DISCUSSION PAPER SERIES

No. 8497

SPILLOVERS FROM THE EURO AREA SOVEREIGN DEBT CRISIS: A MACROECONOMETRIC MODEL BASED ANALYSIS

Francis Vitek and Tamim Bayoumi

INTERNATIONAL MACROECONOMICS

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP8497.asp**

ISSN 0265-8003

SPILLOVERS FROM THE EURO AREA SOVEREIGN DEBT CRISIS: A MACROECONOMETRIC MODEL BASED ANALYSIS

Francis Vitek, IMF
Tamim Bayoumi, IMF and CEPR

Discussion Paper No. 8497
July 2011

Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 8497

July 2011

ABSTRACT

Spillovers from the Euro Area Sovereign Debt Crisis: A Macroeconometric Model Based Analysis*

This paper analyzes past and possible future spillovers from the Euro Area Sovereign Debt Crisis, both within the Euro Area and to the rest of the world. This analysis is based on a structural macroeconometric model of the world economy, disaggregated into fifteen national economies. We find that macroeconomic and financial market spillovers have been small outside of countries with high trade or financial exposures, but that they could become large if severe financial stress were to spread beyond Greece, Ireland and Portugal.

JEL Classification: E44 and F41
Keywords: contagion, euro area sovereign debt crisis, panel unobserved components model and spillovers

Francis Vitek
International Monetary Fund
700 19th Street NW;
Washington, DC,
USA; 20431

Email: fvitek@imf.org

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=172596

Tamim Bayoumi
International Monetary Fund
700 19th Street, NW
Washington DC-20431
USA
Email: tbayoumi@imf.org

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=116357

Submitted 20 July 2011

Spillovers from the Euro Area Sovereign Debt Crisis: A Macroeconometric Model Based Analysis

Francis Vitek and Tamim Bayoumi

Abstract

This paper analyzes past and possible future spillovers from the Euro Area Sovereign Debt Crisis, both within the Euro Area and to the rest of the world. This analysis is based on a structural macroeconometric model of the world economy, disaggregated into fifteen national economies. We find that macroeconomic and financial market spillovers have been small outside of countries with high trade or financial exposures, but that they could become large if severe financial stress were to spread beyond Greece, Ireland and Portugal.

JEL Classification: E44; F41

Keywords: Spillovers; Euro Area Sovereign Debt Crisis; Contagion; Panel unobserved components model

1. Introduction

Severe financial stress has recently afflicted several countries in the periphery of the Euro Area, at times threatening to spread to its core and beyond. Beginning in late 2009, market concerns over fiscal sustainability in Greece manifested through a substantial widening of its sovereign bond spreads, eventually necessitating international financial assistance. In spite of undertaking aggressive fiscal consolidation and receiving unprecedented liquidity support, severe financial stress soon spread to other vulnerable countries in the Euro Area periphery. By late 2010, interrelated market concerns over banking sector losses and fiscal sustainability in Ireland and Portugal had also manifested through a substantial widening of their sovereign bond spreads, eventually necessitating the provision of international financial assistance to both countries.

This Euro Area Sovereign Debt Crisis could intensify and spread further, in spite of a variety of fiscal and financial policy measures taken to contain it. This risk stems primarily from highly interconnected banking sectors and sovereigns within the Euro Area, combined with vulnerable segments in many of these banking sectors, including to potential sovereign debt defaults. Both direct financial transmission via cross border balance sheet exposures, and indirect financial transmission via international bond and stock market contagion, could be triggered

---

Disclaimer: The views expressed herein are those of the authors and should not be attributed to the International Monetary Fund, its Executive Board, or its management.

First Draft: July 11, 2011; *This Draft:* July 11, 2011

Affiliation: International Monetary Fund; 700 19th Street NW; Washington, DC, USA; 20431

Email Address: fvitek@imf.org; tbayoumi@imf.org

by a variety of events. Given the large economic size of the Euro Area, together with its high trade and financial openness, an intensification of the Euro Area Sovereign Debt Crisis could disrupt the global recovery.

While the Euro Area Sovereign Debt Crisis is still unfolding, there exists a rapidly expanding empirical literature analyzing it, which to date has focused on explaining recent bond and credit default swap market developments within the Euro Area. For example, in an investigation of these bond market developments, Arghyrou and Kontonikas (2011) find that the divergence of sovereign bond spreads reflects heightened idiosyncratic sensitivities to a common risk premium and macroeconomic fundamentals, augmented by contagion effects. In particular, Gerlach, Schulz and Wolff (2010) estimate that when this common risk premium rises, countries with large banking sectors having low capital ratios experience greater widening of their sovereign bond spreads. In an investigation of credit default swap market developments, Alter and Schüler (2011) document close interdependencies between credit default swap spreads across banks and sovereigns, with causality running from banks to sovereigns prior to government interventions, and in both directions afterwards.

This paper analyzes past and possible future spillovers from the Euro Area Sovereign Debt Crisis, both within the Euro Area and to the rest of the world. It contributes to the existing empirical literature on the Euro Area Sovereign Debt Crisis by jointly analyzing its global macroeconomic and financial market effects, while accounting for both trade and financial transmission channels, with an emphasis on contagion effects. This analysis is based on a structural macroeconometric model of the world economy, disaggregated into fifteen national economies. This panel unobserved components model features extensive linkages between the real and financial sectors, both within and across economies. The major advanced and emerging economies under consideration are Brazil, Canada, China, France, Germany, Greece, India, Ireland, Italy, Japan, Portugal, Russia, Spain, the United Kingdom, and the United States. We estimate past spillovers from the Euro Area Sovereign Debt Crisis with historical decompositions, which measure the contributions of a variety of real and financial shocks in afflicted countries to the realizations of a variety of macroeconomic and financial market variables in the rest of the world. We then simulate possible future spillovers from an intensification of the Euro Area Sovereign Debt Crisis under alternative scenarios concerning the extent to which it spreads, with and without accounting for monetary policy responses.

We find that macroeconomic spillovers from the Euro Area Sovereign Debt Crisis, identified by the contributions of real and financial shocks in Greece, Ireland and Portugal to recent output market developments in the rest of the world, have been negative but small outside of countries with high trade or financial exposures. In parallel, we estimate that financial market spillovers, identified by the contributions of these shocks to recent bond and stock market developments in the rest of the world, have been benign. However, consistent with IMF (2011a), based on scenarios featuring alternative degrees of international financial market contagion, we find that the Euro Area Sovereign Debt Crisis could generate large macroeconomic and financial market spillovers were it to spread to Spain, and in particular to Italy. The limited scope for monetary policy responses to mitigate these simulated spillovers, and the very large simulated output losses in afflicted countries associated with them, calls for decisive fiscal and financial policy measures to reduce the probabilities associated with these tail risk scenarios.

The organization of this paper is as follows. The next section describes a structural macroeconometric model of the world economy. Estimation of this model is the subject of section three. An analysis of past and possible future spillovers from the Euro Area Sovereign Debt Crisis is conducted within the framework of the estimated model in section four. Finally, section five offers conclusions and policy recommendations.

2. The Panel Unobserved Components Model

Our panel unobserved components model of the world economy consists of multiple large open economies connected by trade and financial linkages. Within each economy, cyclical components are modeled as a multivariate linear rational expectations model of the monetary transmission mechanism derived from postulated behavioral relationships. 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.

The monetary transmission mechanism in each economy operates via interest rate and exchange rate channels, both of which link a short term nominal interest rate, which serves as the instrument of monetary policy, to consumption price inflation and the output gap, which are generally target variables. Under the interest rate channel, monetary policy affects the output gap and by implication inflation by inducing intertemporal substitution in domestic demand in response to changes in a long term real interest rate. Under the exchange rate channel, monetary policy both directly affects inflation, and indirectly affects the output gap and by implication inflation via intratemporal substitution between domestic and foreign demand, by inducing changes in a real effective exchange rate. A financial accelerator mechanism linked to the real value of an internationally diversified equity portfolio amplifies and propagates both of these channels.

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 $Z = S$. Finally, 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 $Z = Y$.

2.1. 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,

$$\hat{\pi}_{i,t}^Y = \phi_{1,1}\hat{\pi}_{i,t-1}^Y + \phi_{1,2}\,\mathrm{E}_t\,\hat{\pi}_{i,t+1}^Y + \theta_{1,1}\ln\hat{Y}_{i,t} + \theta_{1,2}\sum_z \frac{Y_i^{COM^z}}{Y_i}\phi_1(L)\Delta\ln\frac{\hat{S}_{i,t}^{USA}\hat{P}_t^{COM^z}}{\hat{P}_{i,t}^Y} + \varepsilon_{i,t}^{\hat{P}^Y}, \tag{1}$$

where domestic supply shock $\varepsilon_{i,t}^{\hat{P}^Y} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{P}^Y,i}^2)$. 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 commodities, 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 commodity production intensity, measured by the ratio of commodity production to output $\frac{Y_i^{COM}}{Y_i}$.

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,

$$\begin{aligned}\hat{\pi}_{i,t}^C &= \phi_{1,1} \hat{\pi}_{i,t-1}^C + \phi_{1,2} \, \mathrm{E}_t \, \hat{\pi}_{i,t+1}^C + \theta_{1,1} \ln \hat{Y}_{i,t} \\ &\quad + \theta_{2,1} \frac{M_i}{Y_i} \left[\left(1 - \frac{M_i^{COM}}{M_i} \right) \phi_1(L) \Delta \ln \hat{Q}_{i,t}^M + \theta_{2,2} \sum_z \frac{M_i^{COM^z}}{M_i} \phi_1(L) \Delta \ln \frac{\hat{S}_{i,t}^{USA} \hat{P}_{i,t}^{COM^z}}{\hat{P}_{i,t}^Y} \right] + \varepsilon_{i,t}^{\hat{P}^Y} + \phi_1(L) \varepsilon_{i,t}^{\hat{P}^M},\end{aligned} \tag{2}$$

where foreign supply shock $\varepsilon_{i,t}^{\hat{P}^M} \sim \text{iid } \mathcal{N}(0, \sigma_{\hat{P}^M,i}^2)$. The cyclical component of consumption price inflation also depends on contemporaneous, past, and expected future changes in the cyclical components of the import weighted real effective exchange rate 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 output $\frac{M_i}{Y_i}$, as well as their commodity import intensity, measured by the ratio of commodity imports to imports $\frac{M_i^{COM}}{M_i}$.

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,

$$\begin{aligned}\ln \hat{Y}_{i,t} &= \phi_{3,1} \ln \hat{Y}_{i,t-1} + \theta_{3,1} \left(1 - \theta_{4,1} \frac{M_i}{Y_i} \right) \left(\hat{r}_{i,t}^{L,C} + \theta_{3,2} \ln \frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^C} \right) \\ &\quad + \theta_{4,1} \frac{X_i}{Y_i} \phi_3(L) \ln \hat{D}_{i,t}^X + \theta_{4,2} \phi_3(L) \left(\frac{X_i}{Y_i} \ln \hat{Q}_{i,t}^{T,X} - \frac{M_i}{Y_i} \ln \hat{Q}_{i,t}^T \right) + \left(1 - \theta_{4,1} \frac{M_i}{Y_i} \right) \nu_{i,t}^{\hat{D}} + \frac{X_i}{Y_i} \phi_3(L) \nu_{i,t}^{\hat{X}},\end{aligned} \tag{3}$$

where foreign demand shock $\nu_{i,t}^{\hat{X}} = \rho_{\hat{X}} \nu_{i,t-1}^{\hat{X}} + \varepsilon_{i,t}^{\hat{X}}$ with $\varepsilon_{i,t}^{\hat{X}} \sim \text{iid } \mathcal{N}(0, \sigma_{\hat{X},i}^2)$. 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 trade weighted real effective exchange rate.[1] The cyclical component of output also 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,

$$\ln \hat{D}_{i,t} = \phi_{3,1} \ln \hat{D}_{i,t-1} + \theta_{3,1} \left(\hat{r}_{i,t}^{L,C} + \theta_{3,2} \ln \frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^C} \right) + \nu_{i,t}^{\hat{D}}, \tag{4}$$

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

[1] This monetary conditions index $\hat{I}_{i,t}^{MCI}$ is defined as $\hat{I}_{i,t}^{MCI} = \hat{I}_{i,t}^{FCI} + \frac{\theta_{4,2}}{\theta_{3,1}} \left(1 - \theta_{4,1} \frac{M_i}{Y_i} \right)^{-1} \phi_3(L) \left(\frac{X_i}{Y_i} \ln \hat{Q}_{i,t}^{T,X} - \frac{M_i}{Y_i} \ln \hat{Q}_{i,t}^T \right)$, where financial conditions index $\hat{I}_{i,t}^{FCI}$ satisfies $\hat{I}_{i,t}^{FCI} = \hat{r}_{i,t}^{L,C} + \theta_{3,2} \ln \frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^C}$.

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,

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

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 $\hat{r}_{i,t}^{P,Z} = \hat{i}_{i,t}^{P} - \text{E}_{t}\,\hat{\pi}_{i,t+1}^{Z}$, 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 real value of an internationally diversified equity portfolio according to money market relationship,

$$\hat{i}_{i,t}^{S} - \hat{i}_{i,t}^{P} = \phi_{6,1}(\hat{i}_{i,t-1}^{S} - \hat{i}_{i,t-1}^{P}) + \theta_{6,1}\ln\frac{\hat{P}_{i,t}^{STK,S}}{\hat{P}_{i,t}^{C}} + \lambda_{6,j}\varepsilon_{t}^{\hat{i}^{S},M} + (1-\lambda_{6,j}w_{i}^{M})\varepsilon_{i,t}^{\hat{i}^{S}}, \tag{6}$$

where credit risk premium shock $\varepsilon_{i,t}^{\hat{i}^{S}} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{i}^{S},i}^{2})$. The intensity of international money market contagion varies across economies, with $j=1$ for advanced economies and $j=0$ for emerging economies. The cyclical component of the short term real market interest rate $\hat{r}_{i,t}^{S,Z}$ satisfies $\hat{r}_{i,t}^{S,Z} = \hat{i}_{i,t}^{S} - \text{E}_{t}\,\hat{\pi}_{i,t+1}^{Z}$.

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,

$$\hat{i}_{i,t}^{L} = \phi_{7,1}\hat{i}_{i,t-1}^{L} + \phi_{7,2}\,\text{E}_{t}\,\hat{i}_{i,t+1}^{L} + \theta_{7,1}\hat{i}_{i,t}^{S} + \lambda_{7,j}\varepsilon_{t}^{\hat{i}^{L},B} + (1-\lambda_{7,j}w_{i}^{B})\varepsilon_{i,t}^{\hat{i}^{L}}, \tag{7}$$

where duration risk premium shock $\varepsilon_{i,t}^{\hat{i}^{L}} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{i}^{L},i}^{2})$. The intensity of international bond market contagion varies across economies, with $j=1$ for advanced economies and $j=0$ for emerging economies. The cyclical component of the long term real market interest rate $\hat{r}_{i,t}^{L,Z}$ satisfies the same term structure 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 contemporaneous cyclical components of output and the short term output based real market interest rate according to stock market relationship,

$$\ln\frac{\hat{P}_{i,t}^{STK}}{\hat{P}_{i,t}^{Y}} = \phi_{8,1}\ln\frac{\hat{P}_{i,t-1}^{STK}}{\hat{P}_{i,t-1}^{Y}} + \phi_{8,2}\,\text{E}_{t}\ln\frac{\hat{P}_{i,t+1}^{STK}}{\hat{P}_{i,t+1}^{Y}} + \theta_{8,1}\ln\hat{Y}_{i,t} + \theta_{8,2}\hat{r}_{i,t}^{S,Y} + \lambda_{8,j}\varepsilon_{t}^{\hat{P}^{STK},S} + (1-\lambda_{8,j}w_{i}^{S})\varepsilon_{i,t}^{\hat{P}^{STK}}, \tag{8}$$

where equity risk premium shock $\varepsilon_{i,t}^{\hat{P}^{STK}} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{P}^{STK},i}^{2})$. The intensity of international stock market contagion varies across economies, with $j=1$ for advanced economies and $j=0$ for emerging economies.

The cyclical component of the real bilateral exchange rate $\ln\hat{Q}_{i,t}^{USA}$ 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,

$$\ln\hat{Q}_{i,t}^{USA} = \phi_{9,1}\ln\hat{Q}_{i,t-1}^{USA} + \phi_{9,2}\,\text{E}_{t}\ln\hat{Q}_{i,t+1}^{USA} + \theta_{9,1,j}(\hat{r}_{i,t}^{S,Y} - \hat{r}_{USA,t}^{S,Y}) + \varepsilon_{i,t}^{\hat{S}}, \tag{9}$$

where exchange rate risk premium shock $\varepsilon_{i,t}^{\hat{S}} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{S},i}^2)$. 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. The cyclical component of the nominal bilateral exchange rate $\ln\hat{S}_{i,t}^{USA}$ satisfies $\ln\hat{Q}_{i,t}^{USA} = \ln\hat{S}_{i,t}^{USA} + \ln\hat{P}_{USA,t}^{Y} - \ln\hat{P}_{i,t}^{Y}$.[2]

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,

$$\ln\frac{\hat{P}_t^{COM^z}}{\hat{P}_{USA,t}^{Y}} = \phi_{10,1}\ln\frac{\hat{P}_{t-1}^{COM^z}}{\hat{P}_{USA,t-1}^{Y}} + \phi_{10,2}\,\mathrm{E}_t\ln\frac{\hat{P}_{t+1}^{COM^z}}{\hat{P}_{USA,t+1}^{Y}} + \theta_{10,1,j}\ln\hat{Y}_t^{Y} + \varepsilon_t^{\hat{P}^{COM^z}}, \tag{10}$$

where commodity price shock $\varepsilon_t^{\hat{P}^{COM^z}} \sim \text{iid } \mathcal{N}(0,\sigma_{\hat{P}^{COM},z}^2)$. The sensitivity of the relative price of commodities to changes in world output depends on its type $z\in\{e,n\}$, 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.

2.2. Trend Components

The growth rates of 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 $\ln\bar{D}_{i,t}$, the price of equity $\ln\bar{P}_{i,t}^{STK}$, and the price of commodities $\ln\bar{P}_t^{COM^z}$ follow random walks:

$$\Delta\ln\bar{P}_{i,t}^{Y} = \Delta\ln\bar{P}_{i,t-1}^{Y} + \varepsilon_{i,t}^{\bar{P}^Y},\ \varepsilon_{i,t}^{\bar{P}^Y} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{P}^Y,i}^2), \tag{11}$$

$$\Delta\ln\bar{P}_{i,t}^{C} = \Delta\ln\bar{P}_{i,t-1}^{C} + \varepsilon_{i,t}^{\bar{P}^C},\ \varepsilon_{i,t}^{\bar{P}^C} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{P}^C,i}^2), \tag{12}$$

$$\Delta\ln\bar{Y}_{i,t} = \Delta\ln\bar{Y}_{i,t-1} + \varepsilon_{i,t}^{\bar{Y}},\ \varepsilon_{i,t}^{\bar{Y}} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{Y},i}^2), \tag{13}$$

$$\Delta\ln\bar{D}_{i,t} = \Delta\ln\bar{D}_{i,t-1} + \varepsilon_{i,t}^{\bar{D}},\ \varepsilon_{i,t}^{\bar{D}} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{D},i}^2), \tag{14}$$

$$\Delta\ln\bar{P}_{i,t}^{STK} = \Delta\ln\bar{P}_{i,t-1}^{STK} + \varepsilon_{i,t}^{\bar{P}^{STK}},\ \varepsilon_{i,t}^{\bar{P}^{STK}} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{P}^{STK},i}^2), \tag{15}$$

$$\Delta\ln\bar{P}_{t}^{COM^z} = \Delta\ln\bar{P}_{t-1}^{COM^z} + \varepsilon_{t}^{\bar{P}^{COM^z}},\ \varepsilon_{t}^{\bar{P}^{COM^z}} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{P}^{COM},z}^2). \tag{16}$$

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

$$\bar{i}_{i,t}^{P} = \bar{i}_{i,t-1}^{P} + \varepsilon_{i,t}^{\bar{i}^P},\ \varepsilon_{i,t}^{\bar{i}^P} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{i}^P,i}^2), \tag{17}$$

$$\bar{i}_{i,t}^{S} = \bar{i}_{i,t-1}^{S} + \varepsilon_{i,t}^{\bar{i}^S},\ \varepsilon_{i,t}^{\bar{i}^S} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{i}^S,i}^2), \tag{18}$$

$$\bar{i}_{i,t}^{L} = \bar{i}_{i,t-1}^{L} + \varepsilon_{i,t}^{\bar{i}^L},\ \varepsilon_{i,t}^{\bar{i}^L} \sim \text{iid } \mathcal{N}(0,\sigma_{\bar{i}^L,i}^2), \tag{19}$$

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

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

The trend component of the real policy interest rate $\bar{r}_{i,t}^{P,Z}$ satisfies $\bar{r}_{i,t}^{P,Z} = \bar{i}_{i,t}^{P} - \mathrm{E}_t\, \bar{\pi}_{i,t+1}^{Z}$, the trend component of the short term real market interest rate $\bar{r}_{i,t}^{S,Z}$ satisfies $\bar{r}_{i,t}^{S,Z} = \bar{i}_{i,t}^{S} - \mathrm{E}_t\, \bar{\pi}_{i,t+1}^{Z}$, and the trend component of the long term real market interest rate $\bar{r}_{i,t}^{L,Z}$ satisfies $\bar{r}_{i,t}^{L,Z} = \bar{i}_{i,t}^{L} - \mathrm{E}_t\, \bar{\pi}_{i,t+1}^{Z}$. Finally, the trend component of the real bilateral exchange rate $\ln \bar{Q}_{i,t}^{USA}$ satisfies $\ln \bar{Q}_{i,t}^{USA} = \ln \bar{S}_{i,t}^{USA} + \ln \bar{P}_{USA,t}^{Y} - \ln \bar{P}_{i,t}^{Y}$. As an identifying restriction, all innovations are assumed to be independent.

3. 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.

Joint estimation of the parameters and unobserved components of our panel unobserved components model is based on the levels of a total of one hundred twenty four endogenous variables observed for fifteen economies over the sample period 1999Q1 through 2011Q1. The economies under consideration are Brazil, Canada, China, France, Germany, Greece, India, Ireland, Italy, Japan, Portugal, Russia, Spain, 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, and the prices of energy and nonenergy commodities. For a detailed description of this data set, please refer to Appendix A.

3.1. Estimation Procedure

The parameters and unobserved components of our panel unobserved components model are jointly estimated with a Bayesian procedure, conditional on prior information concerning the values of structural parameters, and judgment concerning the paths of trend components. Inference on the parameters is based on an asymptotic normal approximation to the posterior distribution around its mode, which is calculated by numerically maximizing the logarithm of the posterior density kernel. Following Engle and Watson (1981), we employ an estimator of the Hessian which depends only on first derivatives and is negative semidefinite.

Evaluation of the logarithm of the posterior density kernel involves first solving for the unique stationary solution to the multivariate linear rational expectations model governing the evolution of cyclical components with the algorithm due to Klein (2000). The resultant first order vector autoregressive model is then combined with a dynamic factor model governing the evolution of trend components to form a linear state space model expressing the levels of all observed nonpredetermined endogenous variables as a function of an unobserved state vector, which in turn evolves according to a first order vector autoregressive process. This linear state space model is then augmented with a set of stochastic restrictions on selected unobserved state variables summarizing judgment concerning the paths of the trend components of all observed nonpredetermined endogenous variables. The logarithm of the predictive density function is then evaluated, conditional on the parameters associated with this linear state space model, with the filter presented in Vitek (2009), which adapts the filter due to Kalman (1960) to incorporate judgment. Finally, the logarithm of this conditional density function is combined with the logarithm of a multivariate normal density function summarizing prior information concerning the values of parameters. For a detailed discussion of this estimation procedure, please refer to Vitek (2009).

3.2. Estimation Results

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 China, India and Russia, where it is represented by a managed exchange rate regime supported by capital controls. 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. 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 due to 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. Parameter estimation results pertaining to the sample period 1999Q3 through 2011Q1 are reported in Table 7 of Appendix B. The sufficient condition for the existence of a unique stationary rational expectations equilibrium due to 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. 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.

4. Spillover Analysis

We analyze past and possible future spillovers from the Euro Area Sovereign Debt Crisis, both within the Euro Area and to the rest of the world. This analysis is based on our estimated structural macroeconometric model of the world economy. Within this framework, spillovers may be transmitted via both trade and financial channels. Direct financial transmission may occur via cross border bond and stock market exposures, while indirect financial transmission is permitted via international bond and stock market contagion.

4.1. Historical Decompositions

We estimate past spillovers from the Euro Area Sovereign Debt Crisis with historical decompositions, which measure the contributions of a variety of real and financial shocks in afflicted countries to the realizations of a variety of macroeconomic and financial market variables in the rest of the world. The afflicted countries under consideration are those which have received international financial assistance, namely Greece, Ireland and Portugal. The sample subperiod under consideration is 2009Q4 through 2011Q1, during which a substantial widening of the sovereign bond spreads of these countries occurred. The macroeconomic variables under consideration are consumption price inflation and output growth, while the financial market variables under consideration are the short term nominal market interest rate, the long term nominal market interest rate, and the nominal return on equity. The real shocks under consideration are domestic demand shocks, while the financial shocks under consideration are credit risk premium shocks, duration risk premium shocks, and equity risk premium shocks. Estimated historical decompositions of the macroeconomic and financial market variables under consideration are plotted in Figure 1 through Figure 5 of Appendix B. Estimated cumulative output effects arising from real and financial shocks in afflicted countries over the sample subperiod under consideration are reported in Table 1, while estimated cumulative long term nominal market interest rate effects are reported in Table 2, and estimated cumulative equity price effects are reported in Table 3.

We find that macroeconomic spillovers from the Euro Area Sovereign Debt Crisis, identified by the contributions of real and financial shocks in Greece, Ireland and Portugal to recent output market developments in the rest of the world, have been negative but small outside of countries with high trade or financial exposures. To elaborate, we estimate cumulative output losses of 0.0 to 0.7 percent for other European Union member countries over the sample subperiod under consideration, and of 0.0 to 0.2 percent outside of the European Union. These macroeconomic spillovers have been primarily generated by financial shocks, particularly within the Euro Area. To put them into perspective, note that we estimate a cumulative output loss of 8.4 percent for Greece, of 3.6 percent for Ireland, and of 2.7 percent for Portugal. The pattern of macroeconomic spillovers closely reflects trade and financial integration with these countries. In particular, we estimate a cumulative output loss for Spain of 0.2 percent, of which 0.3 percent is accounted for by Portugal, with contributions of 0.1 percent from real shocks and 0.2 percent from financial shocks. Furthermore, we estimate a cumulative output loss for the United Kingdom of 0.7 percent, of which 0.6 percent is accounted for by Ireland, with contributions of 0.5 percent from real shocks and 0.1 percent from financial shocks. Finally, we estimate a cumulative output loss for Russia of 0.2 percent, of which 0.1 percent is accounted for by Greece, with contributions of 0.0 percent from real shocks and 0.1 percent from financial shocks.

We find that financial market spillovers from the Euro Area Sovereign Debt Crisis, identified by the contributions of real and financial shocks in Greece, Ireland and Portugal to recent bond and stock market developments in the rest of the world, have been benign. In particular, we estimate cumulative long term nominal market interest rate declines of 28 to 67 basis points for other European Union member countries over the sample subperiod under consideration, together with cumulative equity price increases of 0.0 to 0.8 percent for other Euro Area member countries, indicative of a flight to quality phenomenon. In contrast, we estimate cumulative long term nominal interest rate increases of 1 to 6 basis points outside of the European Union, together with cumulative equity price declines of 0.2 to 0.6 percent outside of the Euro Area.

Table 1. Estimated cumulative output effects, 2009Q4 through 2011Q1

	Real Shocks			Financial Shocks		
	Greece	Ireland	Portugal	Greece	Ireland	Portugal
Brazil	0.00	0.00	0.00	–0.02	–0.03	–0.02
Canada	0.00	0.00	0.00	–0.02	–0.03	–0.01
China	–0.01	–0.03	0.00	–0.03	–0.04	–0.01
France	–0.01	0.03	0.00	0.02	–0.03	0.01
Germany	–0.03	–0.01	–0.01	–0.01	–0.05	–0.01
Greece	–3.65	–1.32	–0.02	–3.25	–0.16	–0.02
India	–0.01	0.00	0.00	–0.03	–0.03	–0.01
Ireland	–0.01	–3.28	0.00	–0.02	–0.31	–0.01
Italy	–0.05	0.05	0.00	–0.02	–0.08	0.01
Japan	0.00	–0.01	0.00	–0.02	–0.03	–0.01
Portugal	0.01	0.05	–0.97	0.03	–0.03	–1.81
Russia	–0.04	–0.02	–0.01	–0.06	–0.04	–0.03
Spain	–0.01	0.06	–0.09	0.02	–0.01	–0.17
United Kingdom	–0.01	–0.53	–0.01	–0.03	–0.10	–0.02
United States	0.00	–0.03	0.00	–0.02	–0.03	–0.01
World	–0.03	–0.08	–0.01	–0.04	–0.04	–0.02
Advanced Economies	–0.04	–0.08	–0.01	–0.04	–0.04	–0.02
Euro Area Economies	–0.13	–0.09	–0.04	–0.09	–0.05	–0.06
Euro Area Periphery	–0.51	–0.52	–0.17	–0.44	–0.07	–0.31
Euro Area Core	–0.03	0.02	–0.01	–0.01	–0.05	0.00
Other Advanced Economies	0.00	–0.08	0.00	–0.02	–0.04	–0.01
Emerging Economies	–0.01	–0.02	0.00	–0.03	–0.03	–0.01

Note: Cumulative output effects are measured in percent at the annual frequency. Aggregation of cumulative output effects across economies is based on output weights. The Euro Area Periphery consists of Greece, Ireland, Portugal and Spain. The Euro Area Core consists of France, Germany and Italy.

Table 2. Estimated cumulative long term nominal market interest rate effects, 2009Q4 through 2011Q1

	Real Shocks			Financial Shocks		
	Greece	Ireland	Portugal	Greece	Ireland	Portugal
Brazil	0	0	0	2	3	0
Canada	0	1	0	2	2	1
China	0	–3	0	2	3	1
France	–12	–9	–3	–2	0	–3
Germany	–12	–9	–3	–2	0	–3
Greece	–25	–13	–3	445	0	–3
India	0	0	0	2	3	1
Ireland	–12	–10	–3	–2	315	–3
Italy	–12	–9	–3	–2	0	–3
Japan	0	–1	0	2	2	1
Portugal	–12	–9	–6	–2	0	255
Russia	–1	0	–1	1	2	–1
Spain	–12	–9	–3	–2	0	–3
United Kingdom	–1	–65	0	2	–3	0
United States	0	–3	0	2	2	1
World	–3	–7	–1	4	5	1
Advanced Economies	–3	–8	–1	4	5	1
Euro Area Economies	–12	–9	–3	9	16	1
Euro Area Periphery	–13	–10	–3	50	75	15
Euro Area Core	–12	–9	–3	–2	0	–3
Other Advanced Economies	0	–7	0	2	2	0
Emerging Economies	0	–1	0	2	3	0

Note: Cumulative long term nominal market interest rate effects are measured in basis points at the annual frequency. Aggregation of cumulative long term nominal market interest rate effects across economies is based on bond market capitalization weights. The Euro Area Periphery consists of Greece, Ireland, Portugal and Spain. The Euro Area Core consists of France, Germany and Italy.

Table 3. Estimated cumulative equity price effects, 2009Q4 through 2011Q1

	Real Shocks			Financial Shocks		
	Greece	Ireland	Portugal	Greece	Ireland	Portugal
Brazil	0.00	0.02	0.00	–0.15	–0.09	–0.06
Canada	0.01	0.04	0.00	–0.13	–0.07	–0.05
China	0.00	0.04	0.01	–0.16	–0.10	–0.05
France	–0.13	0.44	0.05	0.24	0.02	0.19
Germany	–0.16	0.51	0.03	0.17	–0.02	0.14
Greece	–1.11	–0.90	0.00	–31.72	–0.74	0.11
India	0.01	0.08	0.00	–0.16	–0.08	–0.05
Ireland	–0.02	–17.21	0.04	0.07	–12.30	0.10
Italy	–0.19	0.59	0.06	0.16	–0.12	0.19
Japan	0.00	0.02	0.00	–0.13	–0.08	–0.05
Portugal	–0.12	0.43	–1.56	0.28	0.00	–22.88
Russia	0.00	0.13	0.00	–0.18	–0.07	–0.08
Spain	–0.12	0.40	–0.22	0.22	0.08	–0.35
United Kingdom	0.00	–0.24	0.00	–0.14	–0.22	–0.05
United States	0.00	0.01	0.00	–0.13	–0.08	–0.05
World	–0.02	0.00	0.00	–0.22	–0.13	–0.08
Advanced Economies	–0.03	–0.01	0.00	–0.23	–0.13	–0.08
Euro Area Economies	–0.17	0.04	–0.03	–0.71	–0.30	–0.23
Euro Area Periphery	–0.22	–1.31	–0.24	–3.39	–1.11	–1.43
Euro Area Core	–0.15	0.49	0.04	0.20	–0.02	0.18
Other Advanced Economies	0.00	–0.02	0.00	–0.13	–0.10	–0.05
Emerging Economies	0.00	0.07	0.00	–0.16	–0.09	–0.06

Note: Cumulative equity price effects are measured in percent at the annual frequency. Aggregation of cumulative equity price effects across economies is based on stock market capitalization weights. The Euro Area Periphery consists of Greece, Ireland, Portugal and Spain. The Euro Area Core consists of France, Germany and Italy.

4.2. Scenario Simulations

We simulate possible future spillovers from an intensification of the Euro Area Sovereign Debt Crisis under alternative scenarios concerning the extent to which it spreads, with and without accounting for monetary policy responses worldwide. Under our first scenario, severe financial stress afflicts but remains contained in Greece, Ireland and Portugal, worsening their current situation. This financial stress manifests through heightened risk premia in the money, bond, stock, and foreign exchange markets. It is accompanied by disruptions to the output market associated with confidence effects and fiscal consolidation reactions. Under our second scenario, severe financial stress spreads to Spain, while under our third scenario it also spreads to Italy. These scenarios are driven by unanticipated real and financial shocks all following persistent first order autoregressive processes having coefficients of 0.75. Simulated impulse responses of a variety of macroeconomic and financial market variables under these scenarios are plotted in Figure 6 through Figure 11 of Appendix B. Simulated peak output effects are reported in Table 4, while simulated peak long term nominal market interest rate effects are reported in Table 5, and simulated peak equity price effects are reported in Table 6.

Our first scenario features a sudden loss of confidence in sovereign debt sustainability in Greece, Ireland and Portugal represented by positive duration risk premium shocks which in isolation would increase their long term nominal market interest rates by 450 basis points on impact. Reflecting their highly interconnected banking sectors and sovereigns, heightened risk aversion also afflicts the money markets of these countries, represented by positive credit risk premium shocks which in isolation would raise their short term nominal market interest rates by 150 basis points on impact, as well as their stock markets, represented by positive equity risk premium shocks which in isolation would reduce their equity prices by 45 percent on impact. Furthermore, loss of confidence by households and firms causes them to postpone their consumption and investment expenditures, decreasing domestic demand by 1 percent, while fiscal consolidation reactions by governments reduce it by a further 2 percent. Reflecting the exceptional degree of international financial integration within the Euro Area, we subject its remaining member countries to parallel real and financial shocks which in isolation would increase their long term nominal market interest rates by 50 basis points, raise their short term nominal market interest rates by 16⅔ basis points, reduce their equity prices by 5 percent, and reduce their domestic demand by ⅓ percent. Finally, there is a run on the euro, represented by an exchange rate risk premium shock which in isolation would depreciate it by 2½ percent in nominal effective terms on impact. Accounting for monetary policy responses, this contained sovereign debt crisis is estimated to generate peak output losses of 0.8 to 6.0 percent within the Euro Area, and of 0.2 to 0.7 percent outside of the Euro Area. Abstracting from monetary policy responses raises these estimated peak output losses to 1.0 to 6.2 percent within the Euro Area, and to 0.3 to 0.9 percent outside of the Euro Area. In parallel, with monetary policy stabilization estimated peak long term nominal market interest rate increases range from −30 to 20 basis points outside of the Euro Area, while estimated peak equity price reductions range from 1.9 to 2.8 percent. Without monetary policy stabilization, these estimated peak long term nominal market interest rate increases range from −19 to 22 basis points, while these estimated peak equity price reductions range from 2.1 to 4.1 percent.

Under our second scenario, a sudden loss of confidence in sovereign debt sustainability also occurs in Spain, represented by the same combination of adverse real and financial shocks that Greece, Ireland and Portugal were subjected to under our first scenario, and which continue to apply under this scenario. Reflecting the relative economic size of Spain, we subject the remaining member countries of the Euro Area to parallel real and financial shocks which in isolation would increase their long term nominal market interest rates by 150 basis points, raise their short term nominal market interest rates by 50 basis points, reduce their equity prices by 15 percent, and reduce their domestic demand by 1 percent. Finally, there is a correspondingly larger run on the euro, represented by an exchange rate risk premium shock which in isolation would depreciate it by 7½ percent in nominal effective terms on impact. Accounting for monetary policy responses, this contagious sovereign debt crisis is estimated to generate peak output losses of 1.3 to 6.3 percent within the Euro Area, and of 0.4 to 1.7 percent outside of the Euro Area. Abstracting from monetary policy responses raises these estimated peak output losses to 2.2 to 6.8 percent within the Euro Area, and to 0.6 to 2.1 percent outside of the Euro Area. In parallel, with monetary policy stabilization estimated peak long term nominal market interest rate increases range from −50 to 48 basis points outside of the Euro Area, while estimated peak equity price reductions range from 5.4 to 7.2 percent. Without monetary policy stabilization, these estimated peak long term nominal market interest rate increases range from 41 to 54 basis points, while these estimated peak equity price reductions range from 6.1 to 10.4 percent.

Under our third scenario, a sudden loss of confidence in sovereign debt sustainability also occurs in Italy, represented by the same combination of adverse real and financial shocks that Greece, Ireland, Portugal and Spain were subjected to under our second scenario, and which continue to apply under this scenario. Reflecting the relative economic size of Italy, we subject the remaining member countries of the Euro Area to parallel real and financial shocks which in isolation would increase their long term nominal market interest rates by 300 basis points, raise their short term nominal market interest rates by 100 basis points, reduce their equity prices by 30 percent, and reduce their domestic demand by 2 percent. Finally, there is a correspondingly larger run on the euro, represented by an exchange rate risk premium shock which in isolation would depreciate it by 15 percent in nominal effective terms on impact. Accounting for monetary policy responses, this contagious sovereign debt crisis is estimated to generate peak output losses of 1.2 to 6.7 percent within the Euro Area, and of 0.7 to 2.9 percent outside of the Euro

Area. Abstracting from monetary policy responses raises these estimated peak output losses to 2.8 to 7.5 percent within the Euro Area, and to 1.1 to 3.8 percent outside of the Euro Area. In parallel, with monetary policy stabilization estimated peak long term nominal market interest rate increases range from −73 to 84 basis points outside of the Euro Area, while estimated peak equity price reductions range from 8.6 to 11.6 percent. Without monetary policy stabilization, these estimated peak long term nominal market interest rate increases range from 77 to 95 basis points, while these estimated peak equity price reductions range from 9.8 to 17.5 percent.

Several patterns embedded in these simulated peak output losses associated with an intensification of the Euro Area Sovereign Debt Crisis warrant discussion. In particular, when subjected to severe financial stress, economies with high trade openness such as Ireland experience far smaller output losses than do economies with low trade openness such as Greece, and benefit disproportionately from depreciation of the euro in real effective terms. Furthermore, output losses in the rest of the world are increasing in trade and financial integration with the Euro Area, with exposures concentrated in the United Kingdom and Russia. Finally, even abstracting from the zero lower bound on the nominal policy interest rate, the scope for monetary policy responses to mitigate these output losses is limited, reflecting lags in the monetary transmission mechanism.

Table 4. Simulated peak output effects

	With Monetary Policy Responses			Without Monetary Policy Responses		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Brazil	–0.30	–0.78	–1.31	–0.39	–1.03	–1.74
Canada	–0.17	–0.44	–0.71	–0.25	–0.65	–1.08
China	–0.31	–0.81	–1.36	–0.42	–1.11	–1.89
France	–0.87	–2.62	–4.81	–1.06	–3.10	–5.56
Germany	–0.82	–2.32	–4.19	–1.05	–2.92	–5.18
Greece	–5.99	–6.34	–6.48	–6.22	–6.82	–7.17
India	–0.28	–0.74	–1.23	–0.38	–1.00	–1.70
Ireland	–1.11	–1.28	–1.15	–1.39	–2.15	–2.80
Italy	–0.96	–2.64	–6.70	–1.15	–3.13	–7.46
Japan	–0.23	–0.59	–0.98	–0.30	–0.78	–1.31
Portugal	–4.74	–5.91	–6.22	–4.97	–6.38	–6.89
Russia	–0.63	–1.53	–2.86	–0.83	–2.05	–3.81
Spain	–1.14	–6.20	–6.69	–1.31	–6.69	–7.39
United Kingdom	–0.73	–1.67	–2.80	–0.91	–2.13	–3.60
United States	–0.24	–0.62	–1.06	–0.31	–0.81	–1.38
World	–0.51	–1.36	–2.28	–0.63	–1.67	–2.80
Advanced Economies	–0.54	–1.43	–2.39	–0.66	–1.74	–2.91
Euro Area Economies	–1.15	–3.15	–5.24	–1.35	–3.68	–6.09
Euro Area Periphery	–2.19	–5.63	–5.98	–2.39	–6.16	–6.78
Euro Area Core	–0.88	–2.50	–5.05	–1.08	–3.03	–5.90
Other Advanced Economies	–0.29	–0.72	–1.21	–0.37	–0.94	–1.60
Emerging Economies	–0.35	–0.91	–1.57	–0.48	–1.23	–2.14

Note: Peak output effects are measured in percent at the annual frequency. Aggregation of peak output effects across economies is based on output weights. The Euro Area Periphery consists of Greece, Ireland, Portugal and Spain. The Euro Area Core consists of France, Germany and Italy.

Table 5. Simulated peak long term nominal market interest rate effects

	With Monetary Policy Responses			Without Monetary Policy Responses		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Brazil	20	48	84	22	54	95
Canada	17	43	76	19	47	82
China	18	45	78	22	54	95
France	–56	–151	268	42	122	254
Germany	–56	–151	267	42	122	253
Greece	454	427	408	460	422	394
India	19	46	79	22	54	95
Ireland	446	418	398	452	413	384
Italy	–56	–152	419	41	120	405
Japan	16	41	71	18	44	77
Portugal	454	427	408	460	422	394
Russia	–13	–34	–64	19	48	82
Spain	–57	436	417	41	431	403
United Kingdom	–30	–50	–73	–19	41	79
United States	16	39	68	18	44	78
World	7	19	125	31	79	137
Advanced Economies	7	19	127	31	80	138
Euro Area Economies	–9	–24	336	80	188	322
Euro Area Periphery	157	430	411	215	425	397
Euro Area Core	–56	–151	315	42	121	301
Other Advanced Economies	12	33	58	15	44	78
Emerging Economies	17	41	71	21	54	94

Note: Peak long term nominal market interest rate effects are measured in basis points at the annual frequency. Aggregation of peak long term nominal market interest rate effects across economies is based on bond market capitalization weights. The Euro Area Periphery consists of Greece, Ireland, Portugal and Spain. The Euro Area Core consists of France, Germany and Italy.

Table 6. Simulated peak equity price effects

	With Monetary Policy Responses			Without Monetary Policy Responses		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Brazil	–2.26	–6.51	–10.54	–2.66	–7.60	–12.48
Canada	–1.85	–5.37	–8.63	–2.11	–6.06	–9.85
China	–2.21	–6.35	–10.16	–2.73	–7.80	–12.81
France	–7.34	–21.99	–41.81	–7.81	–23.17	–43.27
Germany	–7.50	–22.30	–42.22	–8.00	–23.56	–43.84
Greece	–56.24	–59.22	–61.61	–56.70	–60.37	–63.03
India	–2.11	–6.10	–9.72	–2.63	–7.54	–12.36
Ireland	–49.25	–51.48	–52.46	–49.85	–53.01	–54.74
Italy	–7.70	–22.70	–60.90	–8.18	–23.87	–62.35
Japan	–1.92	–5.55	–8.95	–2.18	–6.26	–10.19
Portugal	–54.53	–58.30	–60.87	–54.99	–59.44	–62.27
Russia	–2.42	–6.71	–10.98	–3.57	–9.79	–16.84
Spain	–7.74	–57.24	–60.31	–8.21	–58.39	–61.72
United Kingdom	–2.76	–7.21	–11.64	–4.08	–10.42	–17.52
United States	–1.95	–5.61	–9.09	–2.27	–6.47	–10.64
World	–3.32	–9.62	–15.44	–3.76	–10.78	–17.44
Advanced Economies	–3.40	–9.87	–15.83	–3.83	–10.98	–17.73
Euro Area Economies	–10.48	–31.07	–49.48	–10.96	–32.27	–50.99
Euro Area Periphery	–19.33	–57.01	–59.79	–19.80	–58.19	–61.28
Euro Area Core	–7.47	–22.24	–45.97	–7.95	–23.44	–47.49
Other Advanced Economies	–2.03	–5.77	–9.34	–2.45	–6.87	–11.31
Emerging Economies	–2.25	–6.41	–10.32	–2.89	–8.16	–13.58

Note: Peak equity price effects are measured in percent at the annual frequency. Aggregation of peak equity price effects across economies is based on stock market capitalization weights. The Euro Area Periphery consists of Greece, Ireland, Portugal and Spain. The Euro Area Core consists of France, Germany and Italy.

5. Conclusion

This paper analyzes past and possible future spillovers from the Euro Area Sovereign Debt Crisis within the framework of a structural macroeconometric model of the world economy. We find that macroeconomic and financial market spillovers have been small outside of countries with high trade or financial exposures, but that they could become large if severe financial stress were to spread to Spain, and in particular to Italy. The limited scope for monetary policy responses to mitigate these spillovers, and the very large output losses in afflicted countries associated with them, calls for decisive preemptive fiscal and financial policy measures. In particular, as discussed in IMF (2011b), continued fiscal consolidation is needed to alleviate financial market concerns over sovereign debt sustainability in some Euro Area member countries, and to rebuild fiscal space to respond to possible future large adverse real or financial shocks in most Euro Area member countries. At the same time, as further discussed in IMF (2011c), vulnerable segments of the banking sectors of many Euro Area member countries require augmented capital buffers and reduced reliance on short term wholesale funding.

Appendix A. Description of the Data Set

Estimation is based on quarterly data on several macroeconomic and financial market variables for fifteen economies over the sample period 1999Q1 through 2011Q1. The economies under consideration are Brazil, Canada, China, France, Germany, Greece, India, Ireland, Italy, Japan, Portugal, Russia, Spain, the United Kingdom, and the United States. This data was obtained from the GDS database maintained by the International Monetary Fund where available, and from the IFS database compiled by the International Monetary Fund or the CEIC database compiled by Internet Securities Incorporated otherwise.

The macroeconomic variables under consideration are the price of output, the price of consumption, the quantity of output, the quantity of domestic demand, 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. 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 extracted from databases maintained 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.

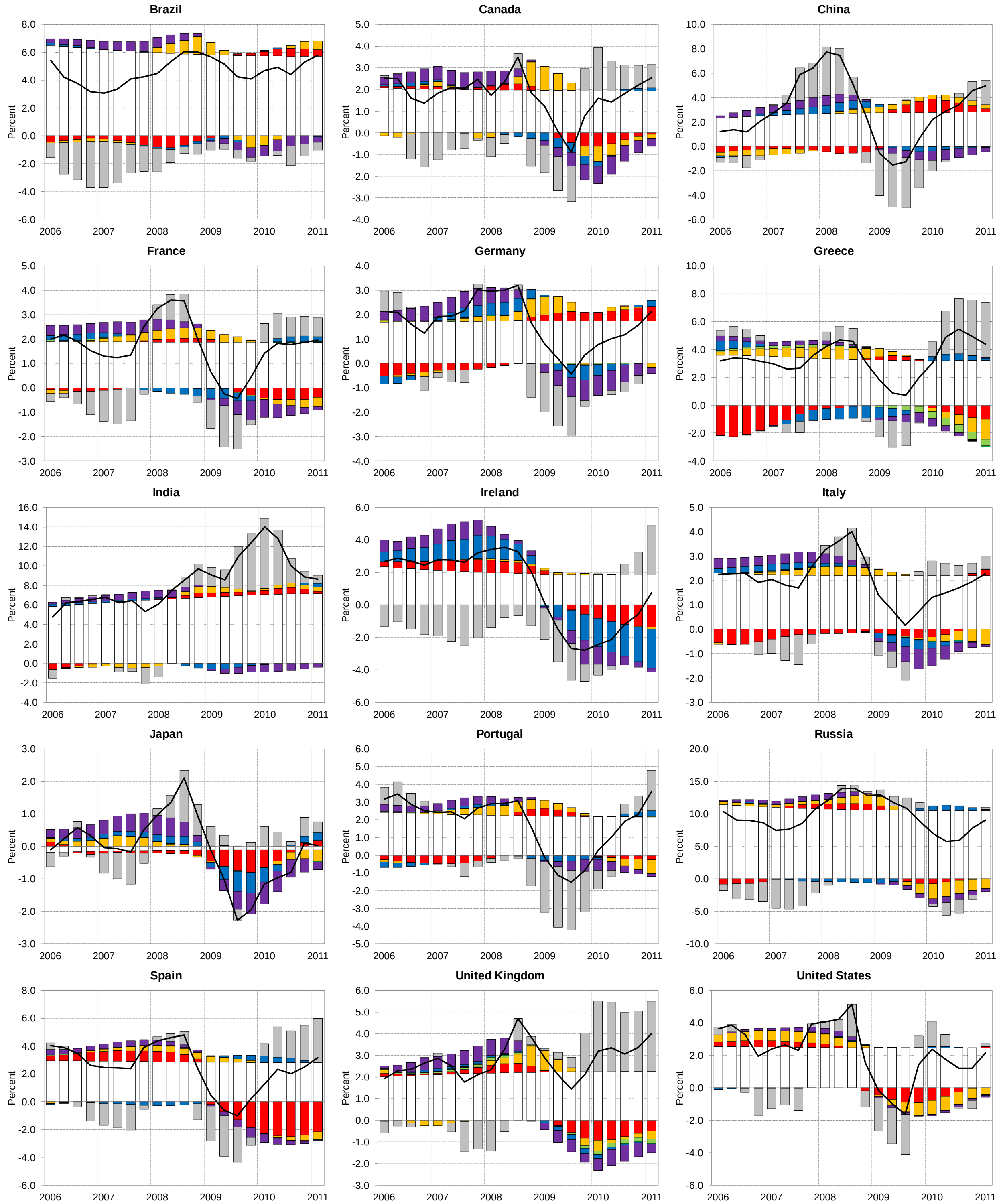
Appendix B. Tables and Figures

Table 7. Parameter estimation results

	Prior		Posterior																															
			World		Brazil		Canada		China		France		Germany		Greece		India		Ireland		Italy		Japan		Portugal		Russia		Spain		United Kingdom		United States	
	Mean	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE	Mode	SE
$\phi_{1.1}$	0.490	4.9e–3	0.453	4.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{1.2}$	0.490	4.9e–3	0.478	4.7e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{1.1}$	0.013	1.3e–3	0.018	1.1e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{1.2}$	0.250	2.5e–2	0.157	1.1e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{2.1}$	0.100	1.0e–2	0.123	9.1e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{2.2}$	0.250	2.5e–2	0.262	2.5e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{3.1}$	0.750	7.5e–3	0.756	6.8e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3.1}$	–1.500	1.5e–1	–1.316	2.4e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{3.2}$	–0.015	1.5e–3	–0.016	5.1e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{4.1}$	1.000	1.0e–1	1.206	3.0e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{4.2}$	–0.150	1.5e–2	–0.137	6.8e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{5.1}$	0.750	7.5e–3	0.756	6.2e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{5.1.0}$	1.250	1.3e–1	...	...	...	...	...	...	1.578	8.2e–2	...	...	...	...	...	...	1.578	8.2e–2	...	...	...	...	...	...	...	...	1.578	8.2e–2	...	...	...	...	...	...
$\theta_{5.1.1}$	1.500	1.5e–1	...	...	1.797	7.0e–2	1.797	7.0e–2	...	...	...	...	1.797	7.0e–2	...	...	...	...	...	...	...	...	1.797	7.0e–2	...	...	...	...	...	...	1.797	7.0e–2	1.797	7.0e–2
$\theta_{5.2.0}$	0.125	1.3e–2	...	...	...	...	...	...	0.124	1.2e–2	...	...	...	...	...	...	0.124	1.2e–2	...	...	...	...	...	...	...	...	0.124	1.2e–2	...	...	...	...	...	...
$\theta_{5.2.1}$	0.125	1.3e–2	...	...	0.122	1.1e–2	0.122	1.1e–2	...	...	...	...	0.122	1.1e–2	...	...	...	...	...	...	...	...	0.122	1.1e–2	...	...	...	...	...	...	0.122	1.1e–2	0.122	1.1e–2
$\theta_{5.3.0}$	0.013	1.3e–3	...	...	...	...	...	...	0.012	1.2e–3	...	...	...	...	...	...	0.012	1.2e–3	...	...	...	...	...	...	...	...	0.012	1.2e–3	...	...	...	...	...	...
$\phi_{6.1}$	0.250	2.5e–3	0.251	2.5e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{6.1}$	–0.001	1.0e–4	–0.001	7.8e–5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{6.0}$	1.200	1.2e–1	...	...	1.186	8.8e–2	...	...	1.186	8.8e–2	...	...	...	...	...	...	1.186	8.8e–2	...	...	...	...	...	...	...	...	1.186	8.8e–2	...	...	...	...	...	...
$\lambda_{6.1}$	0.800	8.0e–2	...	...	...	...	0.839	6.5e–2	...	...	...	...	0.839	6.5e–2	...	...	...	...	...	...	...	...	0.839	6.5e–2	...	...	...	...	...	...	0.839	6.5e–2	0.839	6.5e–2
$\phi_{7.1}$	0.240	2.4e–3	0.236	2.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{7.2}$	0.740	7.4e–3	0.739	4.8e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{7.1}$	0.250	2.5e–2	0.128	6.6e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{7.0}$	1.200	1.2e–1	...	...	1.183	7.5e–2	...	...	1.183	7.5e–2	...	...	...	...	...	...	1.183	7.5e–2	...	...	...	...	...	...	...	...	1.183	7.5e–2	...	...	...	...	...	...
$\lambda_{7.1}$	0.800	8.0e–2	...	...	...	...	0.979	4.3e–2	...	...	...	...	0.979	4.3e–2	...	...	...	...	...	...	...	...	0.979	4.3e–2	...	...	...	...	...	...	0.979	4.3e–2	0.979	4.3e–2
$\phi_{8.1}$	0.240	2.4e–3	0.235	2.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{8.2}$	0.740	7.4e–3	0.724	4.0e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8.1}$	1.000	1.0e–1	0.781	5.6e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{8.2}$	–1.000	1.0e–1	–1.069	8.9e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\lambda_{8.0}$	1.500	1.5e–1	...	...	1.670	7.4e–2	...	...	1.670	7.4e–2	...	...	...	...	...	...	1.670	7.4e–2	...	...	...	...	...	...	...	...	1.670	7.4e–2	...	...	...	...	...	...
$\lambda_{8.1}$	1.000	1.0e–1	...	...	...	...	1.465	3.9e–2	...	...	...	...	1.465	3.9e–2	...	...	...	...	...	...	...	...	1.465	3.9e–2	...	...	...	...	...	...	1.465	3.9e–2	1.465	3.9e–2
$\phi_{9.1}$	0.240	2.4e–3	0.257	1.0e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{9.2}$	0.740	7.4e–3	0.743	9.3e–5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{9.1.0}$	–1.000	1.0e–1	...	...	–0.895	4.3e–2	–0.895	4.3e–2	...	...	...	...	–0.895	4.3e–2	...	...	...	...	...	...	...	...	–0.895	4.3e–2	...	...	...	...	...	...	–0.895	4.3e–2	–0.895	4.3e–2
$\theta_{9.1.1}$	–0.250	2.5e–2	...	...	...	...	...	...	–0.248	1.4e–2	...	...	...	...	...	...	–0.248	1.4e–2	...	...	...	...	...	...	...	...	–0.248	1.4e–2	...	...	...	...	...	...
$\phi_{10.1}$	0.490	4.9e–3	0.480	4.3e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\phi_{10.2}$	0.490	4.9e–3	0.489	4.1e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{10.1.0}$	0.750	7.5e–2	0.628	4.8e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\theta_{10.1.1}$	1.500	1.5e–1	1.439	1.1e–1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{\eta}}$	0.500	5.0e–2	0.413	2.8e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\rho_{\hat{M}}$	0.500	5.0e–2	0.664	2.6e–2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\hat{\eta}^Y}$	...	∞	...	...	3.9e+0	9.6e–4	2.8e–1	5.8e–2	7.4e–1	1.5e–1	1.6e–1	3.4e–2	2.6e–1	5.3e–2	2.1e–1	4.3e–2	4.0e–1	8.3e–2	6.2e–1	1.3e–1	2.6e–1	5.5e–2	1.4e+0	2.9e–1	2.2e–1	4.6e–2	2.8e+0	1.5e–3	3.5e–1	7.3e–2	8.3e–1	1.7e–1	4.7e+0	7.5e–4
$\sigma^2_{\hat{\eta}^M}$	...	∞	...	...	7.2e+0	4.5e–5	6.5e–1	1.3e–1	1.3e+0	2.7e–1	4.3e–1	9.0e–2	7.7e–1	1.6e–1	4.3e–1	8.8e–2	8.4e–1	1.7e–1	1.5e+0	3.0e–1	6.6e–1	1.4e–1	3.1e+0	1.7e–5	3.9e–1	8.0e–2	6.6e+0	1.3e–4	7.0e–1	1.4e–1	1.9e+0	3.2e–4	1.0e+1	1.6e–5
$\sigma^2_{\hat{\eta}}$	...	∞	...	...	1.5e+0	3.0e–1	7.3e–1	1.5e–1	7.1e–1	1.5e–1	2.5e–1	5.2e–2	9.4e–1	1.9e–1	3.0e+0	3.7e–4	3.8e+0	4.2e–4	5.8e+0	9.1e–5	2.5e–1	5.1e–2	6.2e–1	1.3e–1	1.1e+0	2.3e–1	3.9e+0	4.0e–4	5.8e–1	1.2e–1	4.2e–1	8.6e–2	2.1e–1	4.4e–2
$\sigma^2_{\hat{y}}$	...	∞	...	...	1.0e+1	5.1e–5	2.7e+0	3.3e–5	2.6e+0	4.9e–5	8.9e–1	1.8e–1	2.4e+0	8.5e–5	1.2e+1	4.3e–6	3.5e+1	8.1e–7	2.1e+0	7.2e–5	1.6e+0	3.2e–1	1.6e+1	3.6e–6	4.5e+0	2.2e–5	1.1e+1	6.5e–6	3.2e+0	1.6e–4	1.1e+0	2.3e–1	7.5e+0	1.1e–5
$\sigma^2_{\hat{\iota}^P}$	...	∞	...	...	1.4e+0	2.9e–1	3.1e–1	6.4e–2	3.3e–1	6.7e–2	...	...	2.1e–1	4.4e–2	...	...	3.0e–1	6.1e–2	...	...	...	...	5.5e–1	1.1e–1	...	...	1.8e+0	3.6e–4	...	...	6.5e–1	1.3e–1	1.7e+0	7.7e–4
$\sigma^2_{\hat{\iota}^S}$	...	∞	...	...	1.8e–2	3.8e–3	4.2e–3	8.9e–4	3.4e–3	7.2e–4	4.6e–2	9.5e–3	8.0e–2	1.7e–2	8.4e–2	1.7e–2	1.4e–2	2.6e–3	1.9e–1	3.9e–2	5.3e–2	1.1e–2	9.0e–3	1.9e–3	3.0e–2	6.1e–3	1.1e–1	2.1e–2	2.2e–2	4.6e–3	1.3e–2	2.7e–3	1.2e–2	2.6e–3
$\sigma^2_{\hat{\iota}^L}$	...	∞	...	...	1.2e+0	2.6e–1	3.6e–1	7.5e–2	3.5e–1	7.3e–2	2.4e–1	5.0e–2	3.1e–1	6.3e–2	3.1e–1	6.5e–2	4.7e–1	9.8e–2	2.2e–1	4.6e–2	2.7e–1	5.6e–2	2.9e–1	5.9e–2	2.6e–1	5.3e–2	8.4e–1	1.7e–1	2.6e–1	5.4e–2	4.8e–1	1.0e–1	1.4e+0	2.9e–1
$\sigma^2_{\hat{\eta}^{STK}}$	...	∞	...	...	1.7e+3	4.1e–7	1.9e+2	1.9e–6	3.0e+2	1.9e–6	3.0e+2	9.7e–7	3.1e+2	7.3e–7	3.0e+2	1.9e–6	4.3e+2	2.2e–6	2.5e+2	1.8e–6	2.7e+2	8.9e–7	4.2e+2	1.9e–6	2.7e+2	9.8e–7	1.8e+3	3.3e–7	3.7e+2	7.9e–7	6.4e+2	7.1e–7	1.6e+3	1.0e–6
$\sigma^2_{\hat{\varsigma}}$	...	∞	...	...	4.7e+1	1.9e–5	1.8e+1	3.3e–5	9.4e–1	1.8e–1	...	...	2.0e+1	4.8e–5	...	...	1.5e+0	3.1e–1	...	...	...	...	1.2e+1	5.5e–5	...	...	4.9e+0	1.9e–2	...	...	2.7e+1	2.0e–5	...	...
$\sigma^2_{\hat{\eta}^{COM}}$	...	∞	4.4e+1	8.2e–5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\hat{\eta}^{COM}}$	...	∞	4.6e+0	7.7e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\bar{\eta}^Y}$	...	∞	...	...	1.0e–4	4.3e–5	1.8e–5	1.5e–5	9.2e–5	2.0e–5	4.5e–6	5.0e–6	8.2e–7	2.0e–7	7.9e–6	1.5e–6	1.0e–4	2.6e–5	2.3e–4	4.3e–5	5.6e–6	2.0e–6	4.2e–6	1.3e–6	2.0e–5	5.7e–6	2.7e–4	5.0e–5	5.2e–5	3.1e–5	2.1e–6	6.0e–7	2.1e–5	3.3e–5
$\sigma^2_{\bar{\eta}^C}$	...	∞	...	...	1.9e–4	5.7e–5	4.3e–6	1.1e–6	6.3e–5	1.5e–5	2.4e–6	1.7e–6	3.8e–6	1.6e–6	1.0e–6	4.1e–7	2.3e–4	7.5e–5	6.9e–5	1.5e–5	2.1e–6	6.1e–7	6.5e–6	2.1e–6	2.8e–5	8.1e–6	3.0e–4	6.6e–5	1.2e–5	7.7e–6	2.1e–5	5.5e–6	1.1e–5	1.1e–5
$\sigma^2_{\bar{y}}$	...	∞	...	...	2.9e–5	1.4e–5	3.8e–5	1.1e–5	7.6e–5	3.0e–5	2.7e–5	1.5e–5	1.3e–5	1.0e–5	2.5e–4	1.7e–4	9.6e–5	3.2e–5	5.3e–4	1.6e–4	4.6e–5	1.9e–5	7.5e–5	4.7e–5	8.4e–6	1.9e–6	2.5e–4	1.4e–4	1.1e–4	5.8e–5	9.6e–5	5.9e–5	5.3e–5	3.2e–5
$\sigma^2_{\bar{\eta}}$	...	∞	...	...	1.2e–4	4.5e–5	5.8e–5	4.8e–5	6.0e–5	2.1e–5	3.0e–5	1.7e–5	1.7e–5	6.5e–6	2.8e–4	1.8e–4	1.9e–4	6.3e–5	1.1e–3	4.9e–4	4.1e–5	1.6e–5	4.8e–5	2.4e–5	1.4e–5	6.7e–6	4.0e–4	3.8e–4	3.6e–4	1.9e–4	1.3e–4	6.7e–5	1.0e–4	4.3e–5
$\sigma^2_{\bar{\iota}^P}$	...	∞	...	...	1.3e–4	9.8e–6	5.3e–5	1.0e–5	1.3e–5	6.2e–6	...	...	2.3e–5	4.3e–6	...	...	7.0e–5	1.8e–5	...	...	...	...	1.0e–6	3.3e–7	...	...	2.0e–2	5.1e–3	...	...	2.7e–4	1.1e–4	1.4e–4	3.8e–5
$\sigma^2_{\bar{\iota}^S}$	...	∞	...	...	1.2e–4	8.8e–6	4.7e–5	8.0e–6	8.3e–6	3.2e–6	6.9e–5	1.9e–5	5.8e–5	1.9e–5	5.6e–5	1.7e–5	3.1e–4	8.8e–5	5.8e–5	1.8e–5	3.7e–5	1.1e–5	2.8e–6	1.1e–6	5.6e–5	1.8e–5	2.7e–2	7.4e–3	5.6e–5	1.9e–5	2.6e–4	1.3e–4	1.1e–4	3.0e–5
$\sigma^2_{\bar{\iota}^L}$	...	∞	...	...	6.7e–4	3.9e–5	1.8e–6	6.3e–8	1.9e–5	8.3e–6	2.7e–6	1.9e–7	3.5e–6	2.5e–7	1.1e–3	5.1e–4	8.1e–4	2.5e–4	3.2e–4	1.7e–4	2.1e–5	5.0e–6	3.4e–6	1.2e–6	1.5e–4	7.0e–5	1.4e–2	3.8e–3	5.1e–5	1.6e–5	9.9e–6	1.7e–6	8.0e–6	6.5e–7
$\sigma^2_{\bar{\eta}^{STK}}$	...	∞	...	...	6.5e–3	3.9e–3	2.6e–3	1.3e–3	2.0e–2	6.7e–3	4.3e–3	1.9e–3	7.5e–3	2.7e–3	3.2e–2	1.4e–2	9.6e–3	4.4e–3	2.2e–2	8.2e–3	6.1e–3	4.3e–3	9.0e–3	5.9e–3	6.4e–3	3.2e–3	1.6e–2	7.7e–3	6.8e–3	2.5e–3	2.7e–3	7.7e–4	2.7e–3	9.4e–4
$\sigma^2_{\bar{\varsigma}}$	...	∞	...	...	5.5e–3	1.3e–3	5.3e–4	2.3e–4	2.1e–4	3.9e–5	...	...	1.1e–3	4.4e–4	...	...	3.1e–4	1.1e–4	...	...	...	...	4.2e–4	9.4e–5	...	...	1.2e–3	4.5e–4	...	...	1.5e–3	6.3e–4	...	...
$\sigma^2_{\bar{\eta}^{COM}}$	...	∞	3.0e–3	3.7e–3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\sigma^2_{\bar{\eta}^{COM}}$	...	∞	9.5e–4	2.4e–4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

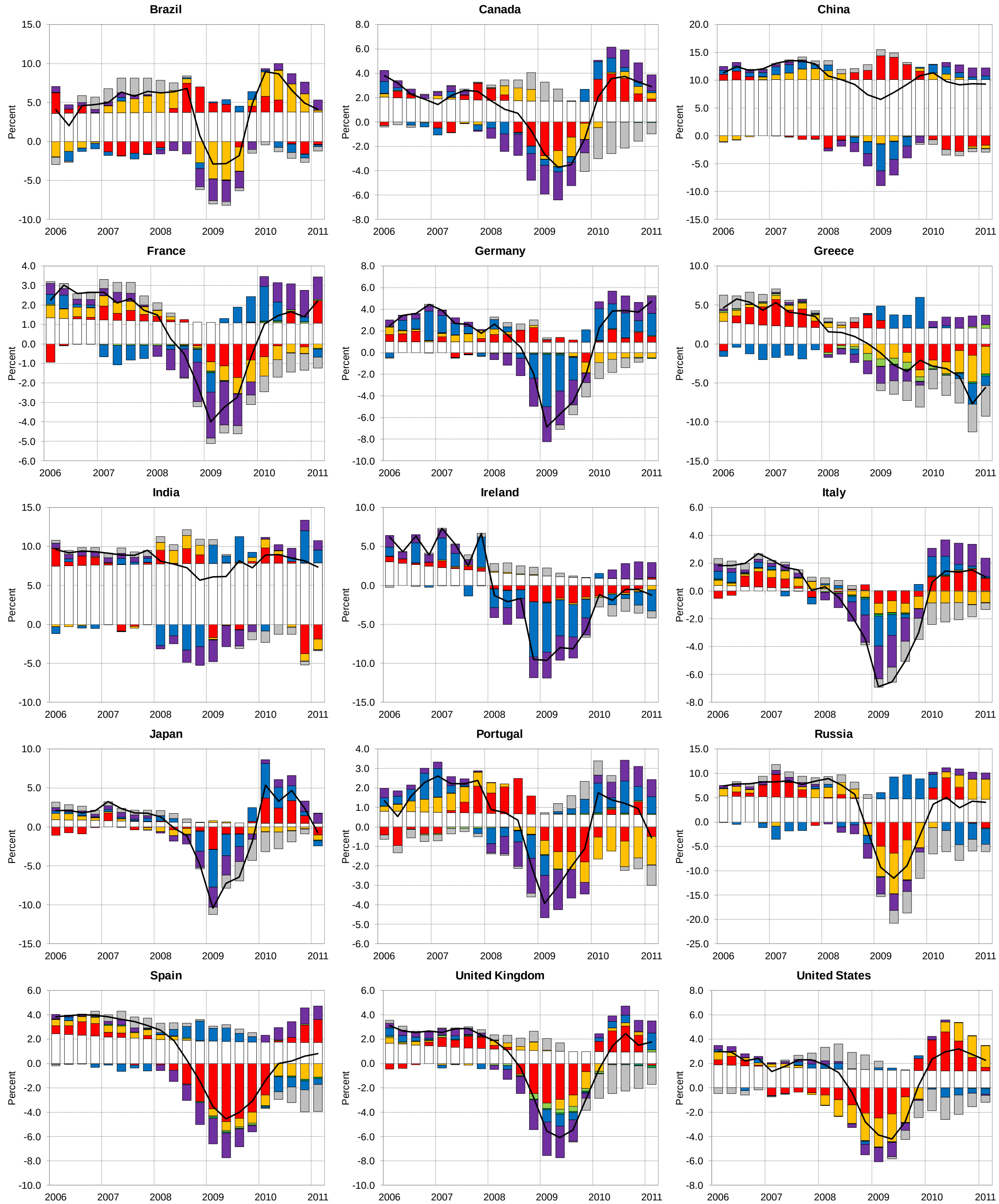
Note: All priors are normally distributed, while all posteriors are asymptotically normally distributed. All observed endogenous variables are rescaled by a factor of 100.

Figure 1. Historical decompositions of consumption price inflation rates



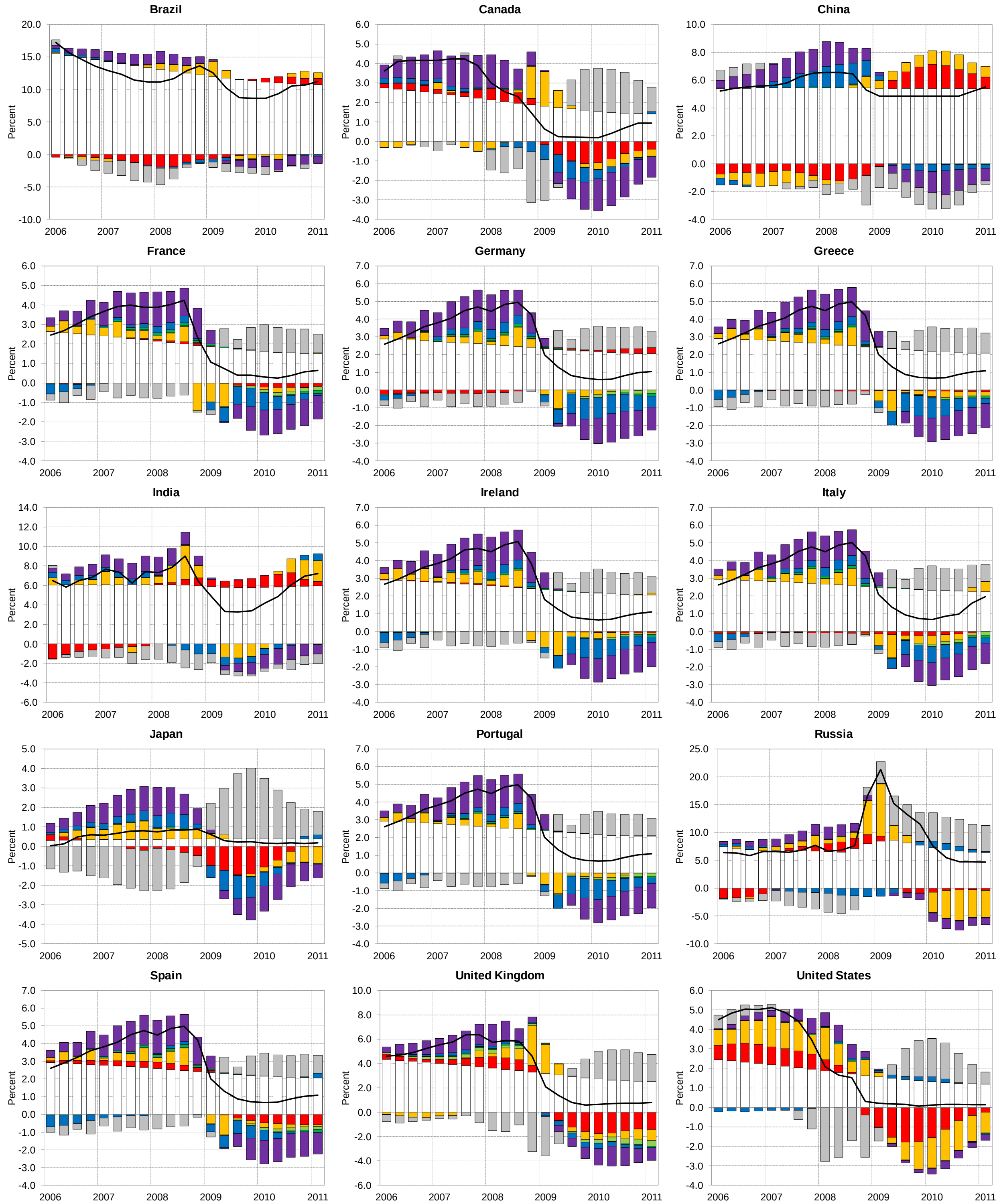
Note: Decomposes the observed consumption price inflation rate ■ as measured by the seasonal logarithmic difference of the price of consumption into the sum of a trend component □ and contributions from demand ■ and risk premium ■ shocks in the domestic economy, demand ■ and risk premium ■ shocks in the crisis economies, demand ■ and risk premium ■ shocks in the rest of the world, and other ■ shocks.

Figure 2. Historical decompositions of output growth rates



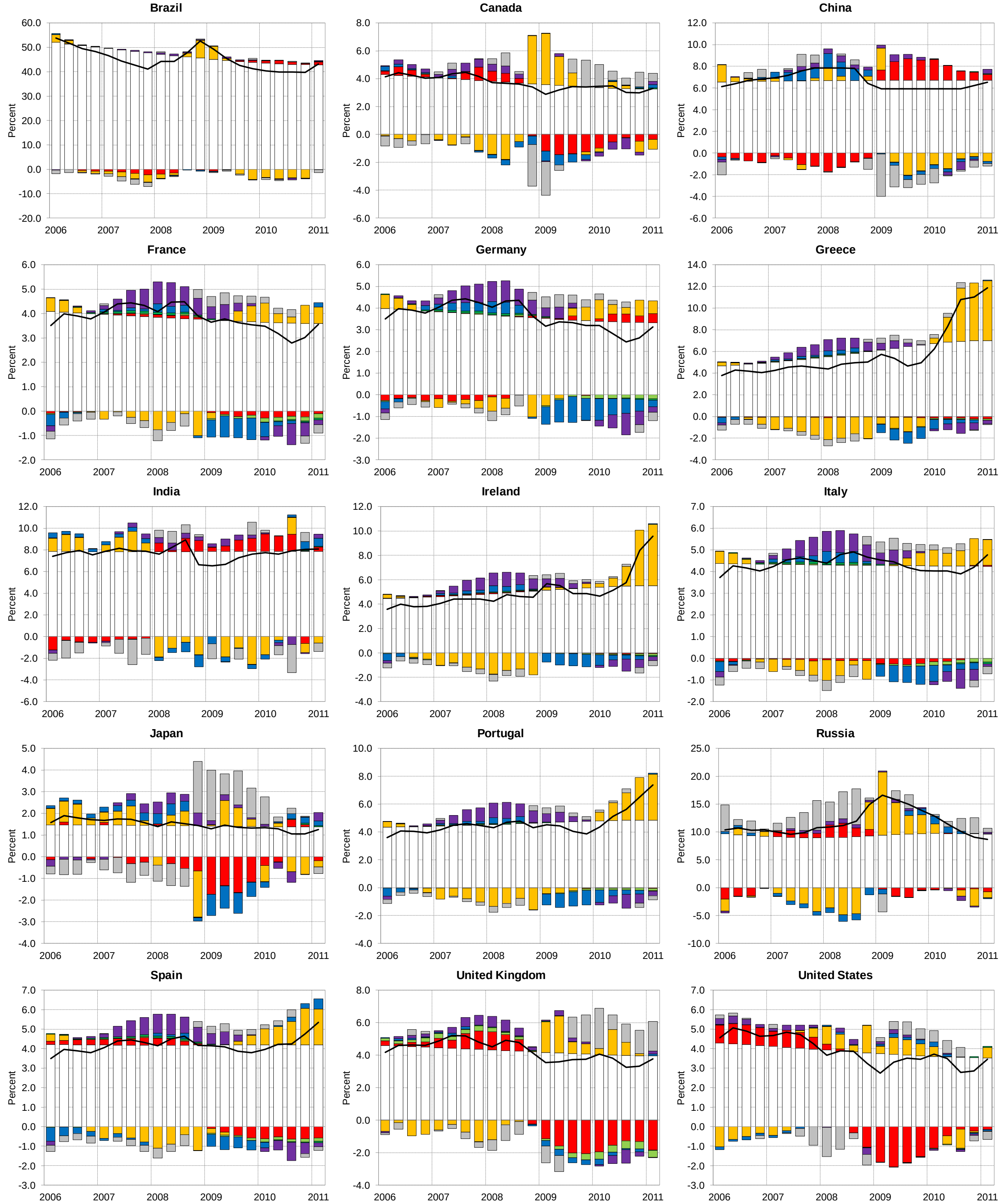
Note: Decomposes the observed output growth rate ■ as measured by the seasonal logarithmic difference of output into the sum of a trend component □ and contributions from demand ■ and risk premium ■ shocks in the domestic economy, demand ■ and risk premium ■ shocks in the crisis economies, demand ■ and risk premium ■ shocks in the rest of the world, and other ■ shocks.

Figure 3. Historical decompositions of short term nominal market interest rates



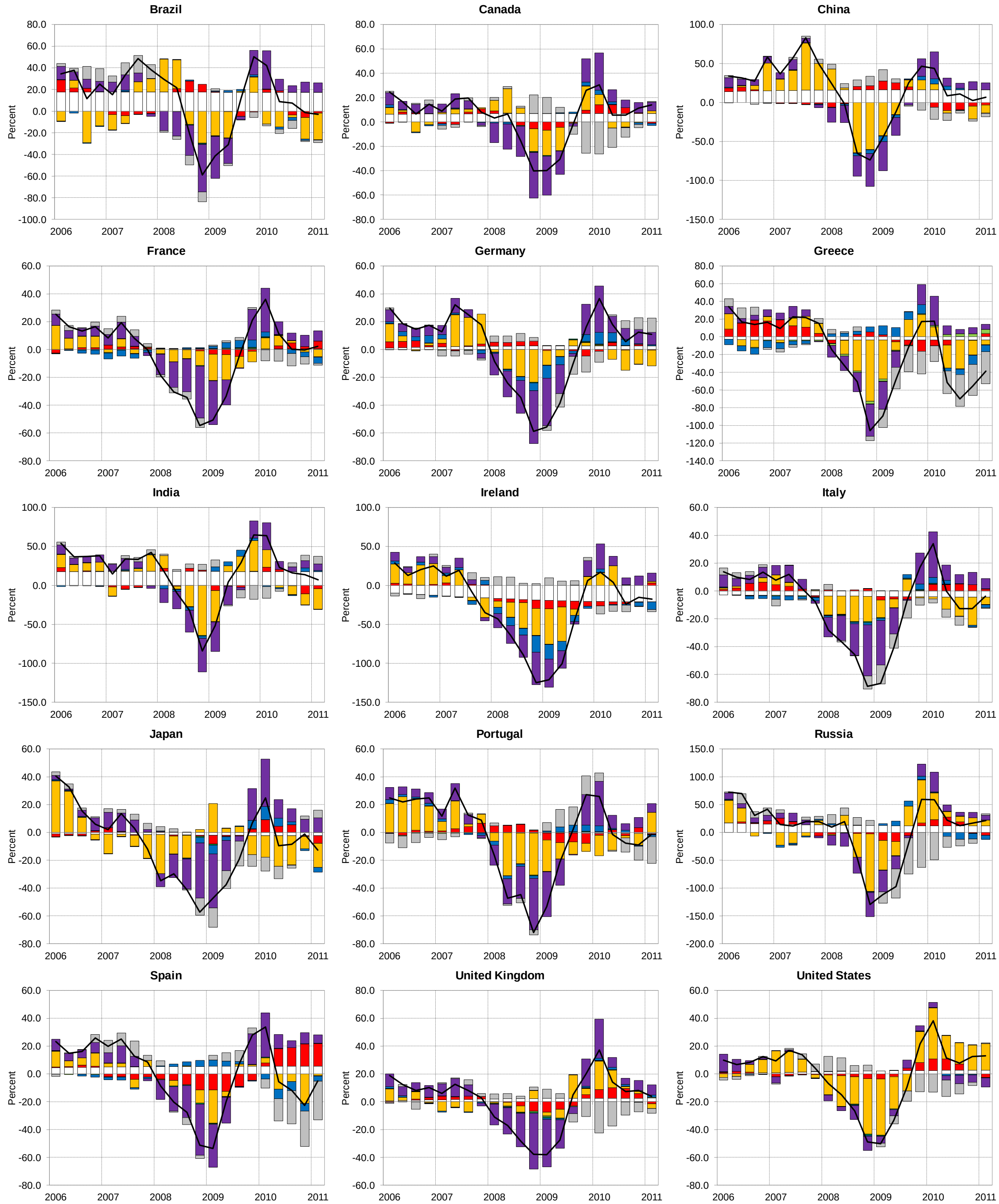
Note: Decomposes the observed short term nominal market interest rate ■ into the sum of a trend component □ and contributions from demand ■ and risk premium ■ shocks in the domestic economy, demand ■ and risk premium ■ shocks in the crisis economies, demand ■ and risk premium ■ shocks in the rest of the world, and other ■ shocks.

Figure 4. Historical decompositions of long term nominal market interest rates



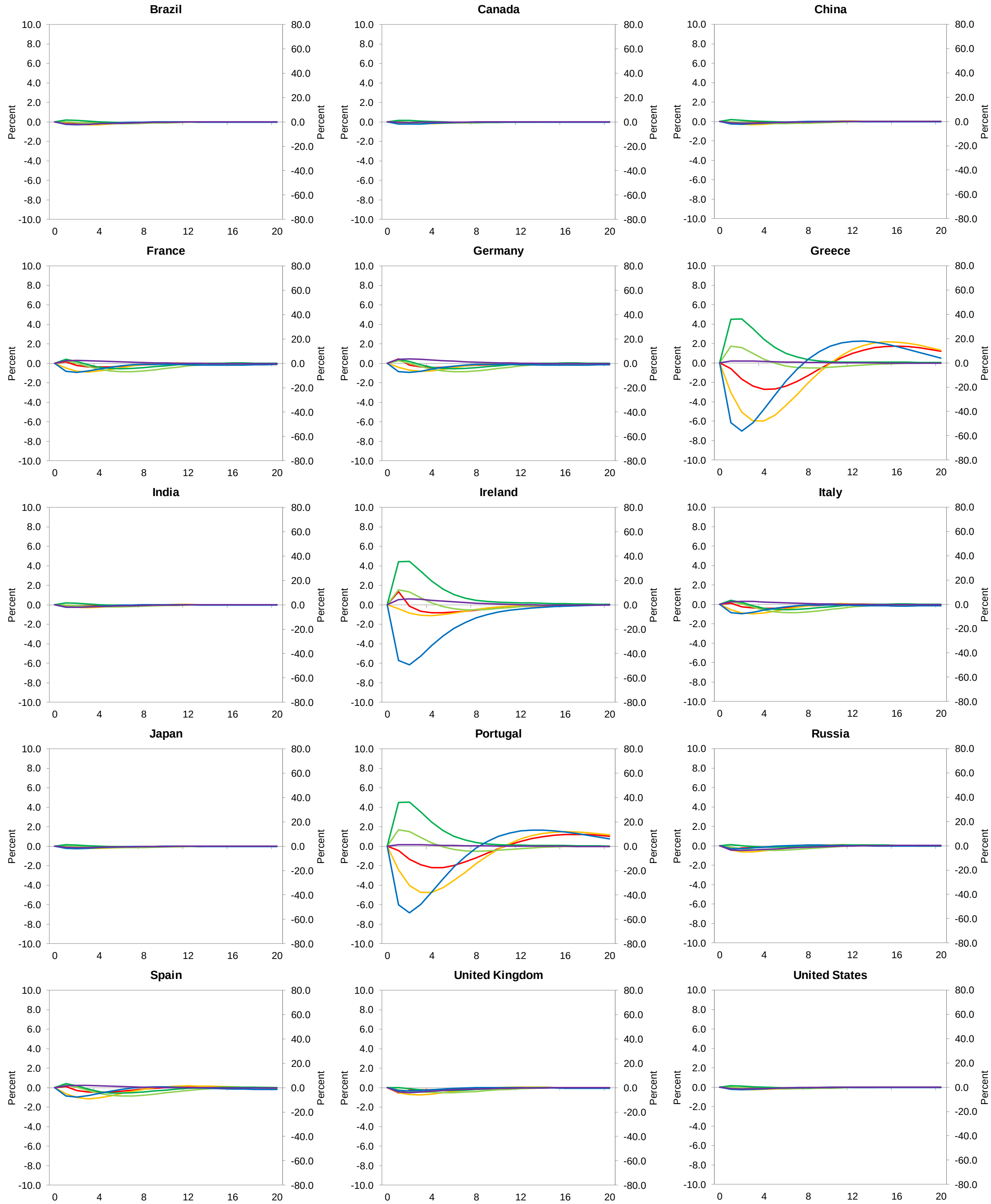
Note: Decomposes the observed long term nominal market interest rate ■ into the sum of a trend component □ and contributions from demand ■ and risk premium ■ shocks in the domestic economy, demand ■ and risk premium ■ shocks in the crisis economies, demand ■ and risk premium ■ shocks in the rest of the world, and other ■ shocks.

Figure 5. Historical decompositions of nominal equity returns



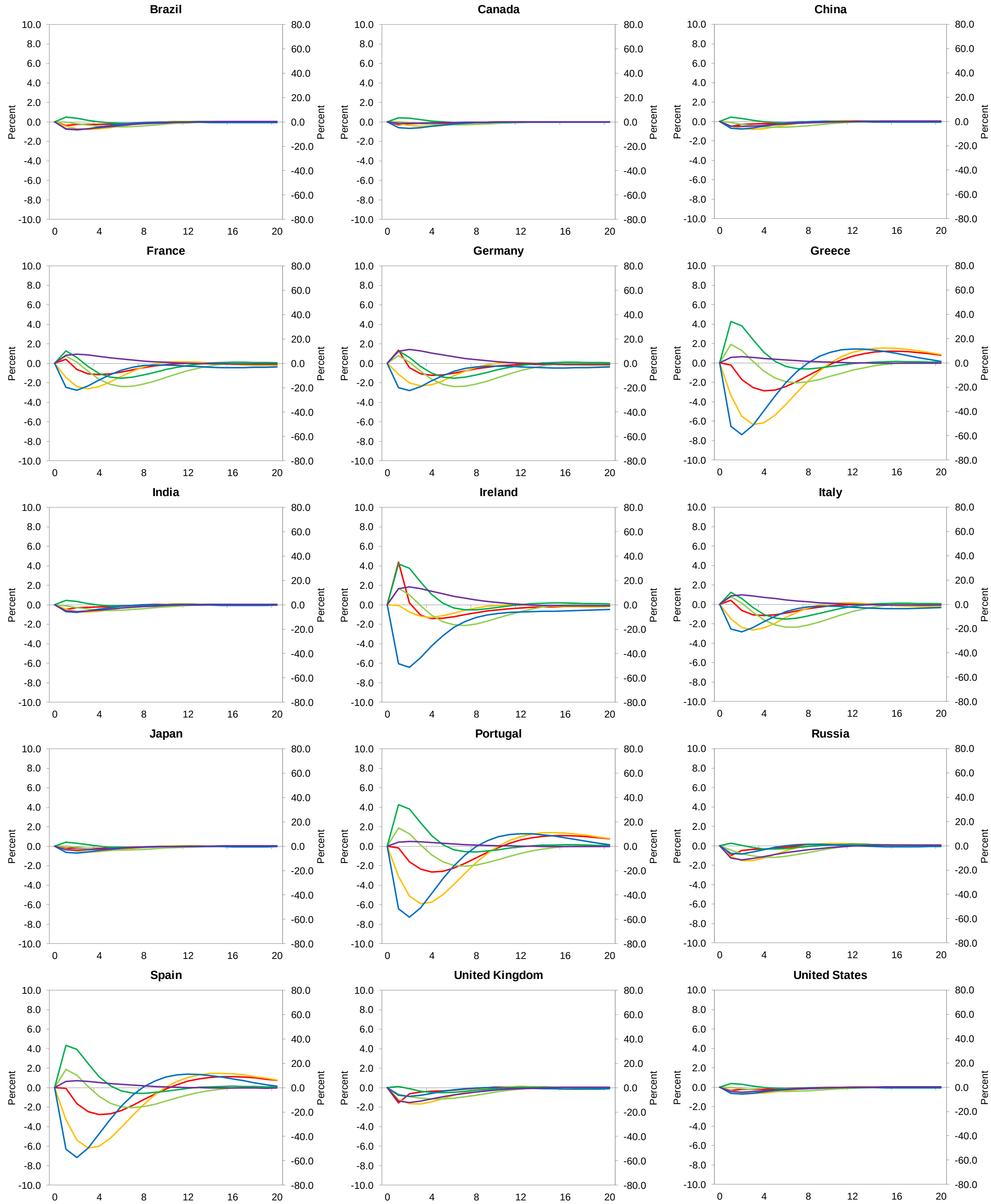
Note: Decomposes the observed nominal equity return ■ as measured by the seasonal logarithmic difference of the price of equity into the sum of a trend component □ and contributions from demand ■ and risk premium ■ shocks in the domestic economy, demand ■ and risk premium ■ shocks in the crisis economies, demand ■ and risk premium ■ shocks in the rest of the world, and other ■ shocks.

Figure 6. Impulse responses under first scenario with monetary policy responses



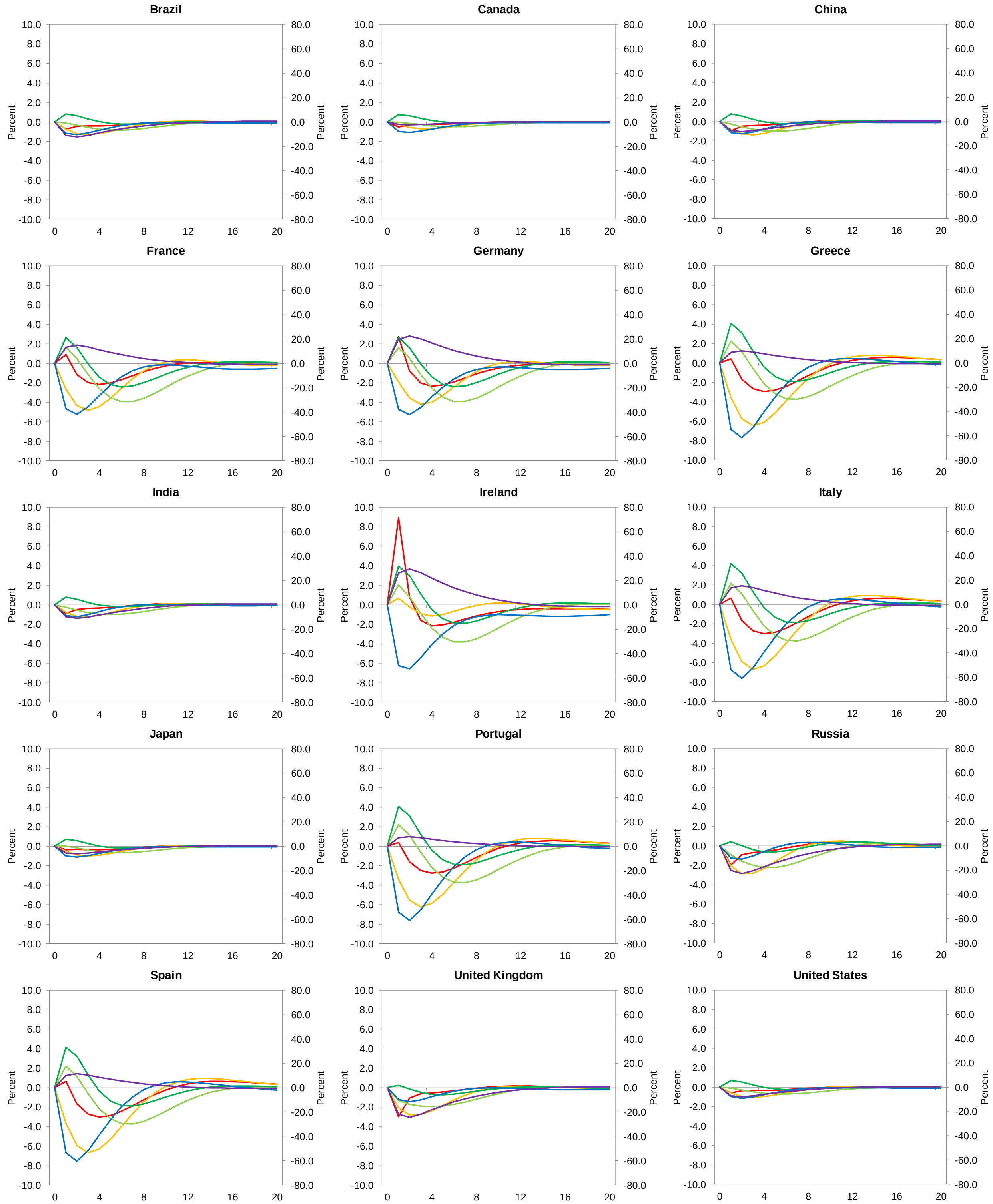
Note: Depicts the impulse responses of consumption price inflation ■ (left scale), output ■ (left scale), the short term nominal market interest rate ■ (left scale), the long term nominal market interest rate ■ (left scale), the price of equity ■ (right scale), and the nominal effective exchange rate ■ (right scale). Inflation and nominal market interest rates are expressed as annual percentage rates.

Figure 7. Impulse responses under second scenario with monetary policy responses



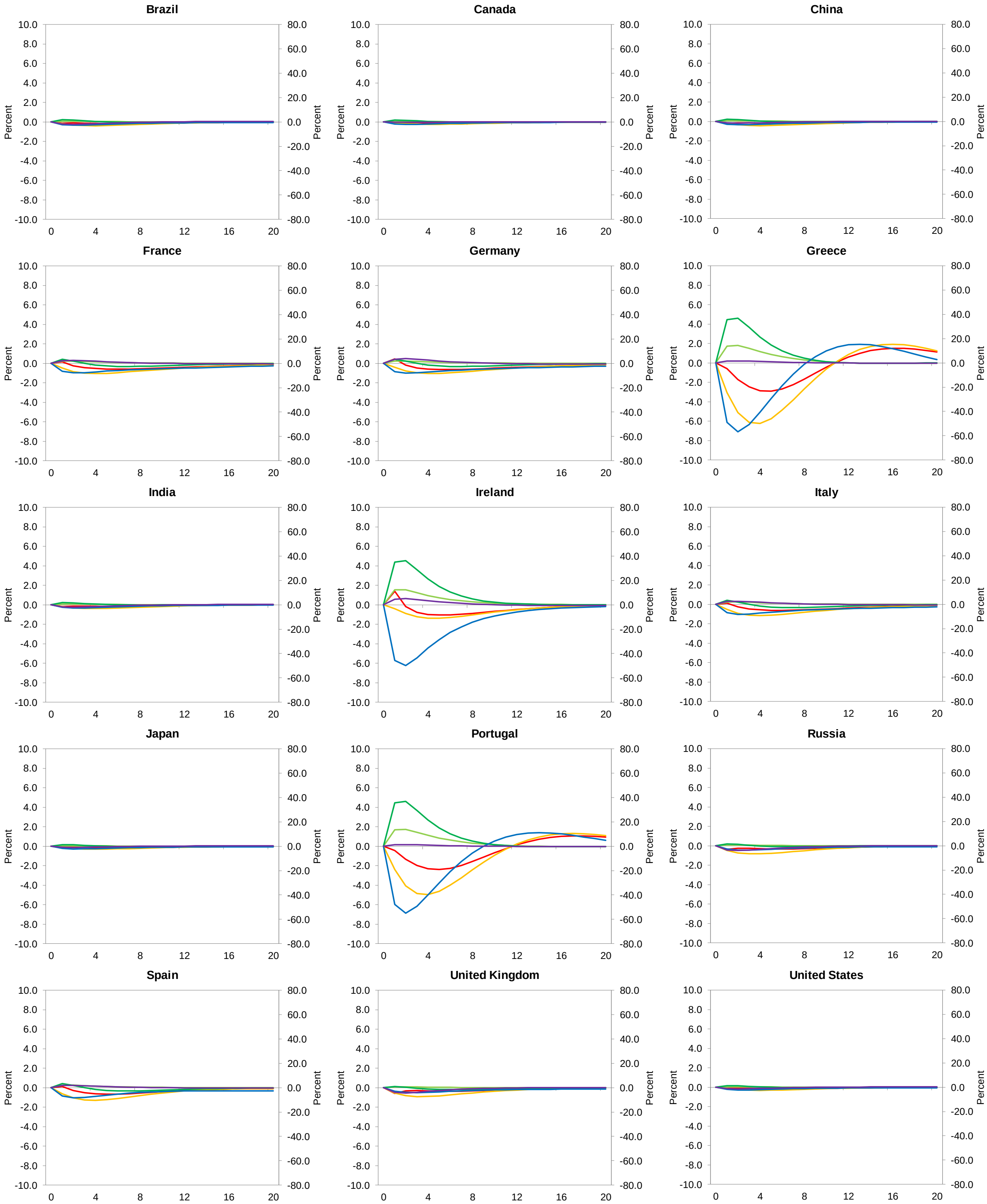
Note: Depicts the impulse responses of consumption price inflation ■ (left scale), output ■ (left scale), the short term nominal market interest rate ■ (left scale), the long term nominal market interest rate ■ (left scale), the price of equity ■ (right scale), and the nominal effective exchange rate ■ (right scale). Inflation and nominal market interest rates are expressed as annual percentage rates.

Figure 8. Impulse responses under third scenario with monetary policy responses



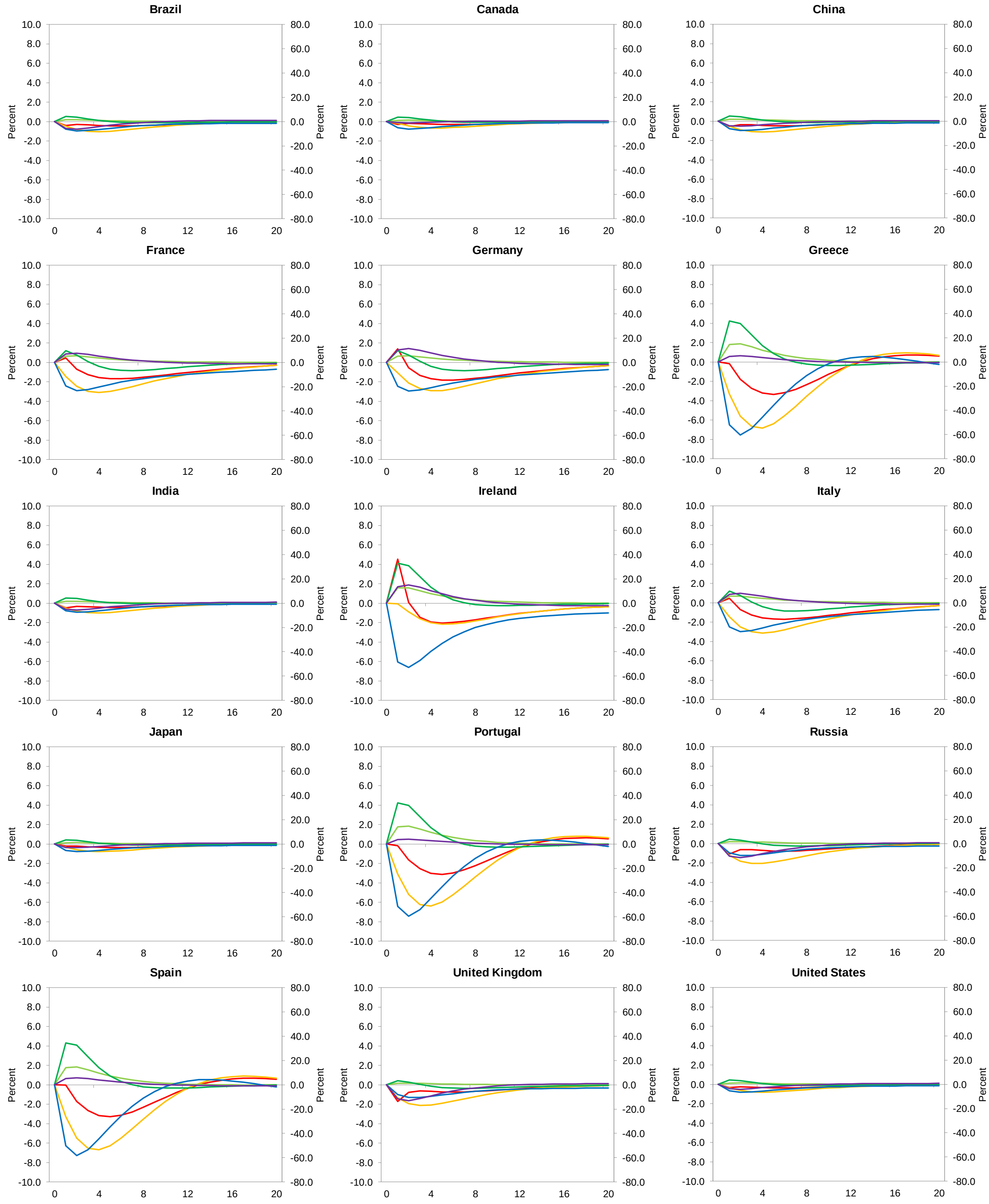
Note: Depicts the impulse responses of consumption price inflation ■ (left scale), output ■ (left scale), the short term nominal market interest rate ■ (left scale), the long term nominal market interest rate ■ (left scale), the price of equity ■ (right scale), and the nominal effective exchange rate ■ (right scale). Inflation and nominal market interest rates are expressed as annual percentage rates.

Figure 9. Impulse responses under first scenario without monetary policy responses



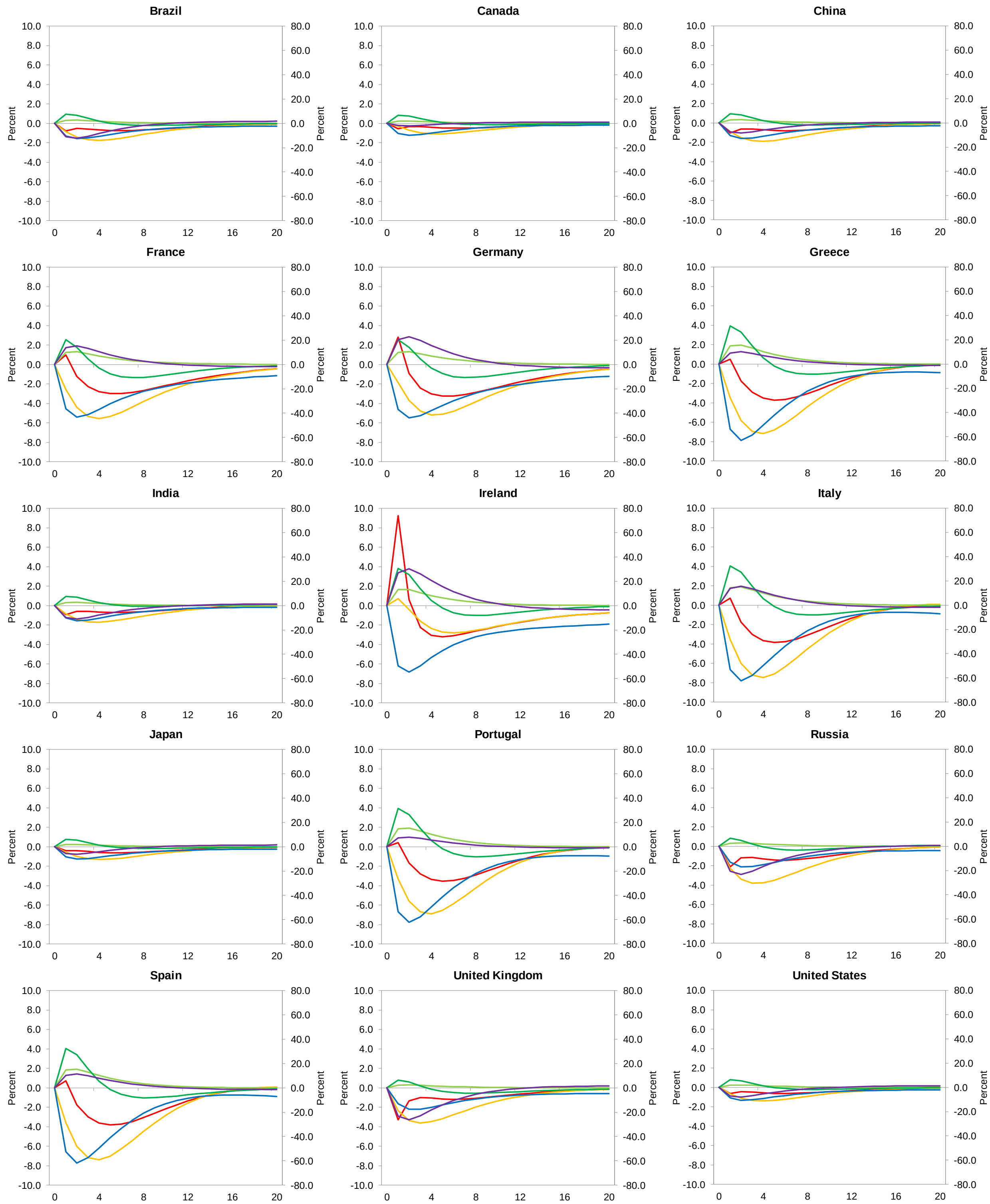
Note: Depicts the impulse responses of consumption price inflation ■ (left scale), output ■ (left scale), the short term nominal market interest rate ■ (left scale), the long term nominal market interest rate ■ (left scale), the price of equity ■ (right scale), and the nominal effective exchange rate ■ (right scale). Inflation and nominal market interest rates are expressed as annual percentage rates.

Figure 10. Impulse responses under second scenario without monetary policy responses



Note: Depicts the impulse responses of consumption price inflation ■ (left scale), output ■ (left scale), the short term nominal market interest rate ■ (left scale), the long term nominal market interest rate ■ (left scale), the price of equity ■ (right scale), and the nominal effective exchange rate ■ (right scale). Inflation and nominal market interest rates are expressed as annual percentage rates.

Figure 11. Impulse responses under third scenario without monetary policy responses



Note: Depicts the impulse responses of consumption price inflation ■ (left scale), output ■ (left scale), the short term nominal market interest rate ■ (left scale), the long term nominal market interest rate ■ (left scale), the price of equity ■ (right scale), and the nominal effective exchange rate ■ (right scale). Inflation and nominal market interest rates are expressed as annual percentage rates.

References

Alter, A. and Y. Schüler (2011), Credit spread interdependencies of European states and banks during the financial crisis, *Unpublished Manuscript*.

Arghyrou, M. and A. Kontonikas (2011), The EMU sovereign-debt crisis: Fundamentals, expectations and contagion, *European Commission Economic Paper*, 436.

Engle, R. and M. Watson (1981), A one-factor multivariate time series model of metropolitan wage rates, *Journal of the American Statistical Association*, 76, 774-781.

Gerlach, S., A. Schulz and G. Wolff (2010), Banking and sovereign risk in the Euro Area, *CEPR Discussion Paper*, 7833.

Hodrick, R. and E. Prescott (1997), Post-war U.S. business cycles: A descriptive empirical investigation, *Journal of Money, Credit, and Banking*, 29, 1-16.

International Monetary Fund (2011a), *Euro Area: Spillover Report*, International Monetary Fund Spillover Report.

International Monetary Fund (2011b), Global prospects and policies, *International Monetary Fund World Economic Outlook*, 1, 1-57.

International Monetary Fund (2011c), Key risks and challenges for sustaining financial stability, *International Monetary Fund Global Financial Stability Report*, 1, 1-74.

Kalman, R. (1960), A new approach to linear filtering and prediction problems, *Transactions ASME Journal of Basic Engineering*, 82, 35-45.

Klein, P. (2000), Using the generalized Schur form to solve a multivariate linear rational expectations model, *Journal of Economic Dynamics and Control*, 24, 1405-1423.

Vitek, F. (2009), Monetary policy analysis and forecasting in the world economy: A panel unobserved components approach, *International Monetary Fund Working Paper*, 238.