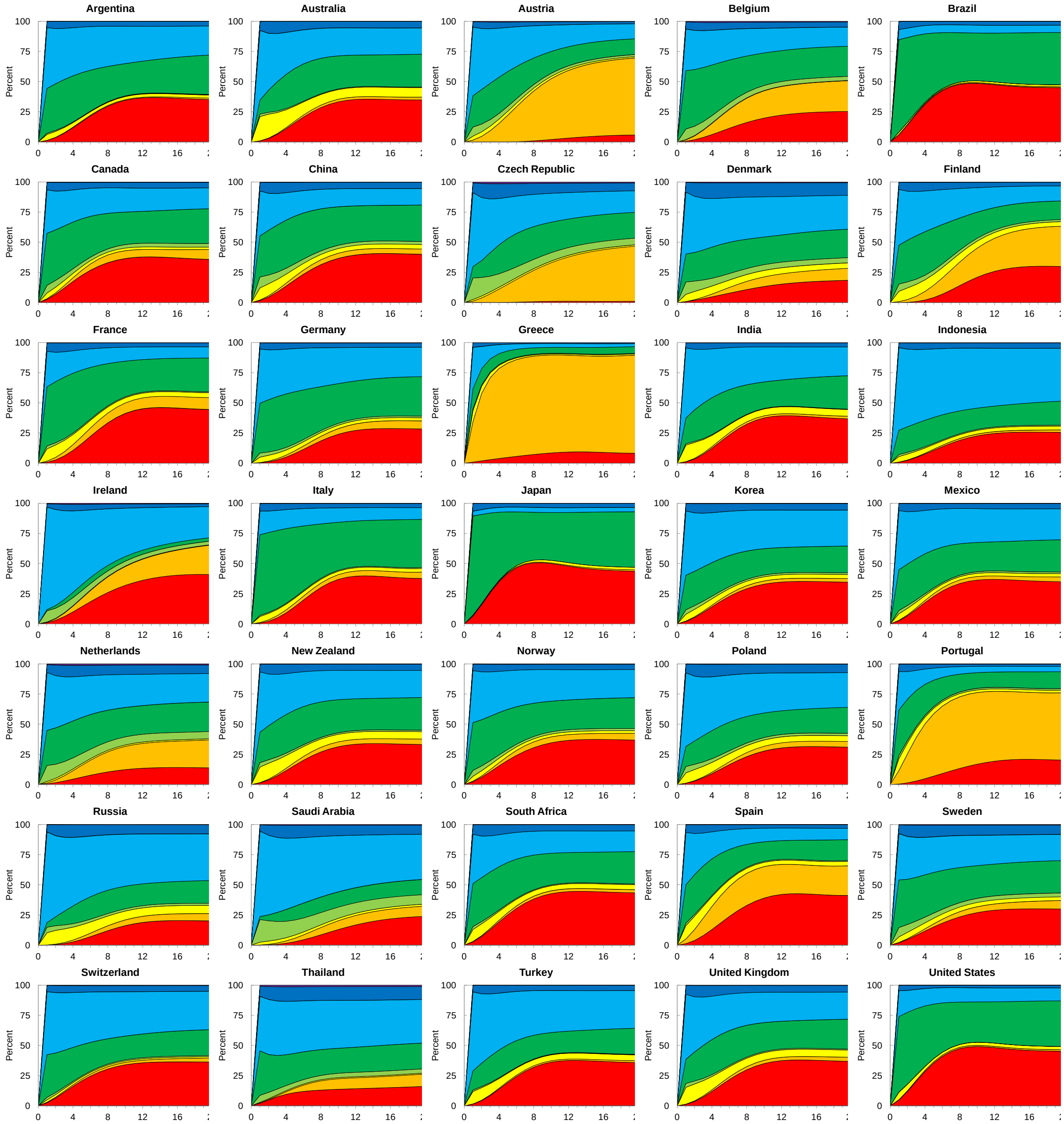
Note: Decomposes the horizon dependent forecast error variance of the nominal policy interest rate into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 18. Forecast Error Variance Decompositions of the Real Effective Exchange Rate



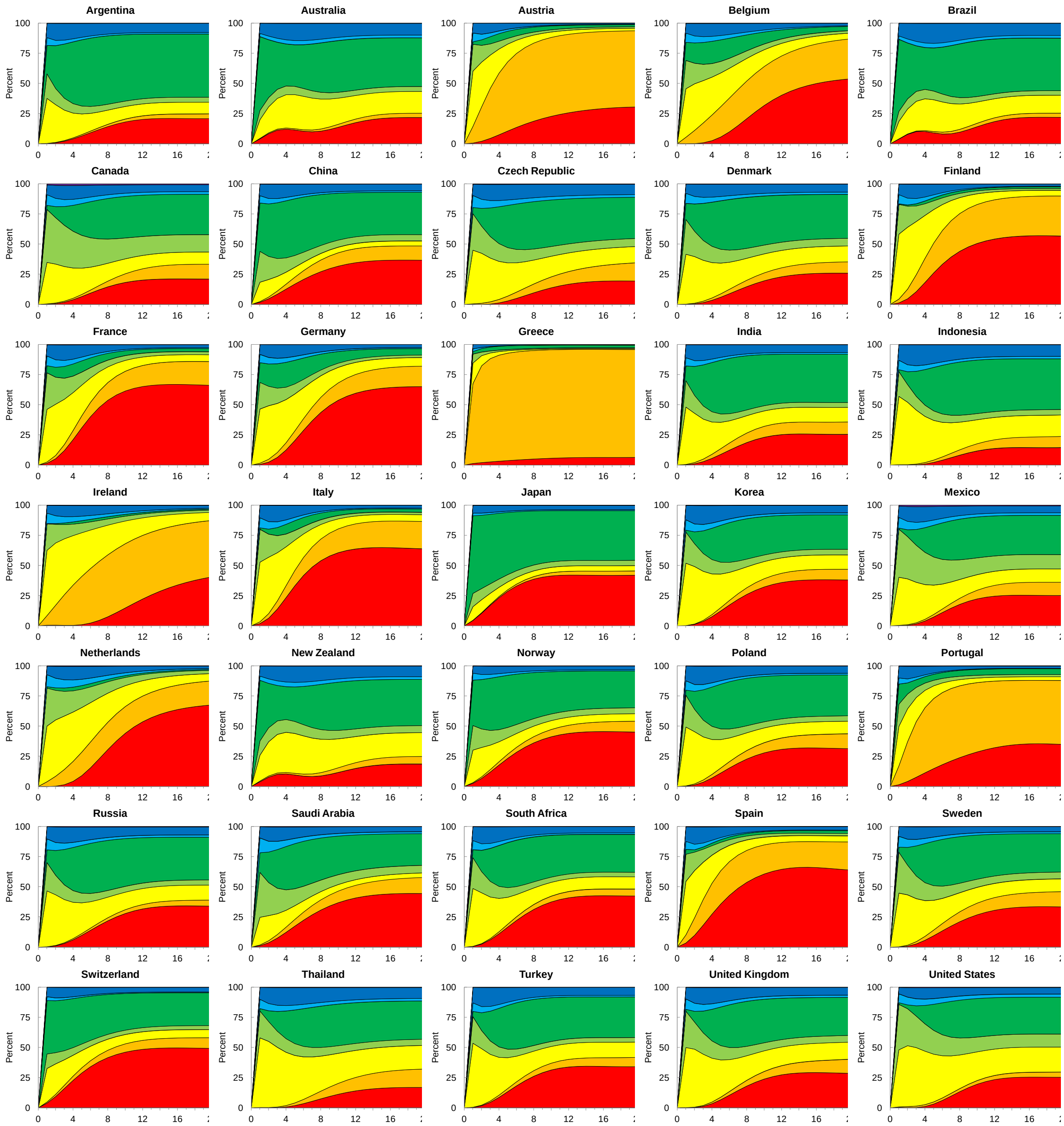
Note: Decomposes the horizon dependent forecast error variance of the real effective exchange rate into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 19. Forecast Error Variance Decompositions of the Fiscal Balance



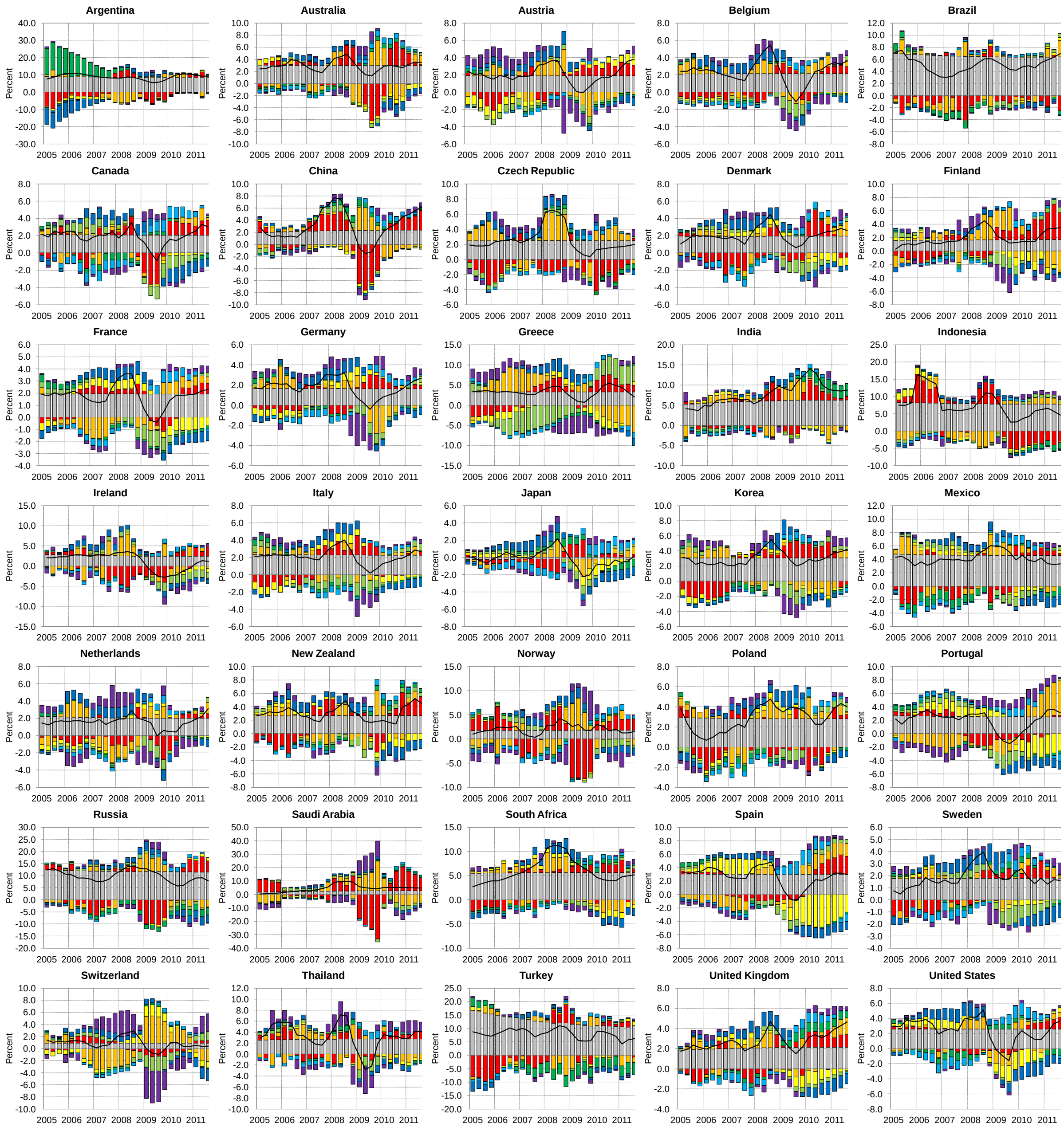
Note: Decomposes the horizon dependent forecast error variance of the ratio of the fiscal balance to nominal output into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 20. Forecast Error Variance Decompositions of the Current Account Balance



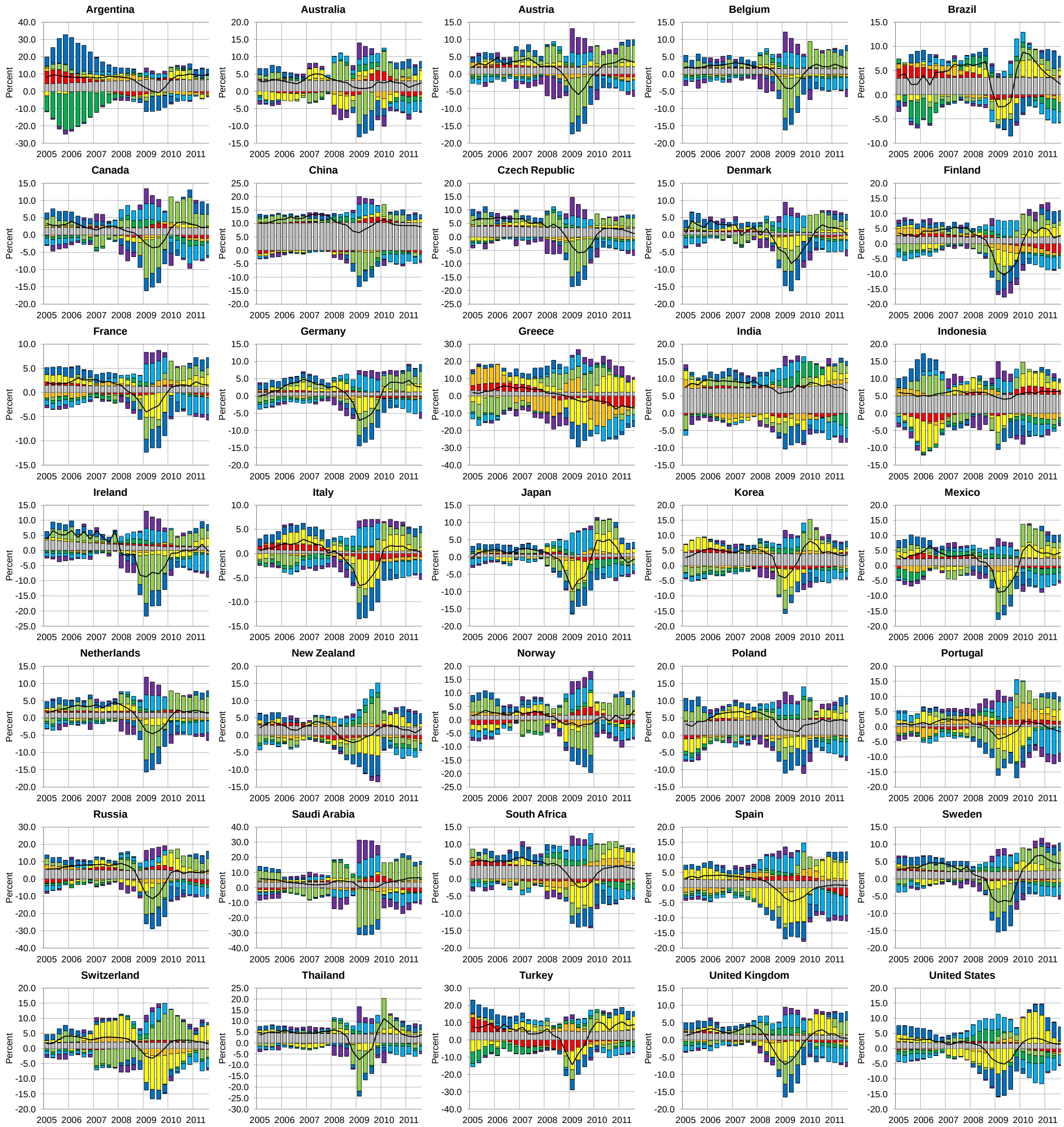
Note: Decomposes the horizon dependent forecast error variance of the ratio of the current account balance to nominal output into contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 21. Historical Decompositions of Consumption Price Inflation



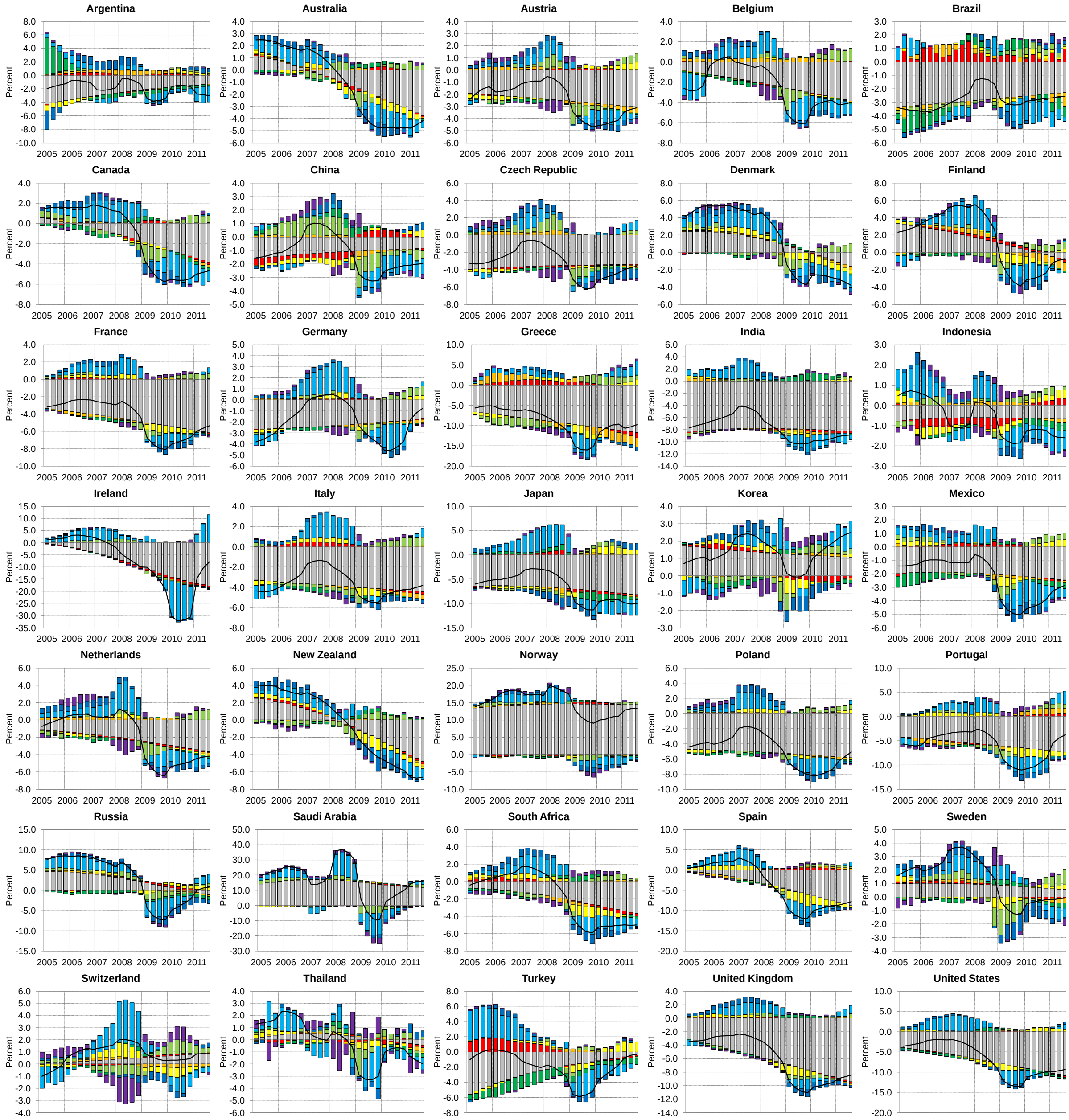
Note: Decomposes observed consumption price inflation ■ as measured by the seasonal logarithmic difference of the consumption price level into the sum of a trend component ■ and contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 22. Historical Decompositions of Output Growth



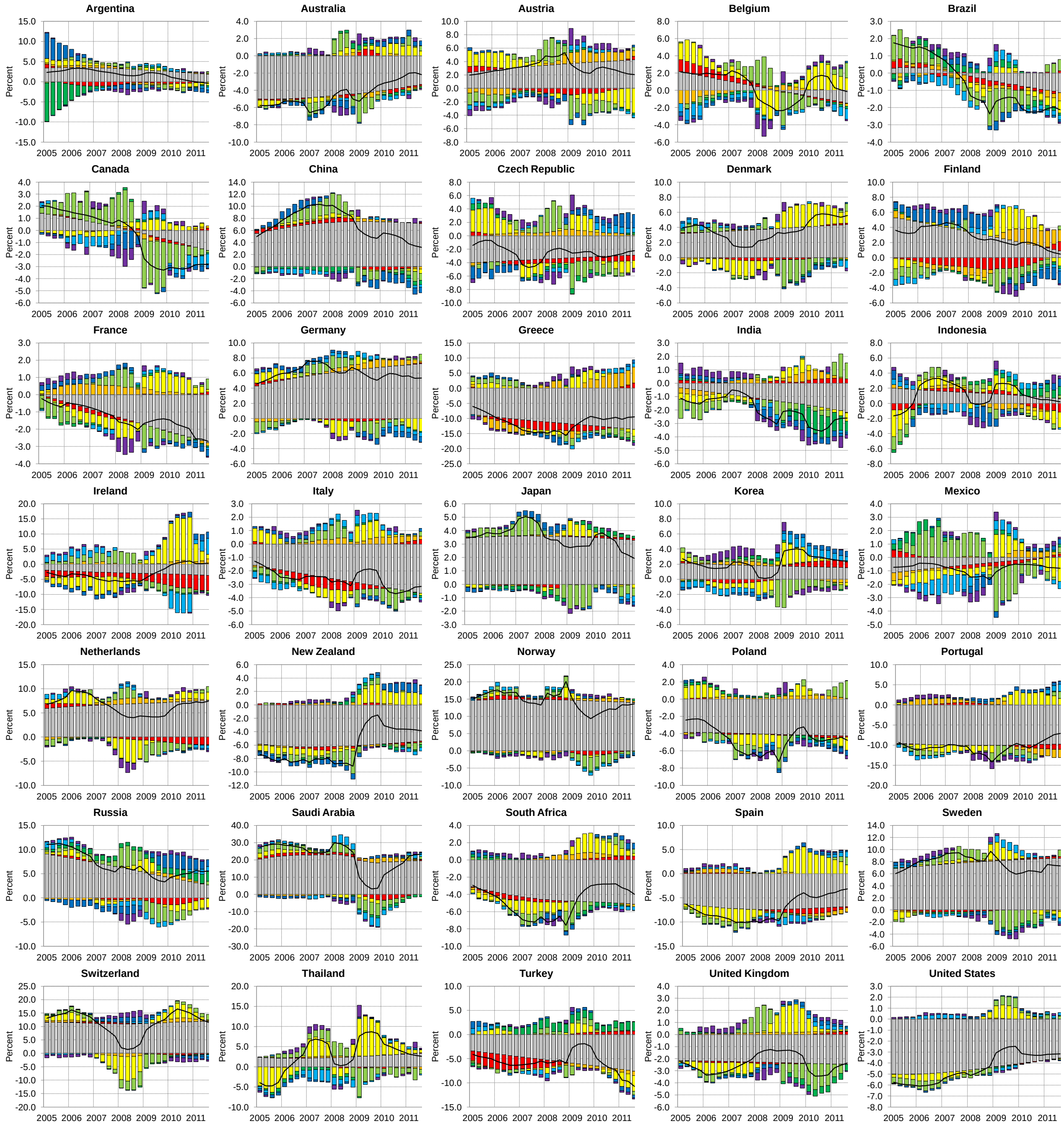
Note: Decomposes observed output growth ■ as measured by the seasonal logarithmic difference of the level of output into the sum of a trend component ■ and contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 23. Historical Decompositions of the Fiscal Balance



Note: Decomposes the observed ratio of the fiscal balance to nominal output ■ into the sum of a trend component ■ and contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 24. Historical Decompositions of the Current Account Balance

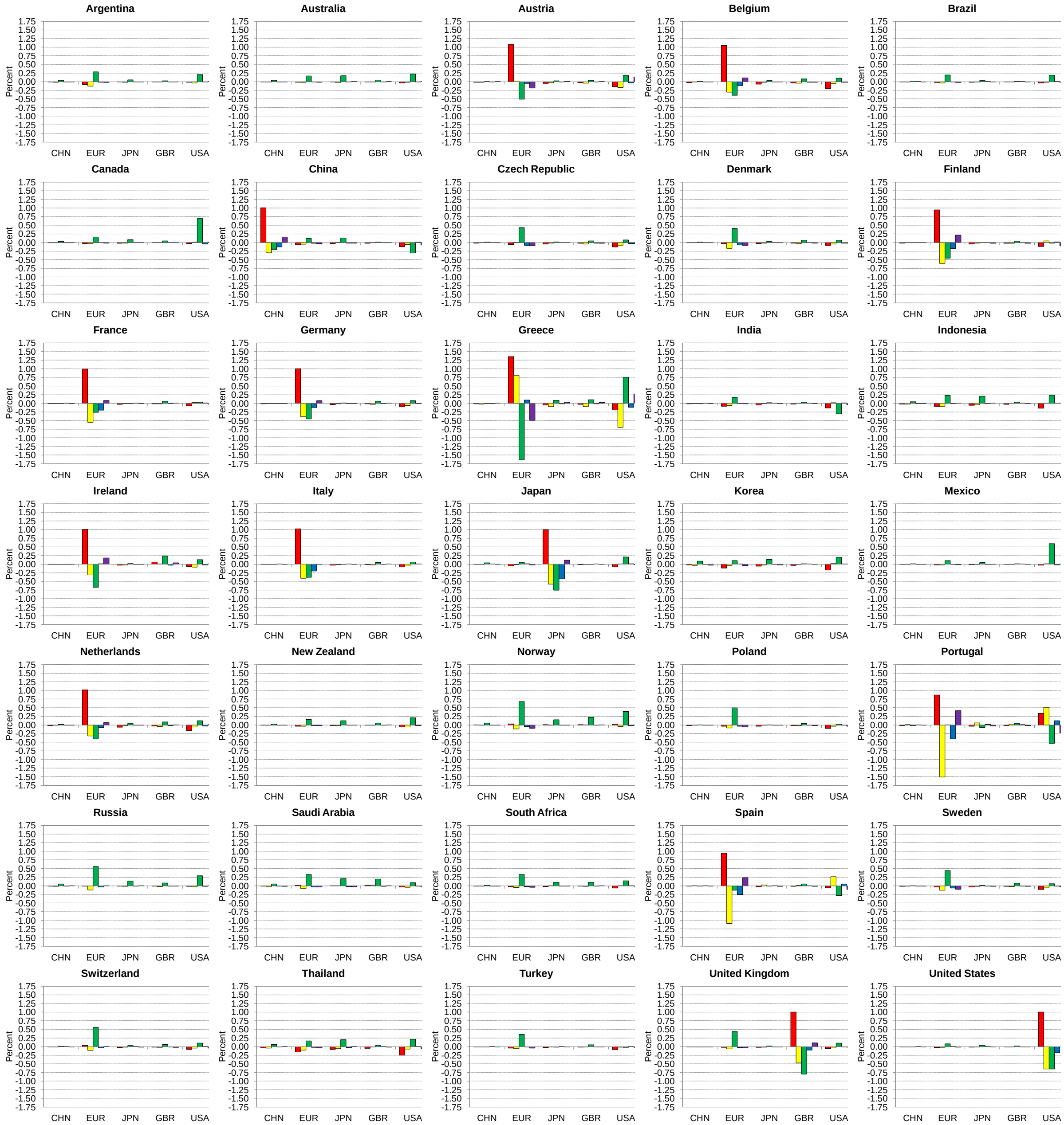


Note: Decomposes the observed ratio of the current account balance to nominal output ■ into the sum of a trend component ■ and contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 25. Simulated Conditional Betas of the Output Gap

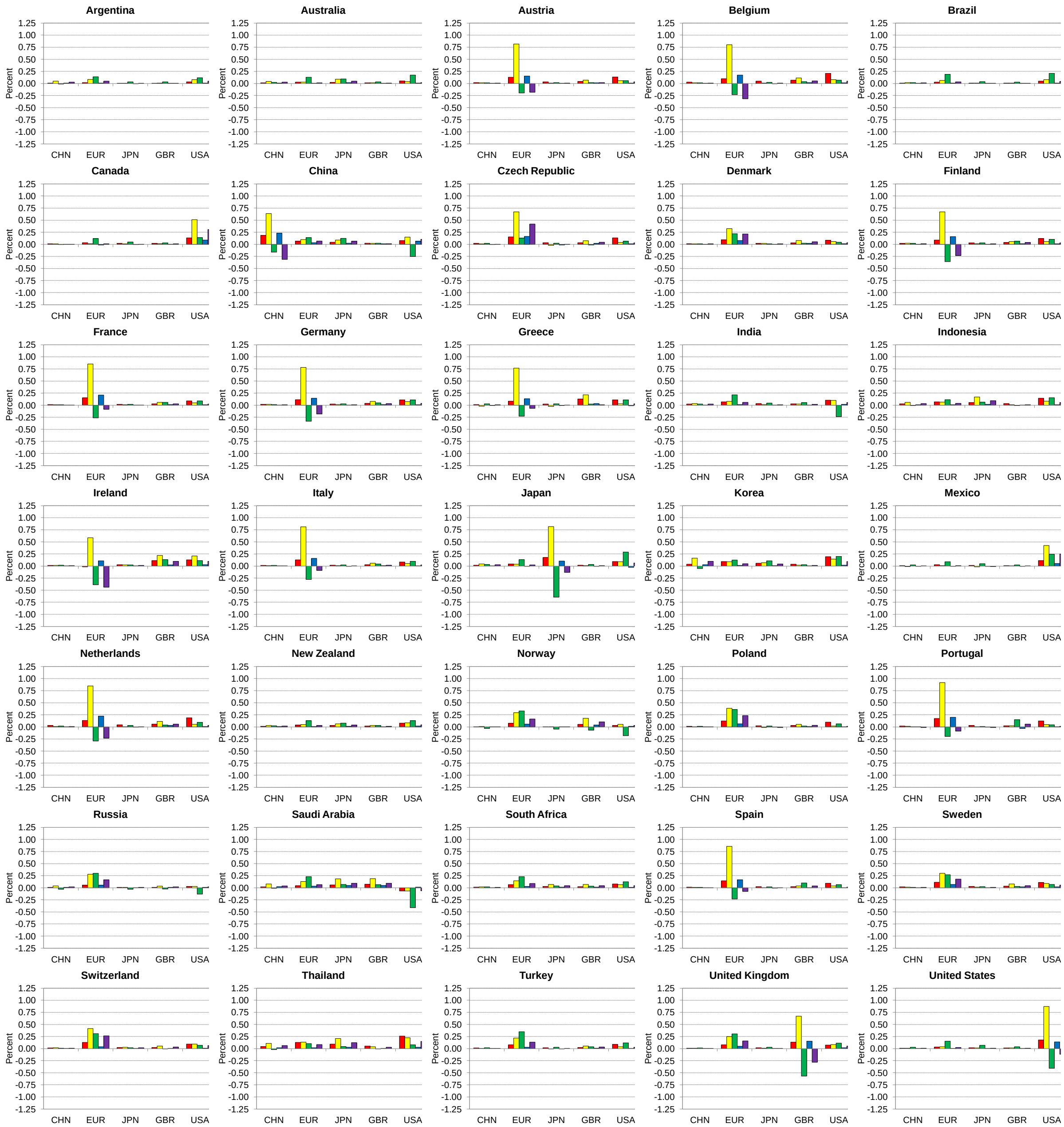
Note: Depicts the betas of the output gap with respect to the contemporaneous output gap in systemic economies conditional on all shocks ■, macroeconomic shocks ■, and financial shocks ■ in each of these systemic economies. These betas are calculated with a Monte Carlo simulation with 999 replications for $2T$ periods, discarding the first T simulated observations to eliminate dependence on initial conditions, where T denotes the observed sample size.

Figure 26. Peak Impulse Responses to Foreign Supply Shocks



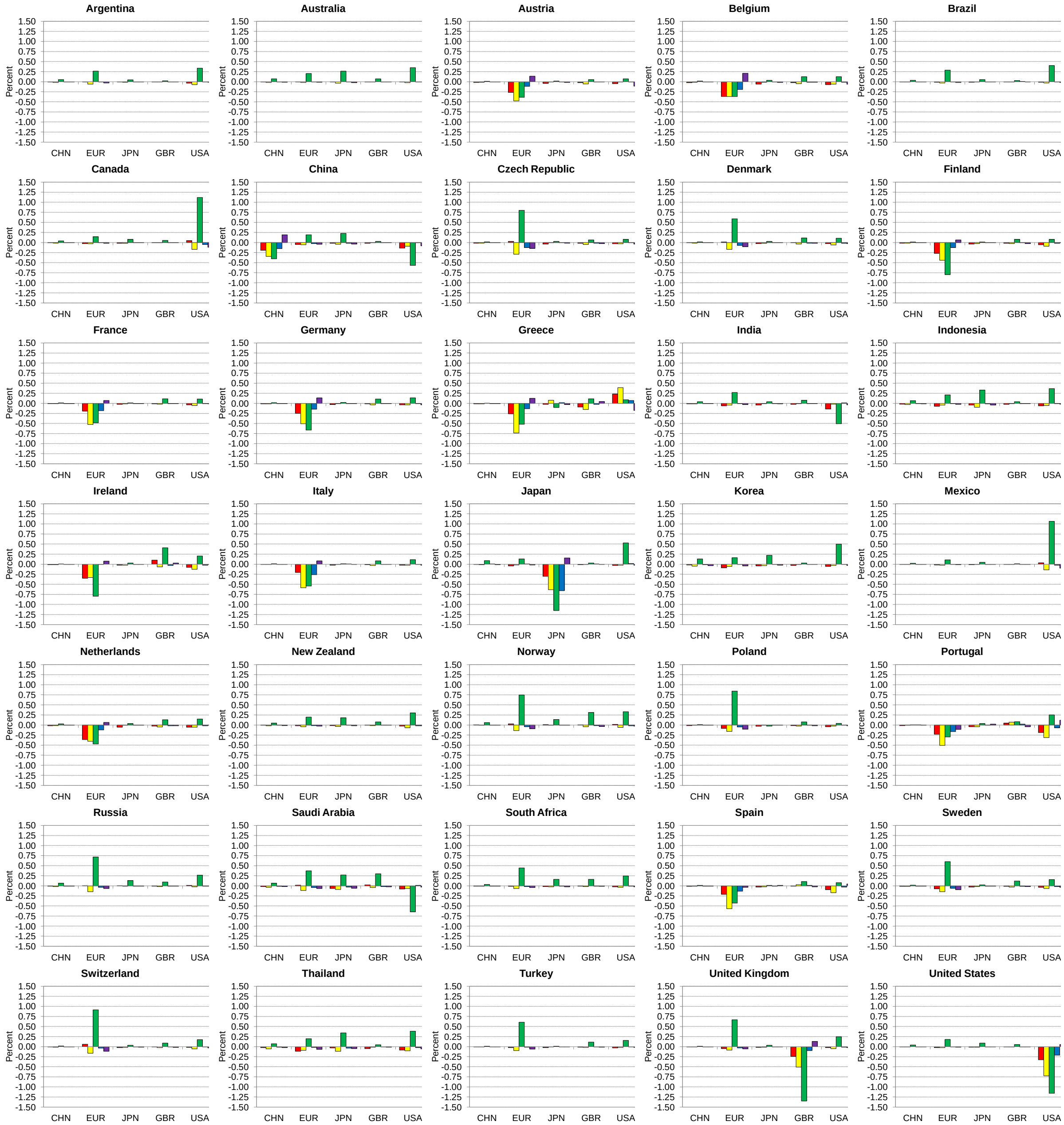
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to domestic supply shocks in systemic economies which raise their consumption price inflation by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 27. Peak Impulse Responses to Foreign Private Demand Shocks



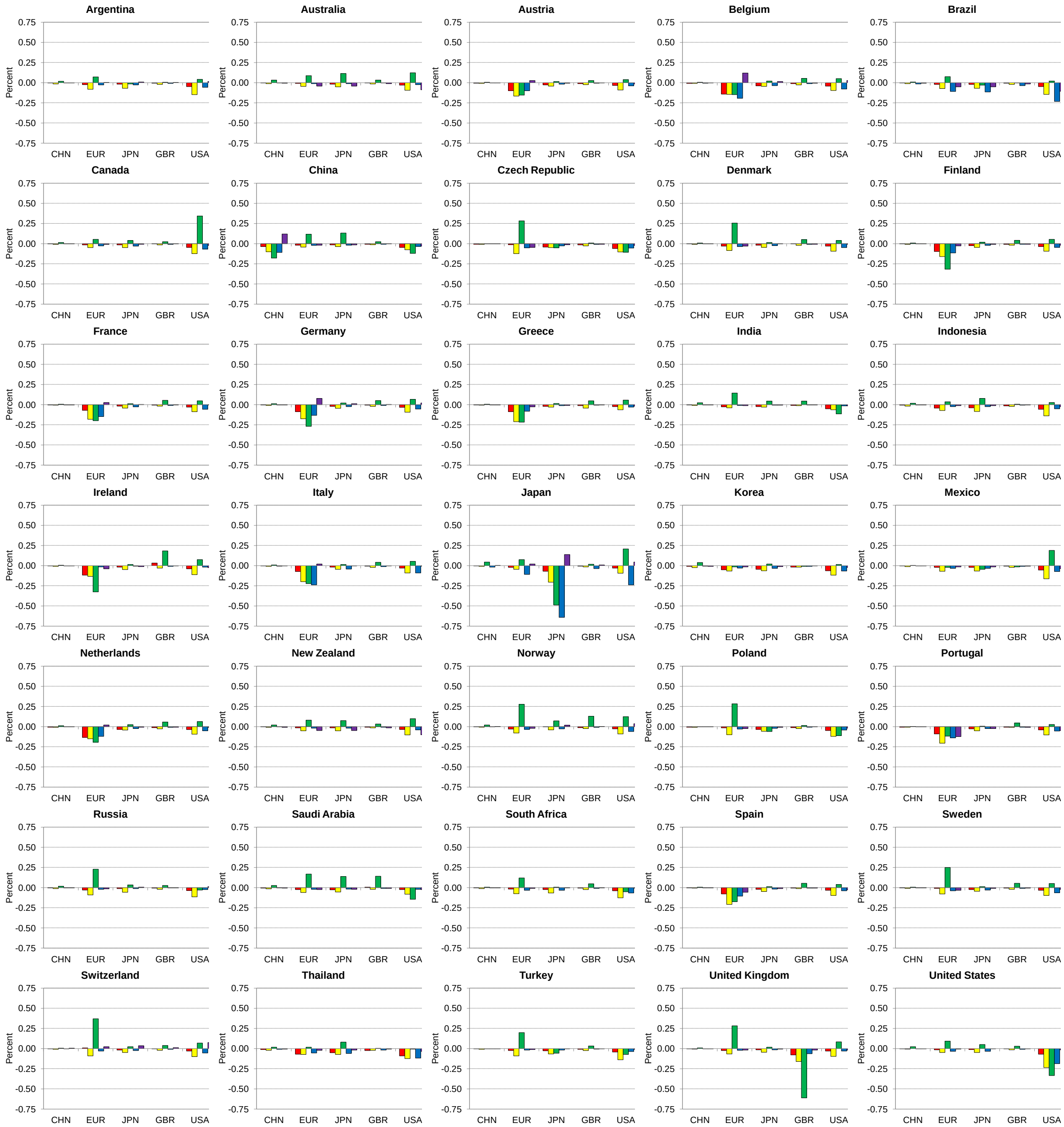
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to private domestic demand shocks in systemic economies which raise their domestic demand by one percent. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 28. Peak Impulse Responses to Foreign Monetary Policy Shocks



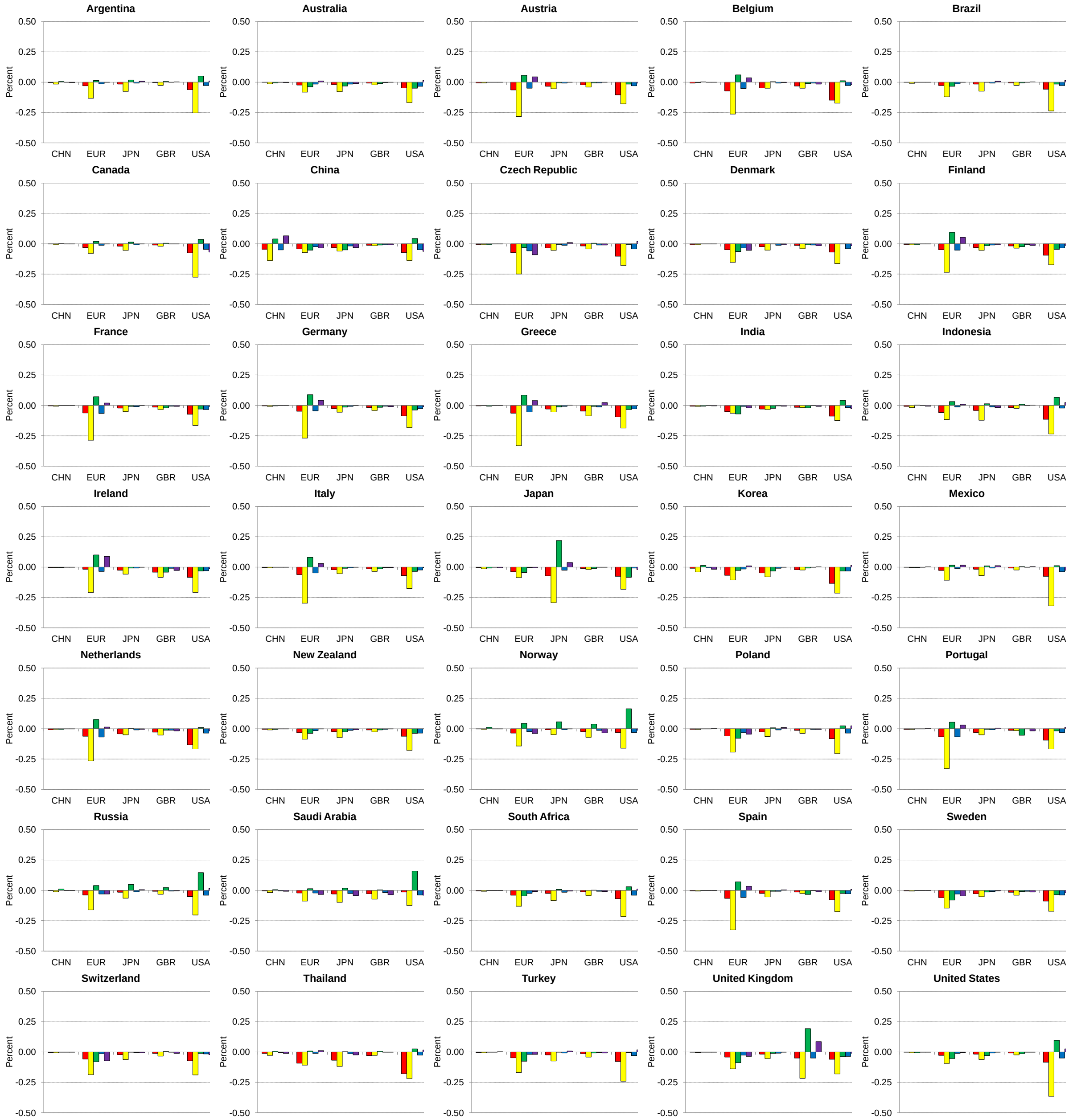
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to monetary policy shocks in systemic economies which raise their nominal policy interest rate by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 29. Peak Impulse Responses to Foreign Credit Risk Premium Shocks



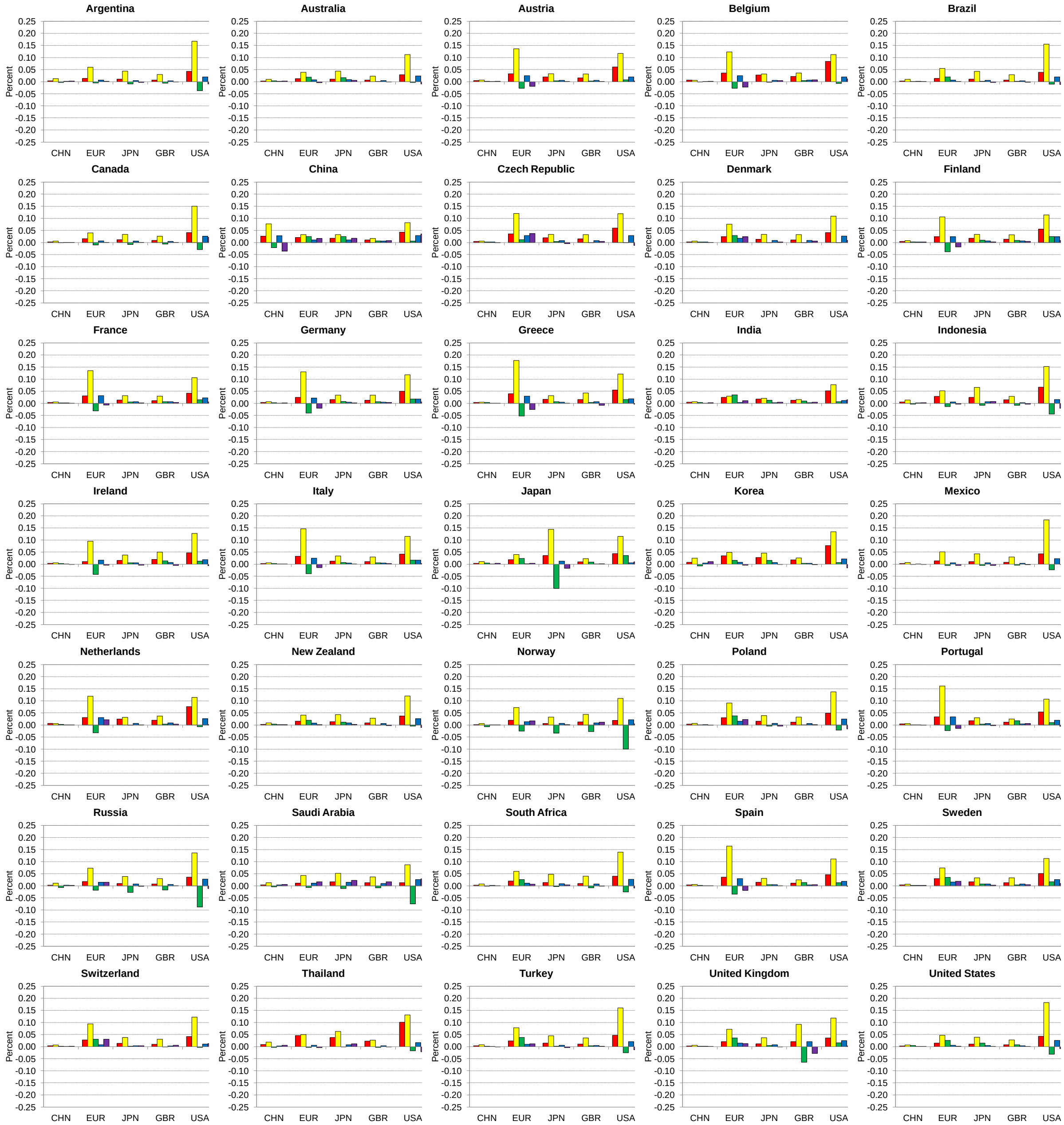
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to credit risk premium shocks in systemic economies which raise their short term nominal market interest rate by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 30. Peak Impulse Responses to Foreign Duration Risk Premium Shocks



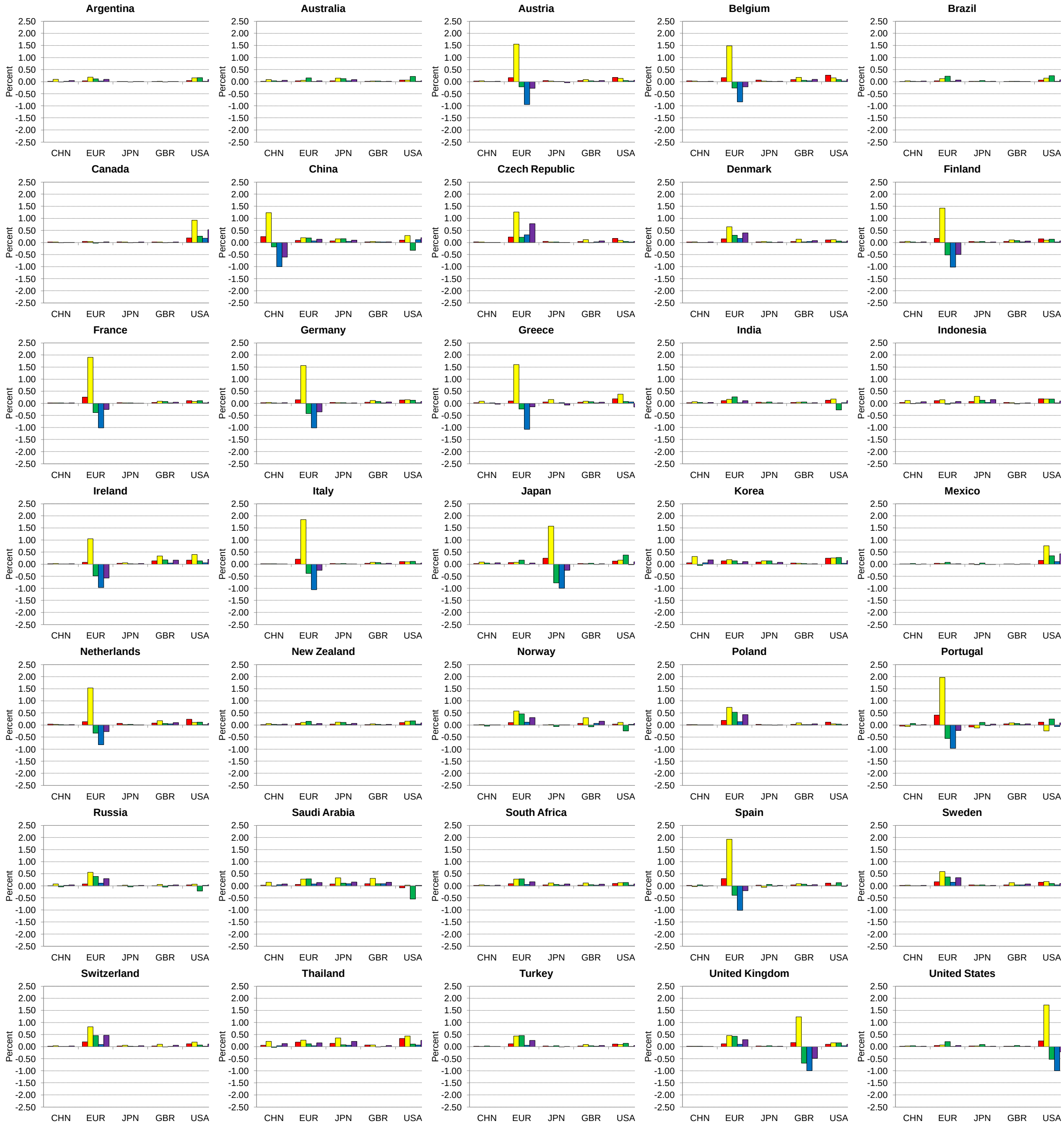
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to duration risk premium shocks in systemic economies which raise their long term nominal market interest rate by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 31. Peak Impulse Responses to Foreign Equity Risk Premium Shocks



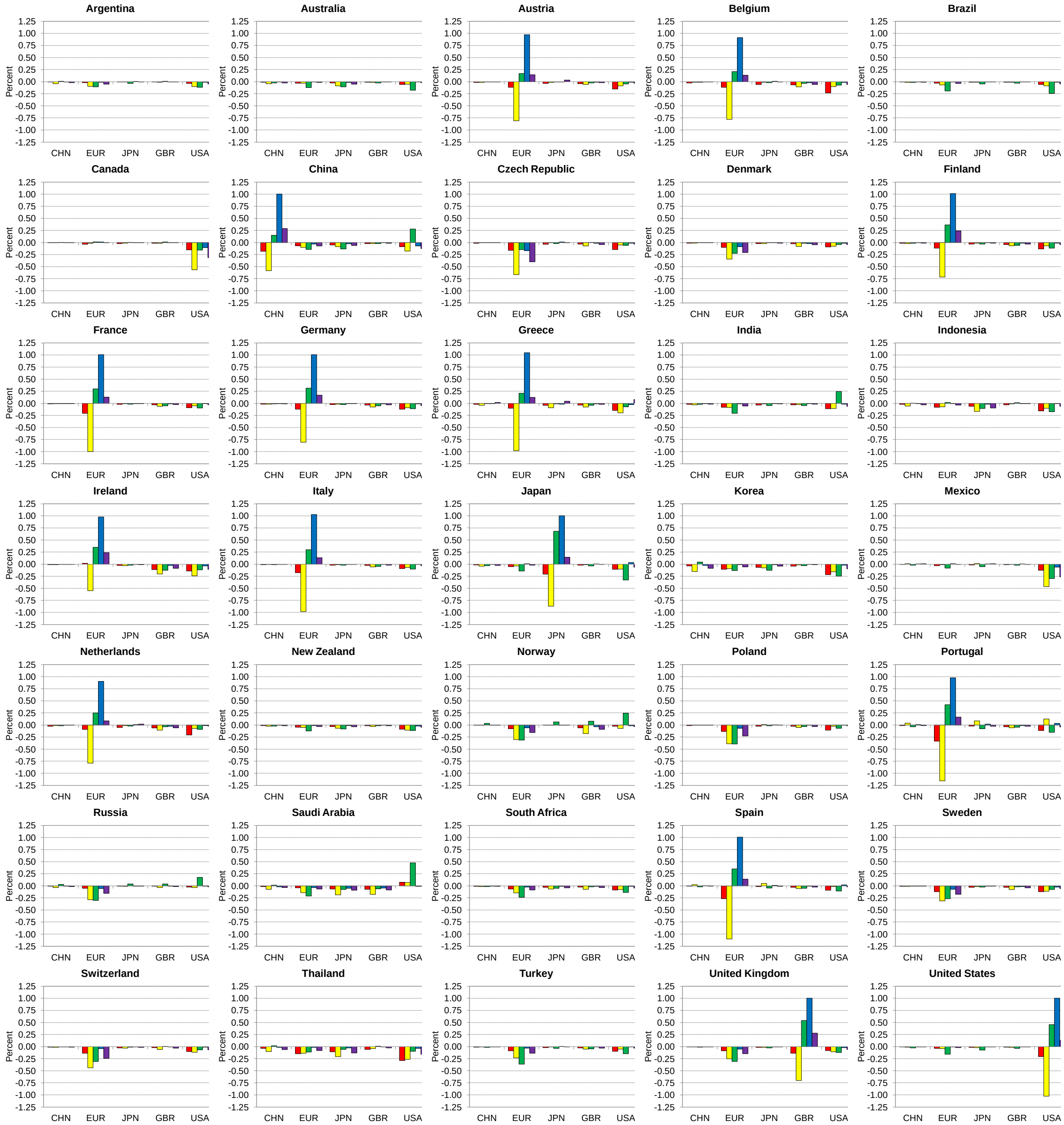
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to equity risk premium shocks in systemic economies which raise their price of equity by ten percent. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 32. Peak Impulse Responses to Foreign Fiscal Expenditure Shocks



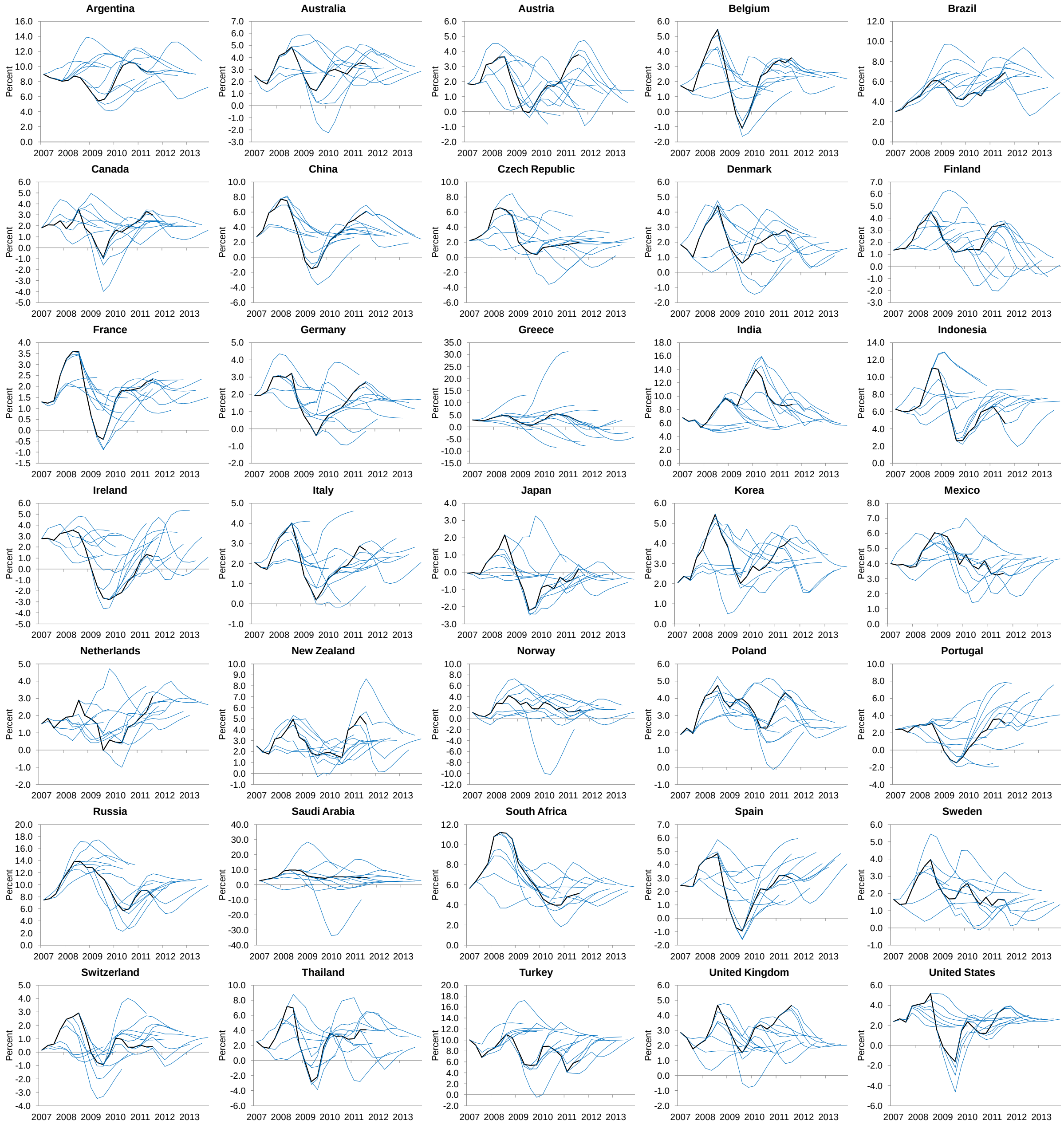
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to fiscal expenditure shocks in systemic economies which reduce their ratio of the fiscal balance to nominal output by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 33. Peak Impulse Responses to Foreign Fiscal Revenue Shocks



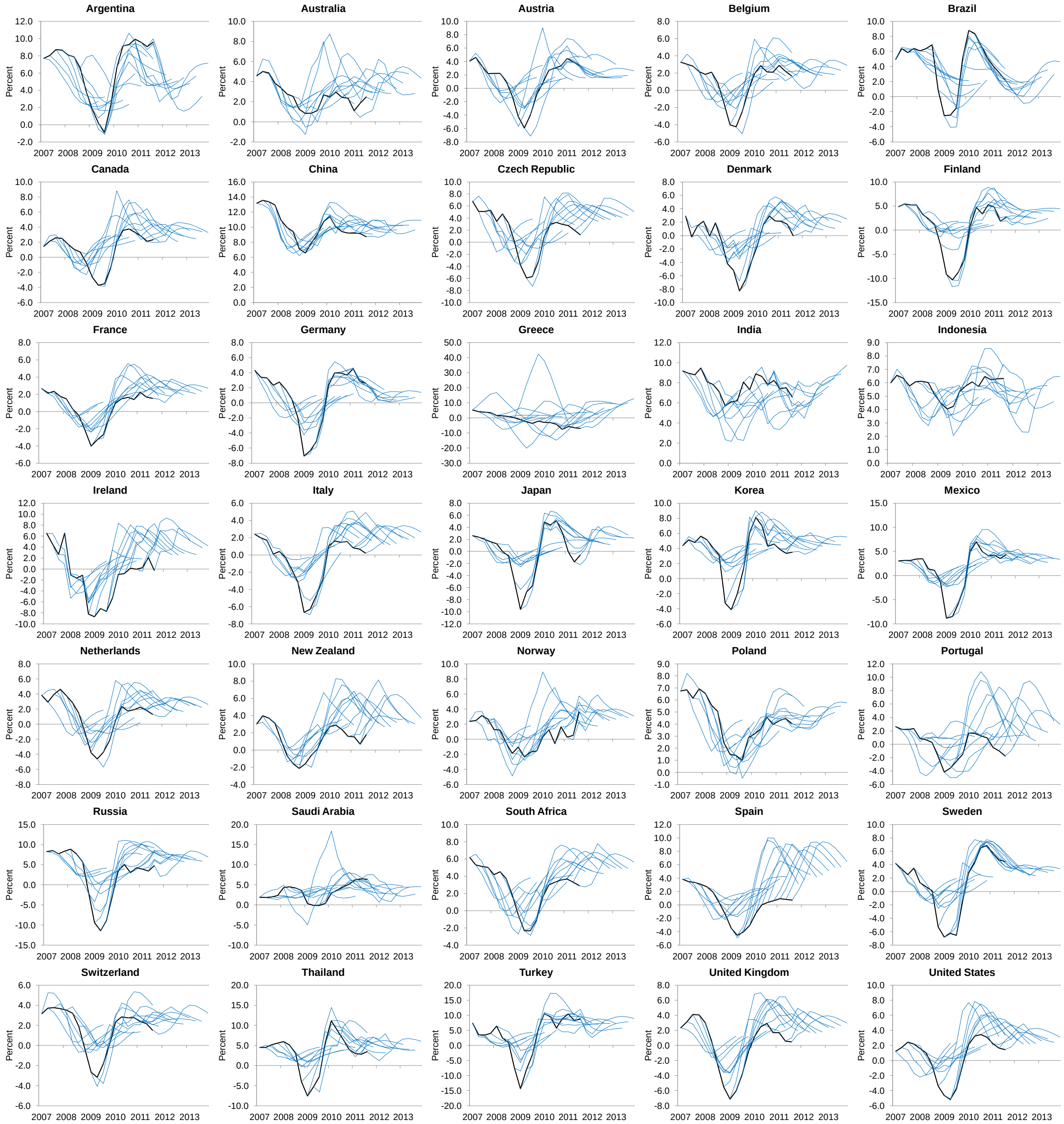
Note: Depicts the peak impulse responses of consumption price inflation ■, output ■, the real effective exchange rate ■, the ratio of the fiscal balance to nominal output ■, and the ratio of the current account balance to nominal output ■ to fiscal revenue shocks in systemic economies which raise their ratio of the fiscal balance to nominal output by one percentage point. Consumption price inflation and the nominal policy interest rate are expressed as annual percentage rates.

Figure 34. Sequential Unconditional Forecasts of Consumption Price Inflation



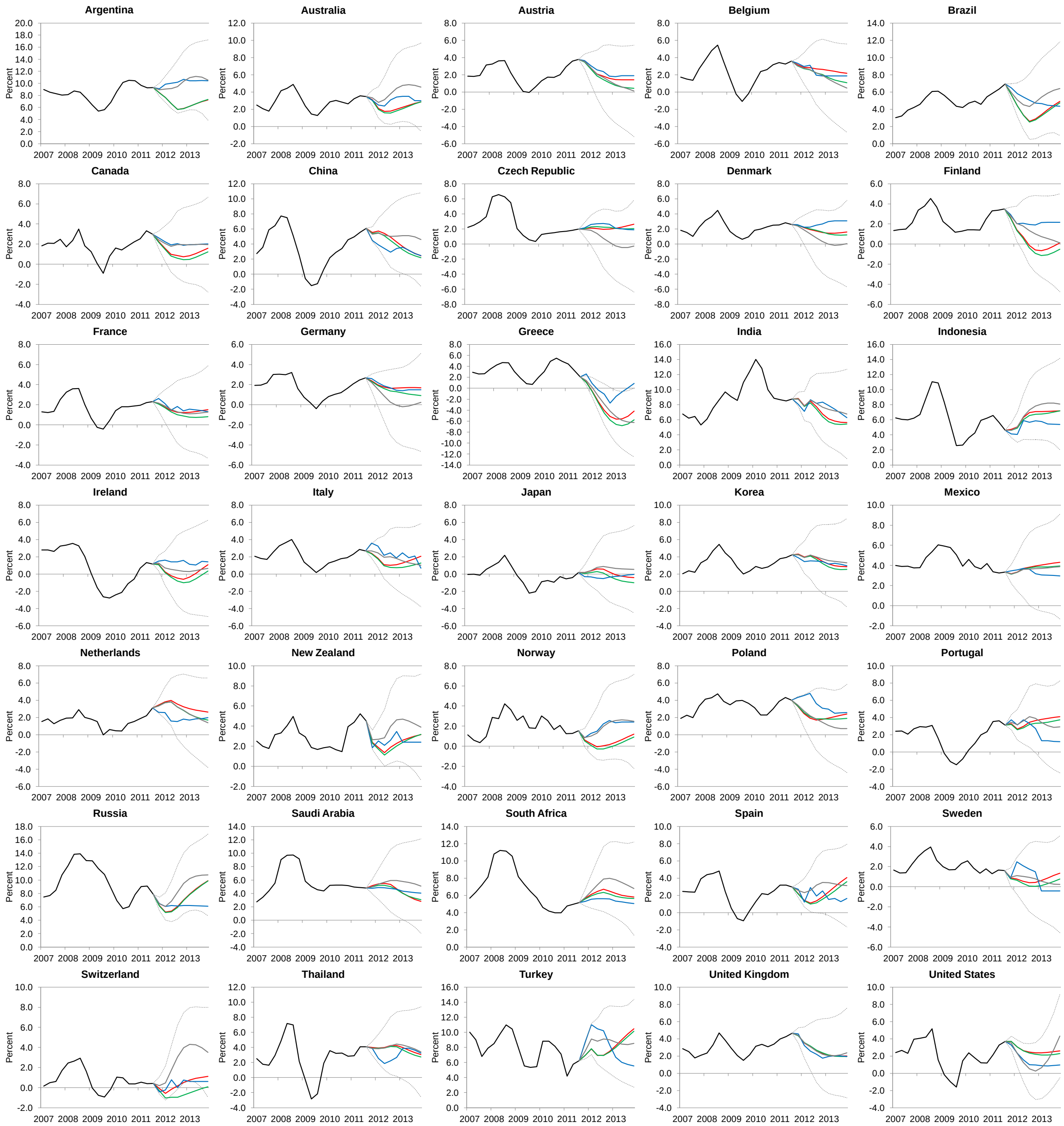
Note: Depicts observed consumption price inflation ■ as measured by the seasonal logarithmic difference of the consumption price level versus sequential unrestricted forecasts ■.

Figure 35. Sequential Unconditional Forecasts of Output Growth



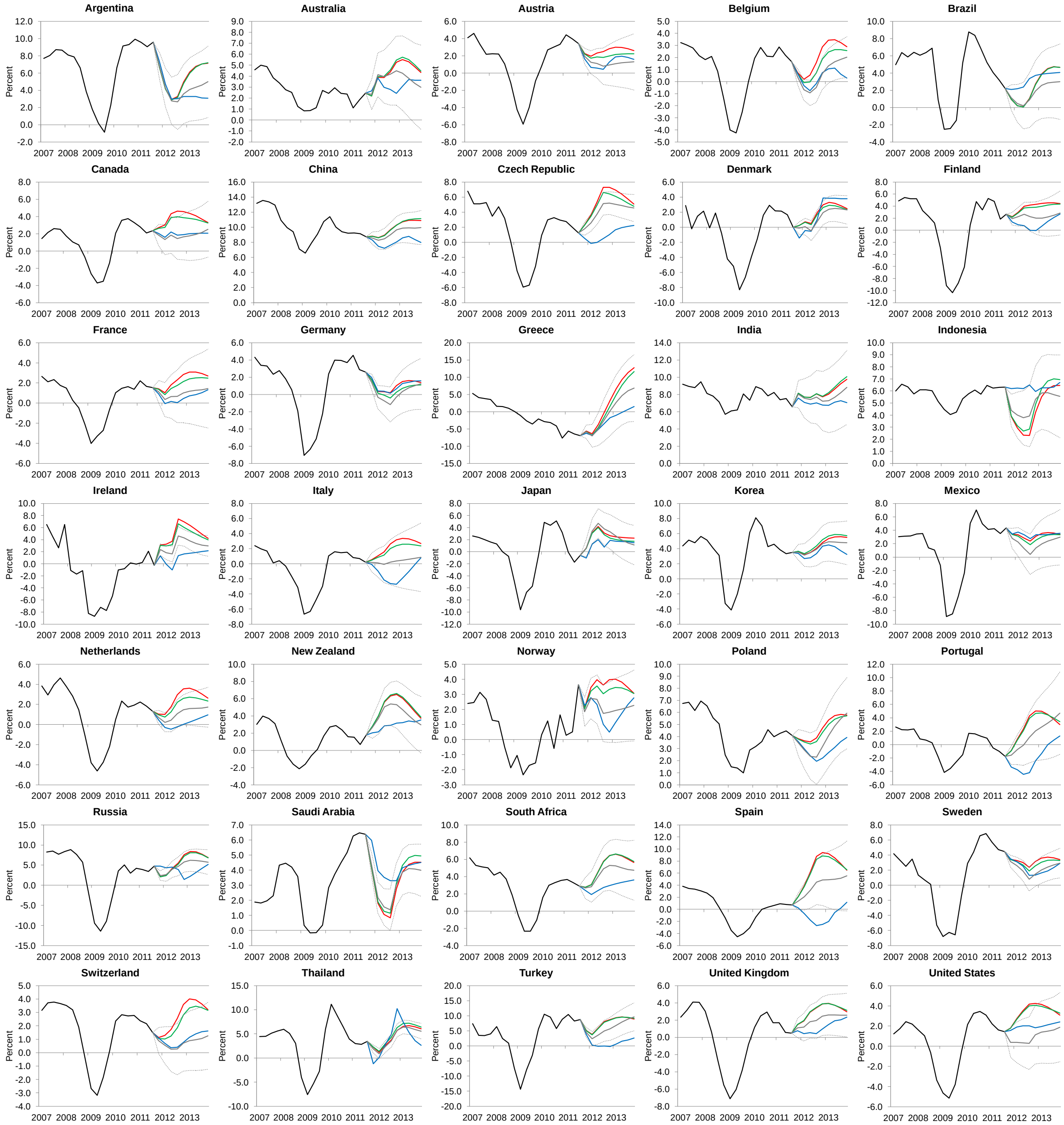
Note: Depicts observed output growth ■ as measured by the seasonal logarithmic difference of the level of output versus sequential unrestricted forecasts ■.

Figure 36. Conditional Forecasts of Consumption Price Inflation



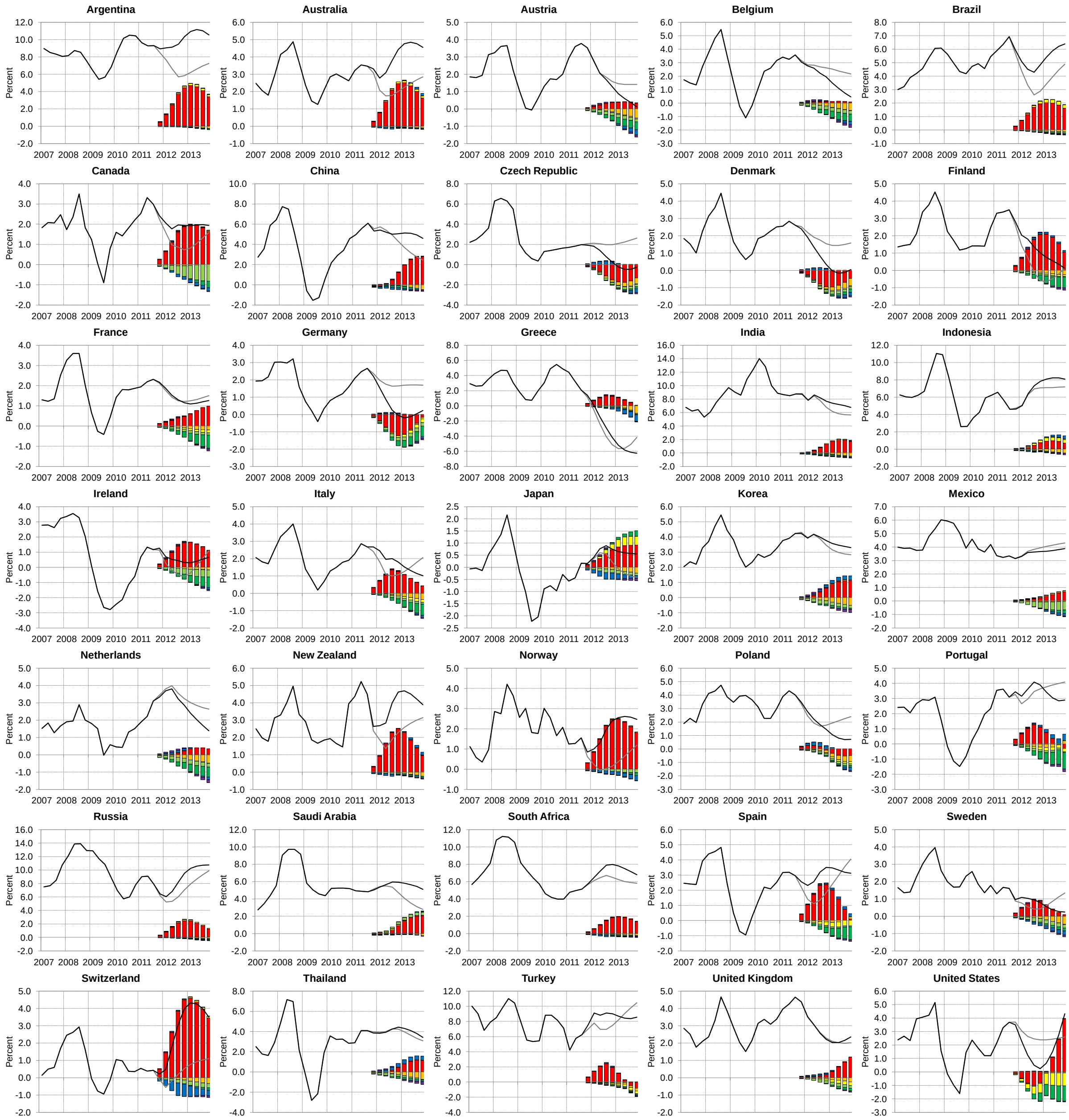
Note: Depicts observed consumption price inflation ■ as measured by the seasonal logarithmic difference of the consumption price level together with unrestricted forecasts ■, restricted forecasts ■, judgmental forecasts ■, and combined forecasts ■. Symmetric 90 percent confidence intervals represented by dashed lines assume normally distributed innovations and known parameters.

Figure 37. Conditional Forecasts of Output Growth



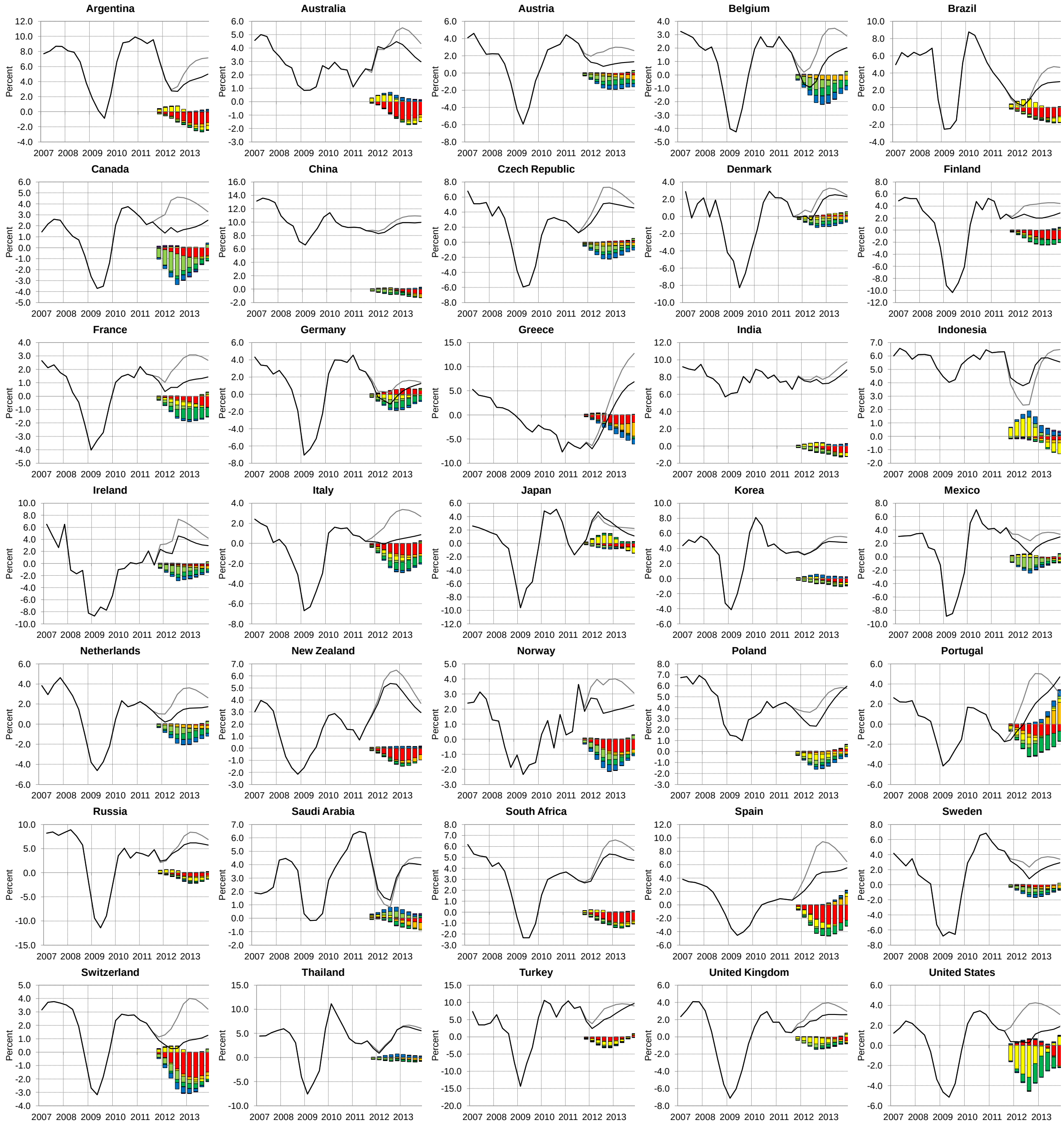
Note: Depicts observed output growth ■ as measured by the seasonal logarithmic difference of the level of output together with unrestricted forecasts ■, restricted forecasts ■, judgmental forecasts ■, and combined forecasts ■. Symmetric 90 percent confidence intervals represented by dashed lines assume normally distributed innovations and known parameters.

Figure 38. Conditional Forecast Decompositions for Consumption Price Inflation



Note: Decomposes the difference between combined forecasts ■ and unrestricted forecasts ■ of consumption price inflation into the sum of a trend component ■ and contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

Figure 39. Conditional Forecast Decompositions for Output Growth



Note: Decomposes the difference between combined forecasts ■ and unrestricted forecasts ■ of output growth into the sum of a trend component ■ and contributions from domestic supply ■, foreign supply ■, domestic demand ■, foreign demand ■, world monetary policy ■, world fiscal policy ■, world risk premium ■, and world terms of trade ■ shocks.

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