Macroeconomic Dynamics, **19**, 2015, 1509–1539. Printed in the United States of America.
doi:10.1017/S1365100513000916

INTERNATIONAL MACROECONOMIC FLUCTUATIONS

SOYOUNG KIM
Seoul National University

JAEWOO LEE
International Monetary Fund

This paper investigates the international dimension of economic fluctuations and transmission of structural shocks by estimating a structural VAR model for the United States, the euro area, and Japan—the three largest economies—over the post-Bretton Woods period. The main findings are as follows: (1) Supply-side shocks (technology and supply-level shocks) explain most of the fluctuations in cross-country output deviations. (2) Real-demand shocks are the most important source of real-exchange-rate fluctuations. (3) Current account is usually influenced by all types of shocks, with technology shocks playing a stronger role. In particular, technology shocks play a prominent role in the existing global imbalance (the large external deficit of the United States). (4) Technology and supply-level shocks generate opposite-signed correlations between output differential and current account, whereas real and nominal-demand shocks generate opposite-signed correlations between real exchange rate and current account.

Keywords: Structural VAR, Current Account, Real Exchange Rate, Cross-Country Output Deviation, Technology Shocks

1. INTRODUCTION

What is the main source of fluctuations in key macro variables of open economies? What are the effects of main structural shocks on key international macro variables? Many past studies have investigated these questions, but most of them focused on one or two variables, on one or two structural shocks, or on one country. In this paper, we attempt to provide empirical answers to these questions from a more

Part of this research was conducted while Soyoung Kim was visiting the Research Department of the International Monetary Fund and the Hong Kong Institute for Monetary Research. We thank David Backus, Sang Young Ju, Hans Genberg, Yongseung Jung, Ken West, and seminar participants at an American Economic Association Meeting, the Hong Kong Institute for Monetary Research, Seoul National University, Sung Kyun Kwan University, and the Bank of Korea. All remaining errors are ours. This paper should not be reported as representing the views of the IMF; the views expressed are those of the authors and do not necessarily reflect the views of the IMF or IMF policy. Address correspondence to: Soyoung Kim, Department of Economics, Seoul National University, San 56-1, Sillim-Dong, Gwanak-Gu, Seoul 151-746, Korea; e-mail: soyoungkim@snu.ac.kr.

 1365-1005/14

comprehensive angle, by considering five key open-macro variables of three major economies in a single structural VAR framework, which is consistent with a wide variety of theoretical open-economy macro models.

The variables under consideration comprise the current account and real exchange rate, which are staples of open-macro analysis, and three cross-country differentials: relative labor productivity, relative output, and relative government consumption. Although existing empirical studies pay limited attention to cross-country differentials, the presence of cross-country differences is the main motivation for analyzing international macroeconomic fluctuations. For example, cross-country output differential has been one of the key variables in analyzing international business cycle synchronization, risk sharing, and monetary union. As for exchange rate or current account, most of the existing studies have investigated the effects of one or two structural shocks—in particular, few studies have analyzed the sources of current-account fluctuations in the presence of a variety of structural shocks. In terms of country coverage, many past studies have focused on a single country, whereas this paper investigates three economies—the United States, the euro area, and Japan—that cover a large part of the world economy.

A structural VAR model comprising these five variables is identified by imposing long-run restrictions, which are consistent with a wide variety of theoretical models [e.g., flexible and sticky price dynamic stochastic general equilibrium (DSGE) models, models under complete market and bonds-only economy]. This consistency of identifying assumptions with a broad spectrum of models is one of the strengths of the long-run identification strategy [Blanchard and Quah (1989)] and makes our econometric approach more general than those based on a particular model. In econometric implementation, we use a nonparametric estimator of the zero-frequency spectral density to avoid possible bias in the estimation and identification of the VAR model with long-run restrictions [Christiano et al. (2007)].

We consider five types of structural shocks: technology, supply-level, government-consumption, real-demand, and nominal-demand shocks. They all have featured prominently in open-macro analysis, though not simultaneously in a single study. Technology shocks have long been at the center of various open-macro models: the intertemporal approach to the current account [Sachs (1981); Glick and Rogoff (1995)], the equilibrium approach to the exchange rate [Stockman (1980)], and various business-cycle models, including the real business cycle model and the new open economy macro models. We consider another type of supply shock—which we call "supply-level" shock—that can have long-run effects on output, motivated by the closed-economy literature, which found that technology shocks play a small role in explaining business cycles [e.g., Gali (1999)]. The importance of supply-level shocks (e.g., labor-supply shocks) as a source of output fluctuations is documented in earlier studies [e.g., Shapiro and Watson (1988) for the closed economy and Ahmed et al. (1993) for the open economy]. Effects of government-consumption (or expenditure in some existing papers) shocks and nominal-demand shocks (e.g., monetary shocks) on current account and real exchange rate have been widely investigated. Corsetti and Muller

(2006), Kim and Roubini (2008), Enders et al. (2011), and Kim (2013) investigate fiscal shocks. Eichenbaum and Evans (1995), Kim (2001), Kim and Roubini (2000), and Scholl and Uhlig (2008) deal with monetary shocks. The discussion on real-demand shocks (e.g., shifts in taste) for domestic versus foreign goods has been an important strand in international business-cycle studies [Stockman and Tesar (1995); Bergin (2006)].

To preview our main results, the impulse responses to various shocks are consistent with theories and many past findings, confirming the empirical merit of our identification strategy. At the same time, a few novel findings follow our five-shock framework. Two supply-side shocks—productivity and supply-level—generate opposite-signed correlations between output and the current account, where productivity shocks increase output and decrease current account balance. Real and nominal demand shocks generate opposite-signed correlations between real exchange rate and current account, where a real demand shock appreciates the real exchange rate and increases current-account balance.

Variance decomposition produces a new result for the study of the role of supply-side shocks. Technology shocks are found to play a prominent role in accounting for the fluctuations of relative output *across* countries, in contrast to recent papers that find productivity (technology) shocks playing a limited role in accounting for output fluctuations *within* countries [e.g., Gali (1999)]. This result points to a hitherto little-understood difference in the propagation of technology shocks in international and domestic dimensions. Supply-level shocks, which include labor-supply shocks, are found to play the second most important role in the fluctuations of relative output [comparable to Ahmed et al. (1993)].

Real demand shocks play a dominant role in accounting for fluctuations in real exchange rate. This result is consistent with that of the study by Clarida and Gali (1994), who find aggregate demand shocks playing an important role in explaining real exchange-rate fluctuations. Current accounts are influenced evenly by all shocks, with no single shock playing a dominant role. Although technology shocks and nominal shocks play somewhat more prominent roles in current-account fluctuations in some countries, the other shocks also make sizable contributions to current-account fluctuations.

Looking into past events separately by historical decomposition, the existing global imbalance—the large deficit in the current-account balance of the United States—is attributed to technology shocks, consistent with the interpretation of Engel and Rogers (2006). This contrasts with the previous large-deficit episode of the 1980s, in which government-consumption shocks are found to have played a dominant role. Historical decomposition also brings out large negative supply-level shocks for the euro area in the 1980s and the 1990s; these shocks offset the positive contribution of strong productivity performance in the 1990s [echoing Blanchard's (2004) reinterpretation of European productivity developments].

The rest of the paper is organized as follows: Section 2 presents the empirical model, Section 3 discusses empirical results, Section 4 reports extended analysis, and Section 5 states the conclusion.

2. EMPIRICAL METHOD

2.1. Structural VAR Model with Long-Run Restrictions

Let the underlying economic relationship be described by the following structural vector moving average (VMA)-form equation:

$$y_t = G(L)e_t, \tag{1}$$

where *G(L)* is a matrix polynomial in the lag operator *L*, y_t is a 5×1 data vector corresponding to our five-variable model, and e_t denotes a vector of structural disturbances. Under the assumption that structural disturbances are mutually uncorrelated, $\mathrm{var}(e_t)$ becomes a diagonal matrix (Λ) of the variances of structural disturbances.

This structural model needs to be identified from the estimated reduced-form VAR model

$$B(L)y_t = u_t, \tag{2}$$

where *B(L)* is a matrix polynomial in the lag operator *L*, and $\mathrm{var}(u_t) = \Sigma$.

Among several ways of uncovering the structural system (1) from the estimated reduced-form system (2), the long-run restriction method pioneered by Blanchard and Quah (1989), who suggest zero restrictions on the elements of long-run structural parameters *G(1),* is adopted in this paper.

Consider the following moving-average representation of a structural VAR model [corresponding to equation (1)] that includes our five variables:

$$\begin{bmatrix} d\left(\log \frac{Y_t}{N_t} - \log \frac{Y_t^*}{N_{t*}^*}\right) \\ d(\log Y_t - \log Y_t^*) \\ d(\log G_t - \log G_t^*) \\ d(\log Q_t) \\ CA_t \end{bmatrix} = \begin{bmatrix} G_{11}(L) & G_{12}(L) & G_{13}(L) & G_{14}(L) & G_{15}(L) \\ G_{21}(L) & G_{22}(L) & G_{23}(L) & G_{24}(L) & G_{25}(L) \\ G_{31}(L) & G_{32}(L) & G_{33}(L) & G_{34}(L) & G_{35}(L) \\ G_{41}(L) & G_{42}(L) & G_{43}(L) & G_{44}(L) & G_{45}(L) \\ G_{51}(L) & G_{52}(L) & G_{53}(L) & G_{54}(L) & G_{55}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{T,t} \\ \varepsilon_{S,t} \\ \varepsilon_{G,t} \\ \varepsilon_{D,t} \\ \varepsilon_{N,t} \end{bmatrix}, \tag{3}$$

$$Gij(1) = 0 \text{ for } ij = 12, 13, 14, 15, 23, 24, 25, 34, 35, 45,$$

where superscript asterisk shows the variables for foreign countries, *Y* is output, *N* is hours of work, *G* is (real) government consumption, *Q* is real exchange rate, and CA is current account. $e_{T,t}$,$e_{S,t}$,$e_{G,t}$, $e_{D,t}$, and $e_{N,t}$ are technology, supply-level, government-consumption, real-demand, and nominal-demand shocks, respectively.

https://doi.org/10.1017/S1365100513000916 Published online by Cambridge University Press

All structural shocks are country-specific shocks or differences between home and foreign shocks. For example, $e_{T,t}$ is a country-specific technology shock or the difference between home- and foreign-technology shocks. Identifying country-specific shocks or differences between home and foreign shocks is consistent with the fact that all variables in the model reflect the differences between home and foreign economic conditions.

The long-run identifying restrictions [$Gij(1) = 0$ for $ij = 12$, 13, 14, 15, 23, 24, 25, 34, 35, 45] state that the long-run effects are governed by a lower-diagonal matrix. The identifying restrictions imply that

1. Supply-level shocks do not have permanent effects on labor-productivity differential.
2. Government-consumption shocks do not have permanent effects on labor-productivity or output differential.
3. Real-demand shocks do not have permanent effects on labor-productivity, output, or government-consumption differential.
4. Nominal-demand shocks do not have permanent effects on labor-productivity differential, output differential, government-consumption differential, or real exchange rate.

These identifying assumptions are consistent with various theoretical models (including those mentioned in the Introduction). Only technology shocks can have permanent effects on relative labor productivity differential. As labor productivity depends only on technology and (stationary) capital–labor ratio in standard DSGE models, a similar assumption has been widely used in closed economy models since Gali (1999) proposed such an identification. A supply-level shock is introduced additionally in the empirical model, as in some closed economy studies such as that of Shapiro and Watson (1988), who introduced labor supply shocks. The supply-side shocks (i.e., technology shocks and supply-level shocks) can have permanent effects on relative output differential, whereas demand-side shocks, such as government-consumption shock and real- and nominal-demand shocks, do not have permanent effects on real quantity variables, such as labor-productivity differential or output differential. This assumption is also consistent with the standard DSGE models and the traditional sticky price models. Clarida and Gali (1994) introduced such an assumption. Real- and nominal-demand shocks (excluding government-consumption shocks) do not have permanent effects on government-consumption differential, as the long-run government consumption level is determined by the government's exogenous decision and supply condition of the economy, which determines the long-run output level. Finally, nominal-demand shocks like monetary shocks do not have permanent effects on real variables, including real exchange rate, consistent with most theoretical models that assume long-run neutrality of money. Blanchard and Quah (1989) introduced a long-run neutrality assumption in the context of the closed economy model, whereas Clarida and Gali (1994) proposed a similar assumption in the context of the open economy model.[1]

2.2. Data and Estimation

To estimate the model with long-run restrictions, we adopt the suggestion by Christian, Eichenbaum, and Vigfusson (2007) and adjust the standard VAR estimator by working with a nonparametric estimator of the zero-frequency spectral density. This procedure is intended to overcome the likely bias in the standard VAR estimator for long-run effects, which can arise when econometricians use only a finite number of lags in estimation.

We consider three largest open economies—the United States, Japan, and the euro area—over the flexible exchange rate regime period. For the United States and Japan, the post-Bretton Woods period (1973:2–2007:2) is considered. For the euro area, the period after the Exchange Rate Mechanism (ERM) (1980:1–2005:4) is considered. Labor productivity and real GDP for each country are used as the log-deviations from the rest of the world, which is proxied by the rest of the G-7 countries (that is, G-7 economies excluding own economy for each case). Labor productivity is constructed as the ratio of real GDP to civilian employment, and the log of real effective exchange rate is used. Current account is used as a ratio to trend GDP.[2]

The transformed data are shown in Figure 1, where all variables are multiplied by 100. It is visually clear that relative output and labor productivity exhibit time-series behavior different from that of output and productivity *within* each country, foreshadowing the difference in empirical findings between this paper and the papers that did not fully consider open economy dimensions. In the VAR model, a constant term and four lags are included.

The Elliott–Rothenberg–Stock DF-GLS test supports the specification of the model in general. For labor productivity (log level deviation from the rest of the world), real GDP (log level deviation from the rest of the world), real government consumption (log level deviation from the rest of the world), and log real effective exchange rate, the null hypothesis of unit root is not rejected at the 5% level of significance. For the current account (as a ratio to the trend GDP), it is rejected at the 5% level. The only exception is the current account of the United States, for which the null hypothesis of unit root is not rejected at the 5% level. Nevertheless, the current account series of the United States is viewed as stationary, in light of evidence in favor of stationarity reported in Marquee and Lee (2009) as well as references therein, and to facilitate comparison across countries/regions.[3]

3. EMPIRICAL RESULTS

3.1. Dynamic Responses to Structural Shocks

Responses of each variable to shocks are reported in Figures 2–4 over four years, together with one standard error band.[4] The names of shocks are denoted at the top of each column of the graphs. The impulse responses of each variable to each shock show some variation across countries, and we discuss primarily patterns

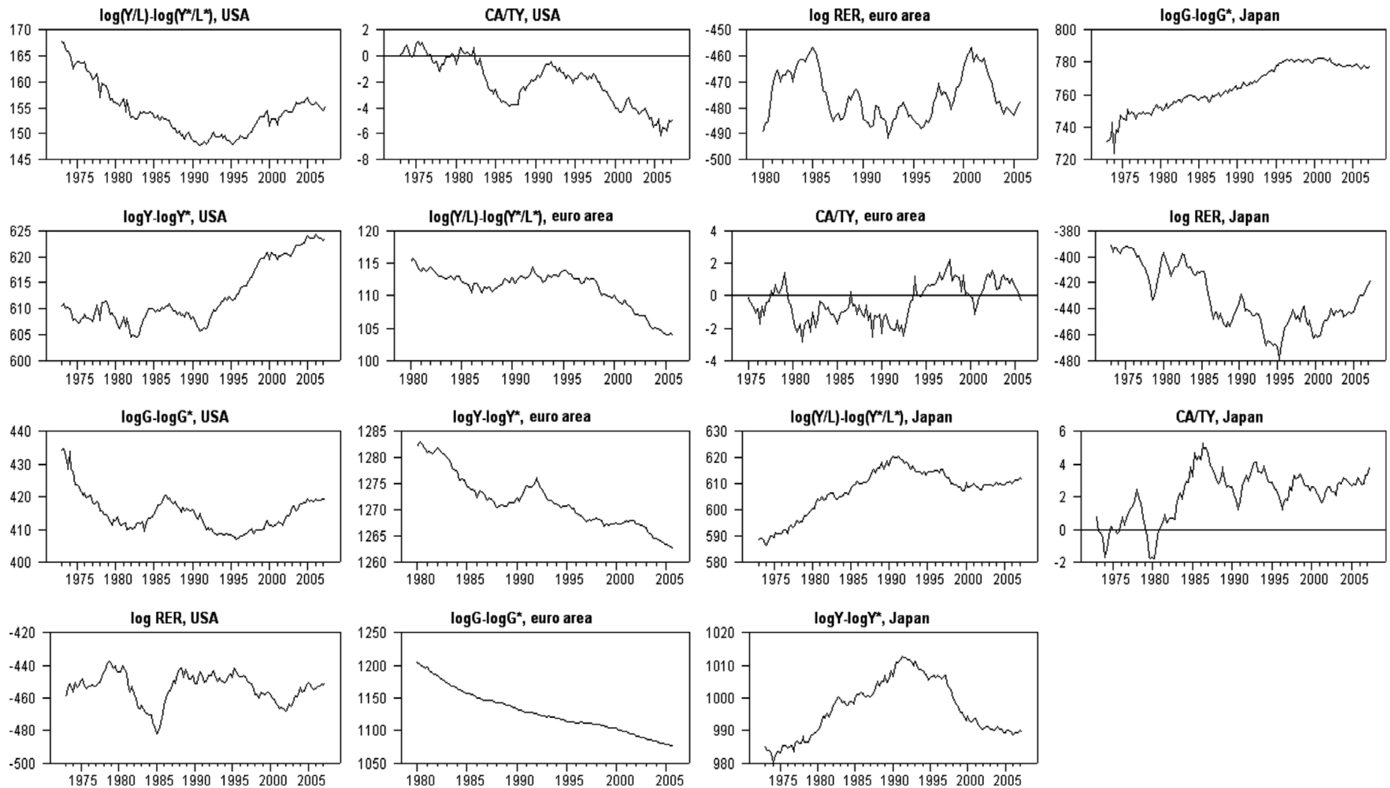

FIGURE 1. Data.

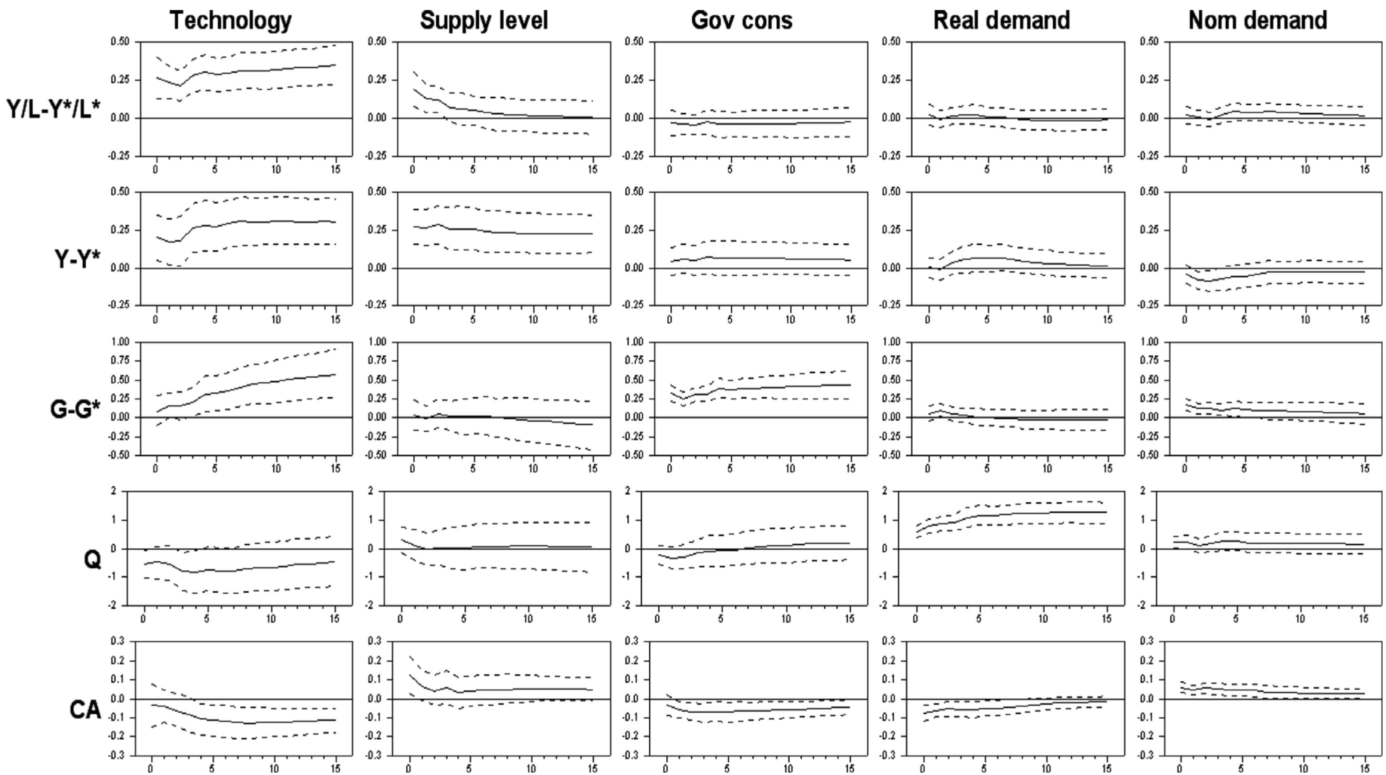

FIGURE 2. Impulse responses to one-standard-deviation shocks: United States.

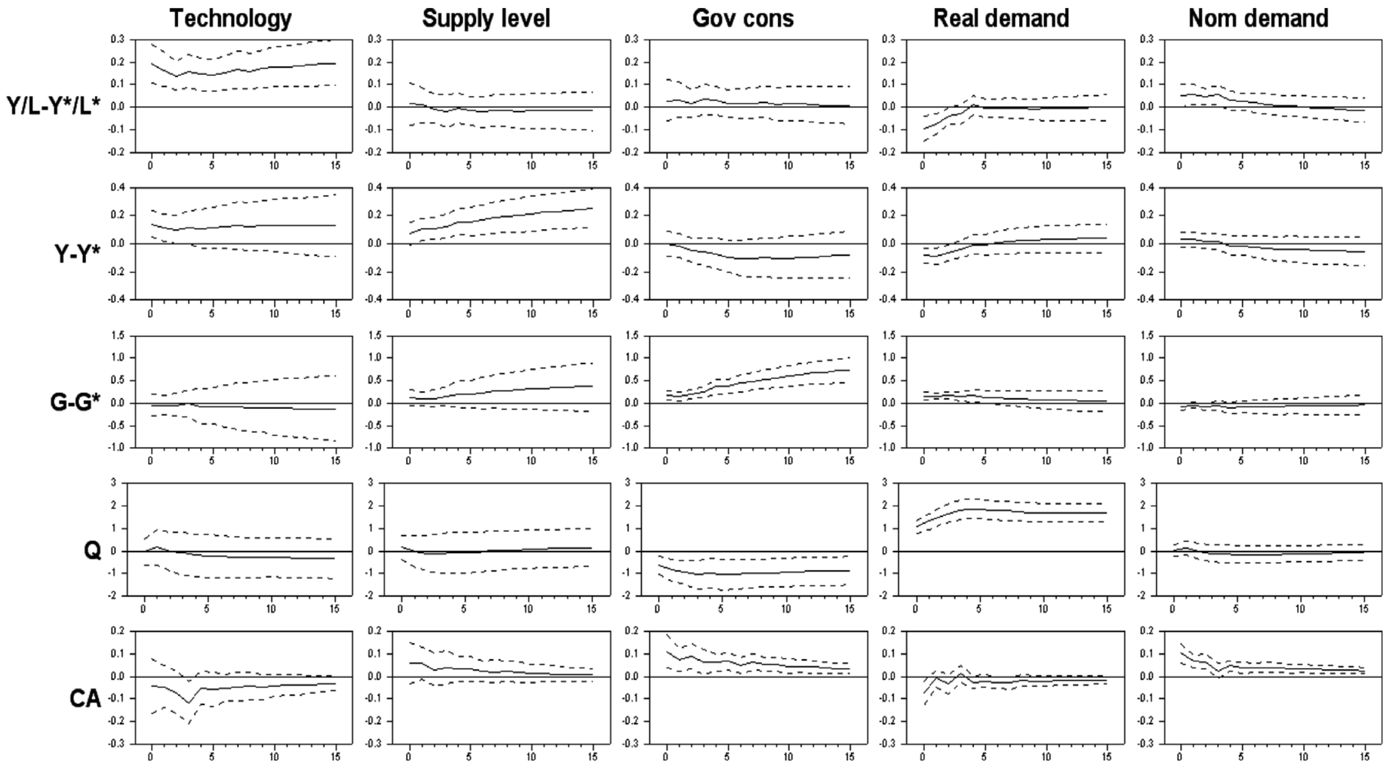

FIGURE 3. Impulse responses to one-standard-deviation shocks: Euro area.

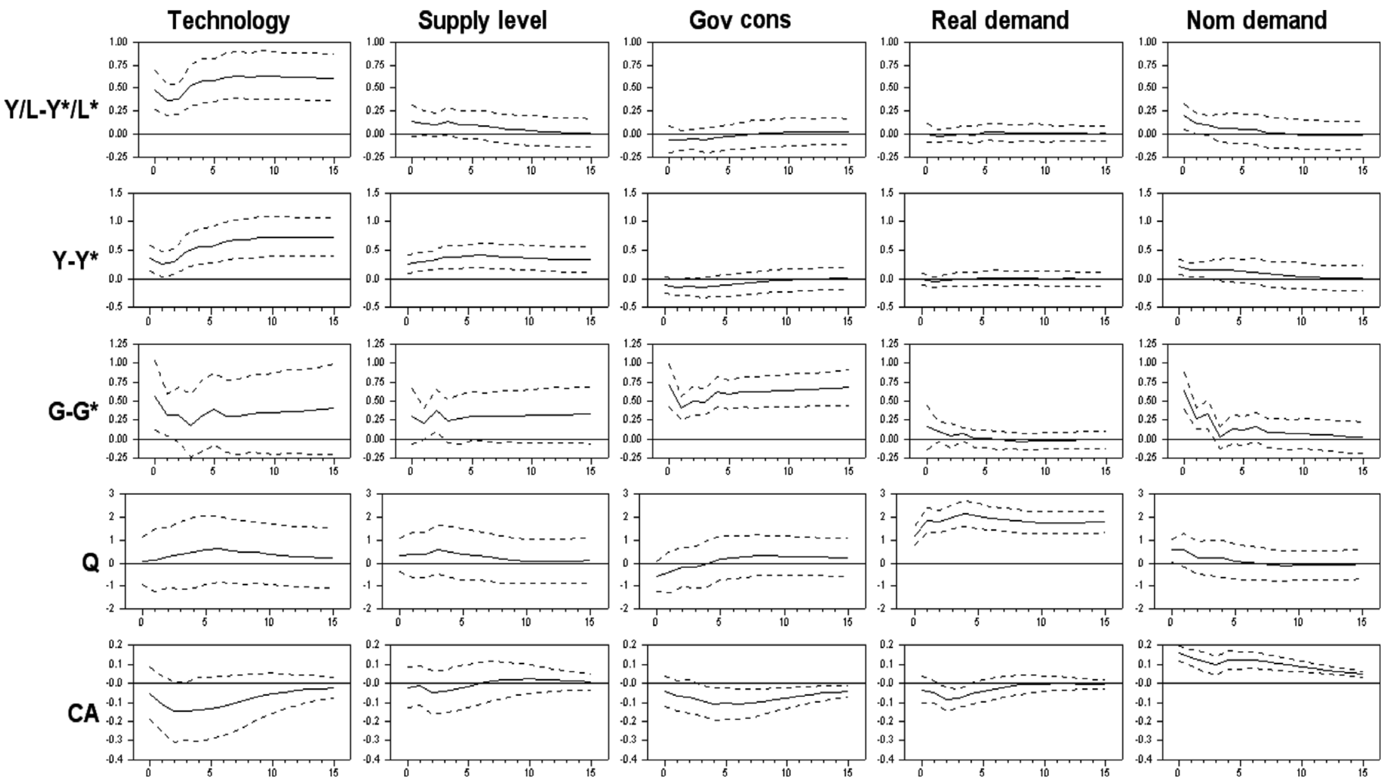

FIGURE 4. Impulse responses to one-standard-deviation shocks: Japan.

that are common across countries, with emphasis on responses whose standard deviation bands are distinctly away from zero.

Positive technology shocks increase relative labor productivity and output in all three economies, having the largest effects in Japan. They worsen current accounts in all countries, persistently in the United States, and more in the short run than in the long run in Japan and the euro area. A short-run worsening in the current account following a permanent technology shock is consistent with the prediction of the basic intertemporal model [Obstfeld and Rogoff (1995)] and recent findings of Corsetti et al. (2009) for the United States.[5] Government consumption tends to rise in response to positive technology shocks—except for the euro area, in which it does not change much—partly because the level of government consumption increases endogenously in response to the permanent output increase induced by positive technology shocks.

The effects of technology shocks on the real exchange rate are different across countries in the short run, but similarly converge to a zero response in the long run (zero responses are well within the interior of the standard error bands in all countries). The diversity of short-run responses in three economies is not surprising given theoretical results that the effects of technology shocks on real exchange rate are ambiguous.[6] In the United States, in particular, the exchange rate appreciates in the short run, consistent with the results of existing studies [Corsetti et al. (2006); Enders and Muller (2009); and Enders et al. (2009)]. The long-run zero responses suggest that the counteracting factors—the terms of trade and Harrod–Balassa–Samuelson effects—cancel each other out in the long run, consistent with results obtained from single-equation estimations [e.g., Lee and Tang (2007)].

In response to supply-level shocks, relative output increases both in the short run and in the long run, with the standard error bands clearly above the zero line. Differently from the case of technology shocks, labor productivity does not change much even in the short run. We find a temporary increase in productivity in the United States and Japan, and a very small change in productivity in the euro area. Again, differently from the case of technology shocks, the current account improves in the short run in the United States and the euro area. Whereas technology shocks increase the investment need and worsen current account balances, supply-level shocks without productivity improvement do not necessarily generate a strong increase in investment or worsen current account balances. Real exchange rate does not respond much. Government consumption tends to increase, again as an endogenous response to a permanent increase in output under supply-level shocks.

Government-consumption shocks bring about permanent increases in government consumption in all countries. In the euro area, in particular, government consumption increases over time, leading to a long-run effect that is far larger than the initial effect. Current account balance deteriorates in Japan and the United States, whereas it improves in the euro area. Diverse current account responses are to be expected, given the theoretical ambiguity of the effects of permanent increases in government consumption.[7]

Real exchange rate appreciates in all countries in response to government-consumption shocks. Real exchange rate appreciation is strong and clear in the euro area, whereas a small and short-run appreciation is found in the United States and Japan. Real exchange rate appreciation is consistent with the basic theoretical predictions; as government consumption falls mostly on domestic goods, the real exchange rate appreciates. Output and labor productivity responses have wide confidence bands that include zero responses.

Real demand shocks depreciate the real exchange rate in both the short run and long run and worsen current accounts in the short run in all countries. However, they have little effect on the other variables—productivity, output, and government consumption. These responses are consistent with theoretical predictions on the effect of taste shocks in favor of foreign goods, which can be regarded as a type of demand shock often discussed in international business cycle studies; as the relative demand for foreign goods over domestic goods increases, the relative price of foreign goods increases (the real exchange rate depreciates), and the current account worsens.[8]

Nominal demand shocks increase current account in all countries, depreciate the real exchange rate in the short run, increase government consumption in the short run in the United States and Japan, and increase output in the short run in Japan. The current account improvement and the real exchange rate depreciation following monetary shocks are also found in past studies, including those of Eichenbaum and Evans (1995), Kim and Roubini (2000), and Kim (2001). These responses are consistent with the following theoretical prediction: A nominal shock (e.g., monetary expansion) depreciates the real exchange rate and improves current account and output in the short run.[9]

Finally, the impulse responses reveal interesting correlations that are generated by various structural shocks. First, nominal- and real-demand shocks generate opposite correlations between current account and real exchange rate. As predicted by the theory, real-demand shocks (e.g., taste shocks) tend to generate a negative correlation, but nominal-demand shocks (e.g., monetary shocks) tend to generate a positive correlation, especially in the United States and Japan. These results urge caution in unconditional statements on the relationship between exchange rate and current account. Second, two types of supply shocks generate opposite correlations between current account and relative output. Technology shocks generate a negative correlation, but supply-level shocks generate a positive correlation, especially in the United States and Japan. This finding suggests that distinguishing two types of supply shocks is important in explaining the comovement between relative output and current account.

3.2. Sources of International Macroeconomic Fluctuations

To compare the relative importance of structural shocks in accounting for international fluctuations, Tables 1–9 report the forecast error variance decomposition. The numbers in parentheses are one-standard-error bands. The variance

TABLE 1. Forecast error variance decomposition of labor productivity differential (difference)

	Steps	United States	Euro area	Japan
Technology	4	50.4 (21.5, 79.0)	49.4 (21.9, 75.7)	57.9 (29.5, 84.2)
	16	50 (21.5, 78.0)	47.2 (22.4, 11.7)	57.1 (30.5, 82.1)
Supply level	4	32.4 (7.7, 60.1)	12.3 (1.4, 24.8)	12.6 (1.4, 24.4)
	16	32.1 (8.2, 58.6)	13.1 (2.4, 25.2)	13.2 (2.3, 24.4)
Gov cons	4	8.2 (1.0, 15.6)	13.7 (1.7, 26.8)	8.1 (0.8, 15.2)
	16	8.3 (1.1, 15.8)	13.5 (2.5, 25.5)	8.4 (1.1, 15.3)
Real demand	4	4.7 (0.8, 8.4)	16.7 (4.0, 28.5)	4.2 (0.5, 7.2)
	16	4.9 (1.0, 8.7)	17.5 (5.7, 29.1)	4.5 (0.8, 7.7)
Nom demand	4	4.3 (0.7, 7.9)	8.0 (1.0, 15.2)	17.2 (3.8, 31.1)
	16	4.6 (1.0, 8.0)	8.7 (2.0, 15.4)	16.9 (4.0, 30.1)

TABLE 2. Forecast error variance decomposition of labor productivity differential (level)

	Steps	United States	Euro area	Japan
Technology	4	58.1 (27.7, 85.6)	53.0 (24.8, 79.6)	63.0 (33.9, 88.9)
	16	68.8 (44.1, 90.8)	58.9 (27.7, 84.7)	73.8 (53.3, 92.2)
Supply level	4	25.3 (3.7, 50.8)	11.9 (1.1, 24.3)	12.6 (1.0, 25.7)
	16	14.2 (2.3, 25.9)	13.5 (1.3, 26.5)	8.8 (1.1, 16.3)
Gov cons	4	9.1 (0.5, 18.2)	13.6 (1.1, 27.5)	8.7 (0.5, 15.9)
	16	9.2 (0.5, 19.3)	13.4 (1.5, 26.1)	7.5 (0.5, 14.4)
Real demand	4	3.8 (0.3, 7.0)	11.8 (2.2, 21.6)	3.6 (0.3, 6.6)
	16	3.6 (0.4, 6.1)	7.3 (1.7, 12.7)	2.9 (0.2, 5.4)
Nom demand	4	3.6 (0.3, 7.1)	9.8 (0.9, 19.3)	12.1 (1.9, 23.5)
	16	4.2 (0.3, 7.8)	6.9 (1.3, 12.6)	7.0 (1.2, 12.9)

decomposition is reported twice for each variable, for both the levels and first differences, except for the current account, in which the result is reported only for the level.

Fluctuations in relative labor productivity are mainly explained by technology shocks. For the level of relative labor productivity, technology shocks explain more than 53% of variation in all three economies (for the difference of relative labor productivity, it explains more than 47% in all cases). In the United States, supply-level shocks also play a significant role, explaining more than one-fourth of the one-year-horizon variation in both the level and difference of relative labor productivity.

Fluctuations in relative output are mostly explained by technology shocks and supply-level shocks. The combination of the two shocks explains more than 61% of the relative output variations in all three economies, although the relative

TABLE 3. Forecast error variance decomposition of output differential (difference)

	Steps	United States	Euro area	Japan
Technology	4	35.8 (11.8, 60.6)	40.6 (12.9, 67.5)	45.2 (16.3, 73.0)
	16	36.0 (12.6, 60.3)	38.6 (14.8, 61.6)	45.9 (19.5, 71.6)
Supply level	4	45.2 (18.9, 72.9)	21.9 (4.2, 43.3)	24.9 (4.5, 47.0)
	16	44.5 (18.6, 71.2)	22.6 (6.1, 40.0)	24.0 (4.9, 44.5)
Gov cons	4	8.0 (1.3, 13.8)	13.9 (3.0, 25.6)	9.4 (1.2, 18.7)
	16	8.0 (1.4, 13.8)	14.2 (4.3, 24.0)	9.8 (1.4, 19.0)
Real demand	4	5.7 (1.4, 9.2)	17.0 (5.6, 29.9)	4.7 (0.8, 7.9)
	16	6.0 (1.6, 9.5)	17.3 (7.3, 27.8)	4.8 (1.1, 7.9)
Nom demand	4	5.2 (1.4, 9.0)	6.5 (0.8, 12.1)	15.8 (3.5, 28.3)
	16	5.5 (1.6, 9.3)	7.3 (1.9, 12.6)	15.5 (4.0, 26.7)

TABLE 4. Forecast error variance decomposition of output differential (level)

	Steps	United States	Euro area	Japan
Technology	4	32.4 (5.7, 60.1)	34.8 (5.4, 66.2)	38.8 (6.8, 70.2)
	16	44.4 (12.9, 72.5)	30.4 (4.3, 60.7)	56.4 (26.2, 84.1)
Supply level	4	47.3 (15.7, 79.8)	29.2 (4.1, 58.7)	33.7 (6.5, 64.1)
	16	37.3 (8.6, 67.4)	37.5 (7.7, 68.0)	25.4 (4.9, 48.7)
Gov cons	4	8.3 (0.6, 15.8)	14.9 (1.8, 28.3)	10.8 (0.6, 22.4)
	16	8.5 (0.5, 15.5)	17.1 (1.8, 34.8)	7.8 (0.6, 14.9)
Real demand	4	5.4 (0.5, 9.3)	14.1 (2.3, 27.6)	4.0 (0.3, 7.2)
	16	5.4 (0.4, 9.2)	8.0 (1.7, 14.3)	3.0 (0.2, 5.0)
Nom demand	4	6.6 (0.6, 12.9)	6.9 (0.5, 13.2)	12.6 (1.3, 23.9)
	16	4.4 (0.5, 7.9)	7.1 (0.7, 12.9)	7.4 (1.1, 13.3)

TABLE 5. Forecast error variance decomposition of government consumption differential (difference)

	Steps	United States	Euro area	Japan
Technology	4	20.2 (5.8, 35.9)	24.9 (5.3, 47.8)	24.6 (5.5, 44.9)
	16	24.2 (9.1, 39.9)	26.9 (7.3, 48.6)	25.4 (6.9, 45.3)
Supply level	4	16.4 (2.8, 32.0)	22.5 (3.6, 44.9)	12.6 (2.5, 23.7)
	16	16.5 (3.3, 32.0)	22.1 (4.1, 42.1)	12.5 (2.7, 23.3)
Gov cons	4	41.2 (22.2, 60.4)	25.3 (5.1, 47.5)	27.2 (8.0, 47.0)
	16	38.6 (21.0, 55.5)	28.1 (8.8, 47.7)	26.9 (8.2, 45.9)
Real demand	4	7.7 (1.8, 13.2)	17.5 (4.9, 31.3)	5.9 (0.8, 10.4)
	16	7.4 (2.0, 12.5)	14.1 (5.0, 24.0)	6.0 (1.0, 10.4)
Nom demand	4	14.5 (3.3, 26.0)	9.8 (1.9, 17.8)	29.7 (12.4, 47.9)
	16	13.4 (3.3, 23.3)	8.8 (2.2, 15.7)	29.3 (12.4, 46.9)

TABLE 6. Forecast error variance decomposition of government consumption differential (level)

	Steps	United States	Euro area	Japan
Technology	4	23.4 (4.0, 45.3)	24.6 (2.7, 50.2)	26.0 (5.7, 48.0)
	16	42.0 (11.5, 69.6)	25.6 (2.4, 2.5)	29.2 (4.4, 56.3)
Supply level	4	14.4 (1.4, 29.6)	21.6 (2.0, 46.1)	15.5 (2.4, 30.1)
	16	13.5 (1.2, 28.1)	23.6 (2.2, 48.4)	17.8 (2.0, 35.5)
Gov cons	4	42.9 (20.4, 64.8)	28.3 (5.3, 52.7)	33.7 (12.3, 56.0)
	16	33.6 (12.8, 57.0)	40.1 (15.3, 67.6)	41.4 (17.2, 67.2)
Real demand	4	6.8 (0.7, 12.6)	18.2 (3.6, 33.9)	4.8 (0.5, 8.5)
	16	4.3 (0.5, 6.8)	5.9 (1.0, 11.0)	2.6 (0.3, 4.4)
Nom demand	4	12.4 (1.8, 23.5)	7.2 (0.6, 13.9)	20.0 (6.7, 34.8)
	16	6.5 (0.8, 11.6)	4.8 (0.3, 9.2)	9.0 (2.4, 15.9)

TABLE 7. Forecast error variance decomposition of real exchange rate (difference)

	Steps	United States	Euro area	Japan
Technology	4	32.8 (11.6, 55.1)	16.0 (4.6, 29.0)	21.7 (4.9, 38.8)
	16	33.0 (13.3, 53.7)	16.6 (5.1, 29.5)	22.6 (6.0, 39.5)
Supply level	4	20.3 (5.2, 37.0)	13.2 (3.1, 24.0)	16.0 (2.7, 31.2)
	16	20.2 (5.7, 36.0)	13.5 (3.4, 24.2)	16.5 (3.2, 31.5)
Gov cons	4	11.7 (3.1, 20.7)	19.3 (4.1, 34.9)	15.0 (3.9, 26.6)
	16	12.3 (4.0, 21.0)	19.3 (4.3, 34.4)	15.6 (4.2, 27.1)
Real demand	4	27.4 (10.7, 45.3)	47.0 (28.3, 66.2)	33.6 (16.1, 51.8)
	16	26.7 (11.1, 42.5)	26.1 (27.8, 64.7)	32.0 (15.6, 49.0)
Nom demand	4	7.8 (1.7, 14.0)	4.5 (1.1, 7.9)	13.6 (2.6, 25.6)
	16	7.7 (2.0, 13.5)	4.6 (1.2, 7.8)	13.3 (2.6, 24.9)

TABLE 8. Forecast error variance decomposition of real exchange rate (level)

	Steps	United States	Euro area	Japan
Technology	4	28.3 (4.5, 53.8)	12.8 (1.5, 26.6)	20.5 (2.7, 41.8)
	16	24.5 (3.8, 47.5)	11.9 (1.3, 24.1)	21.9 (3.3, 43.9)
Supply level	4	15.2 (1.8, 31.4)	11.1 (1.0, 23.4)	14.2 (1.3, 29.8)
	16	14.9 (1.3, 31.3)	10.5 (0.9, 21.6)	13.2 (1.7, 26.7)
Gov cons	4	10.5 (1.1, 20.8)	21.0 (3.2, 38.9)	11.1 (1.3, 22.4)
	16	10.2 (1.5, 19.7)	20.1 (2.6, 38.1)	11.1 (1.4, 22.1)
Real demand	4	39.8 (17.6, 64.1)	51.8 (31.0, 72.9)	44.1 (22.1, 66.0)
	16	44.9 (22.4, 67.2)	54.4 (4.3, 74.7)	46.1 (24.7, 69.7)
Nom demand	4	6.2 (0.5, 12.0)	3.3 (0.3, 6.3)	10.1 (1.0, 20.5)
	16	5.4 (0.4, 10.3)	3.1 (0.2, 6.1)	7.8 (0.9, 13.8)

TABLE 9. Forecast error variance decomposition of current account (level)

	Steps	United States	Euro area	Japan
Technology	4	32.7 (7.4, 60.4)	32.0 (7.0, 9.8)	35.3 (5.5, 67.5)
	16	48.5 (18.1, 77.1)	32.3 (5.8, 62.8)	35.1 (5.6, 65.7)
Supply level	4	24.7 (4.5, 49.2)	19.0 (2.5, 9.0)	15.8 (1.3, 33.8)
	16	18.4 (2.7, 37.6)	18.1 (2.3, 36.9)	16.3 (2.0, 34.1)
Gov cons	4	16.4 (2.2, 32.4)	23.7 (5.4, 44.1)	13.0 (1.2, 26.8)
	16	15.6 (2.1, 30.2)	25.1 (5.6, 47.3)	17.2 (2.3, 34.1)
Real demand	4	14.9 (2.6, 28.0)	1.8 (1.7, 17.5)	10.7 (1.4, 20.9)
	16	10.2 (1.5, 18.6)	9.1 (1.3, 17.5)	7.7 (1.0, 15.1)
Nom demand	4	11.3 (2.2, 20.4)	15.9 (3.8, 28.6)	25.2 (8.1, 43.2)
	16	7.3 (1.4, 13.0)	15.3 (3.3, 28.1)	23.6 (8.0, 38.8)

importance between them varies across economies and horizons. When we look at the role of technology shocks in greater detail, they explain 32—46% of the variations in the United States, 30–41% in the euro area, and 38–57% in Japan. The other three demand shocks play relatively minor roles; each shock explains less than 20% at all horizons in all countries. Government-consumption shocks play some role in the euro area (13–18%) and Japan (7–11%). Real-demand shocks play some role in the euro area (8–18%), whereas nominal-demand shocks play some role in Japan (9–11%). For other cases, each shock explains less than 10% at all horizons.

This result on relative output contrasts with the results of studies, such as by Gali (1999) and Francis and Ramey (2005), involving closed economies. Their studies say that technology shocks play quite a limited role in explaining output fluctuations.[10] The difference is that we find that the role of technology shock in explaining the asymmetry of output fluctuations across countries is very large, whereas results of studies on closed economies refer to the fluctuation in output level itself (including the portion that is common across countries).[11] When we apply our identification assumption to output levels (not differences in output of trading partners), we also find similar results that technology shocks play a limited role in fluctuations in output.[12]

Fluctuations in relative government consumption are explained primarily by shocks to government consumption: 33–43%, 25–41%, and 26–42% of fluctuations in the United States, the euro area, and Japan, respectively. Technology shocks play the second most important role, explaining 20–42%, 24–27%, and 24–30% of fluctuations in the United States, the euro area, and Japan, respectively, reflecting the endogenous responses of government consumption to output, which were discussed earlier.

In explaining real-exchange rate fluctuations, real-demand shocks play the most important role. In the euro area, real-demand shocks explain more than 26–55% of the variation in the level and difference of real exchange rate. They explain 32–47% of the variation in Japan and 26–45% in the United States. On the other hand, technology shocks play the largest role among the other four shocks; they explain 24–33%, 11–17%, and 20–23% of the variation in the United States, the euro area, and Japan, respectively. The other three shocks play some roles, and the contribution of nominal-demand shocks is relatively small: 5–8% in the United States, 3–5% in the euro area, and 7–14% in Japan.

This result is consistent with that of the study by Clarida and Gali (1994) in terms of the importance of demand shocks broadly construed, but has some differences in the role of nominal shocks. They find that demand shocks are the most important source of real-exchange-rate fluctuations in their investigation of supply, demand, and monetary shocks in the context of the Mundell–Flemming–Dornbusch model. Our demand shocks and government-consumption shocks are similar to their demand shocks as regards identifying assumptions, making our results consistent with theirs in terms of the primary role played by demand shocks in explaining exchange-rate fluctuations.

As for the role of nominal shocks, some differences seem to arise at first glance, because Clarida and Gali (1994) also document an important role of monetary shocks. However, their results do not necessarily contradict ours, given that the exchange rates under consideration are different. Clarida and Gali (1994) investigate the bilateral exchange rate of the United States vis-à-vis Germany, Japan, Canada, and the United Kingdom, whereas we investigate effective exchange rates of the United States, the euro area, and Japan. They find an important role of monetary shocks for the U.S.–German and U.S.–Japan rates, but a small role for the other two (the U.S.–Canada and U.S.–U.K. rates). The heterogeneous effects on bilateral rates imply that the effects of nominal shocks on multilateral effective exchange rates may be relatively small, as shown by our results.

As for more recent studies, our results on exchange rate are compatible with those of the study by Lubik and Schorfheide (2005), who find that nominal-exchange-rate movements are not much explained by technology shocks, government-consumption shocks, or monetary policy shocks. However, our results are quite different from those of the study by Bergin (2003, 2006), who find an important role for monetary policy shocks but a less important role for taste shocks.[13]

Turning to current-account fluctuations, technology shocks are the most important source of fluctuations. The contributions are 32–49%, 32–33%, and 35–36% in the United States, in the euro area, and in Japan, respectively. However, no single shock explains more than 50% of current-account fluctuations in any country, and other shocks are also important sources of current-account fluctuations. In the United States, supply-level and government-consumption shocks explain 18–25% and 15–17% of the fluctuations, respectively. In the euro area, supply-level, government-consumption, and nominal-demand shocks explain 18–19%, 23–26%, and 15–16% of the fluctuations, respectively. In Japan, supply-level, government-consumption, and nominal-demand shocks explain 15–17%, 13–18%, and 23–25%, respectively. These results suggest that although technology shocks are important, no single source of shocks consistently plays a dominant role in explaining current-account dynamics, urging caution against attempts to find a monocausal explanation for current-account imbalances in all places and periods.

In summary, technology shocks play a substantial role in explaining fluctuations in relative labor productivity, relative output, and current account, but play a weaker role in explaining fluctuations in exchange rate and government consumption. Two supply-side shocks—technology and supply-level—explain most of the fluctuations in relative output, a sharp contrast to their relatively minor roles in explaining fluctuations in output levels *within* each country. In explaining current-account fluctuations, various types of structural shocks play some role, although technology shocks play the most important role. Finally, real-demand shocks are the most important source of exchange-rate fluctuations, whereas technology shocks play a secondary role.

4. EXTENDED EXPERIMENTS

4.1. Historical Decomposition

Although the forecast error variance decomposition reports the contribution of each structural shock averaged over the sample period, it does not show directly the role of each shock in different historical episodes. In this section, we examine the historical role of each structural shock by using historical decomposition, reported in Figures 5–7. The first column (named "deterministic") shows the actual series (dashed line) and the contribution of the deterministic part (solid line). In other columns (under the name of each shock), the dashed line shows the difference between the actual series and the contribution of the deterministic part, and the solid line shows the contribution of each structural shock in explaining that difference. Although log-differenced values for labor productivity, output, and real exchange rate are used in the estimation, we construct the log-level decompositions by cumulating the decomposed contributions for a better exposure.[14]

The results are consistent with the main findings from the variance decomposition and highlight the roles played by particular shocks in different places and at different times. Technology shocks explain most of the historical variations in labor productivity in all three economies. Relative output fluctuations are explained mostly by technology shocks and supply-level shocks. Interestingly, negative supply-level shocks have been prominent in the 1980s and 1990s in the euro area, offsetting the strong productivity development in the 1990s. This resonates with the result of the study by Blanchard (2004), who finds that labor supply in European countries is lower than that in the United States, thus offsetting the strong productivity growth of Europe. In contrast, relative output fluctuations in Japan and the United States are predominantly explained by productivity shocks, with supply-level shocks playing a relatively minor role. In particular, Japan's boom in the 1970s and 1980s and its prolonged recession since 1990 are mostly attributed to productivity shocks.

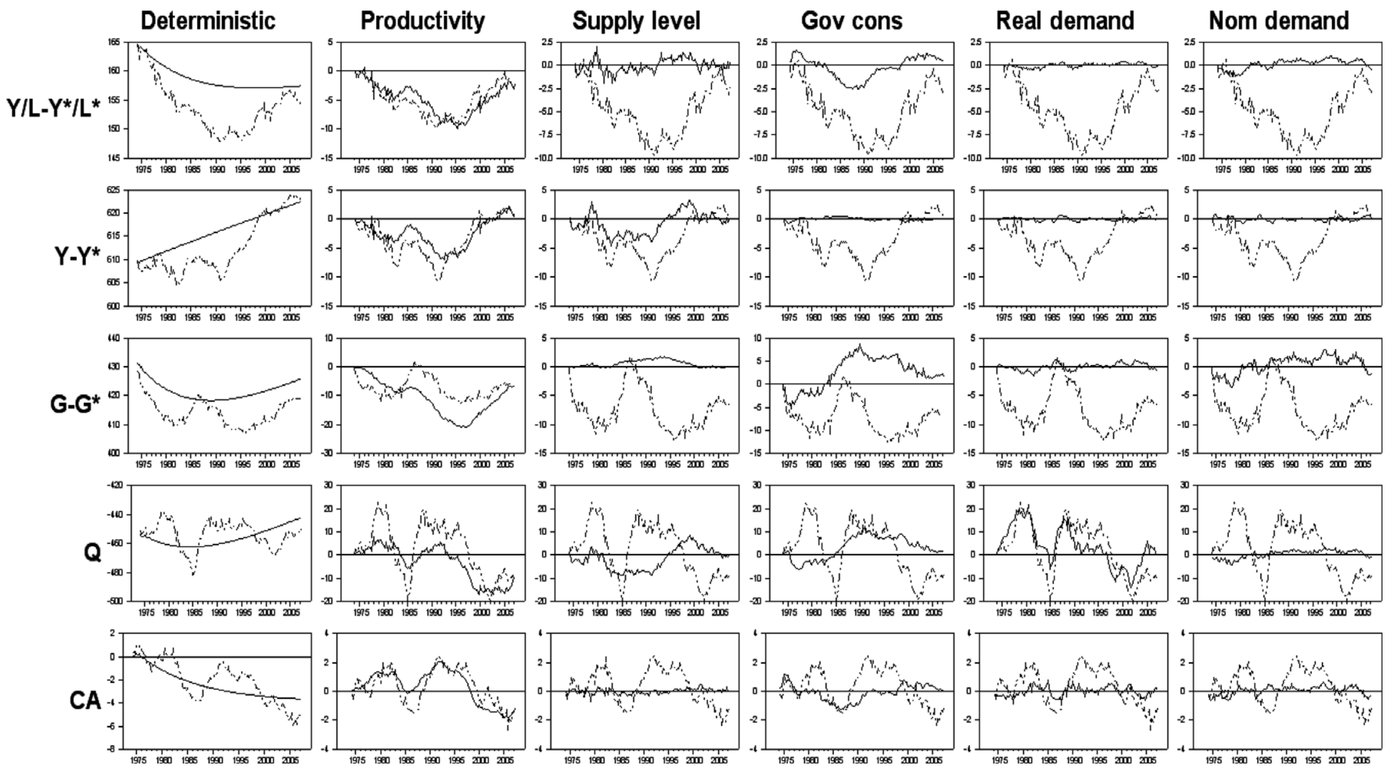

FIGURE 5. Historical decomposition: United States.

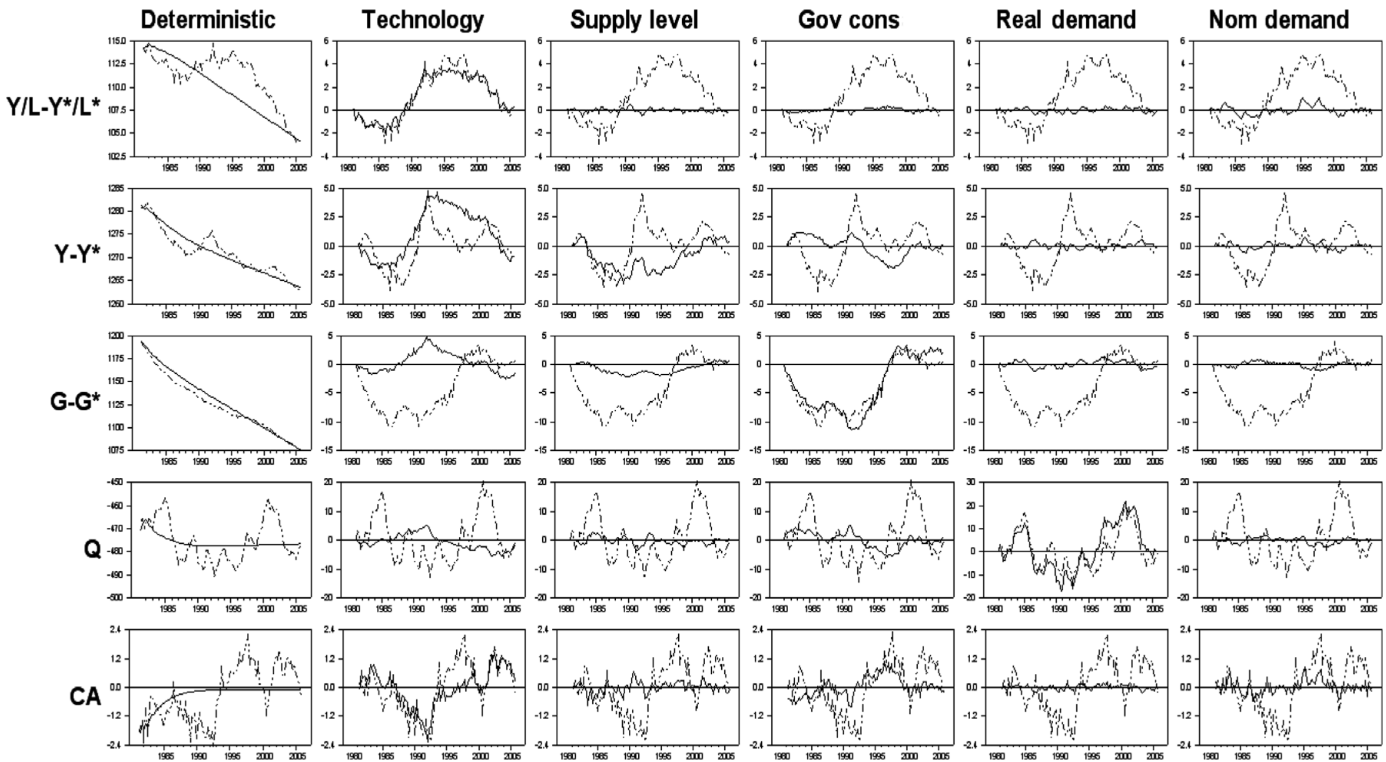

FIGURE 6. Historical decomposition: Euro area.

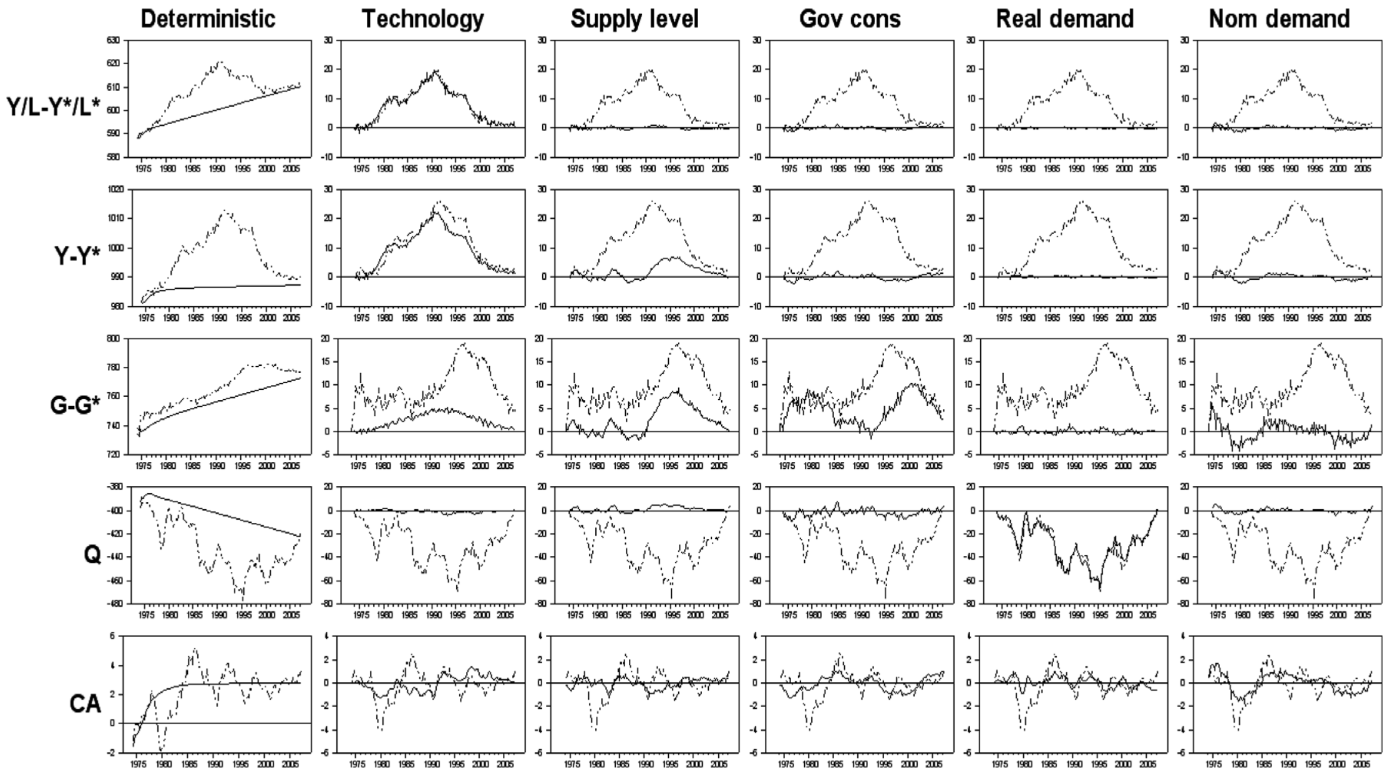

FIGURE 7. Historical decomposition: Japan.

Relative government consumption is mainly explained by government-consumption shocks, especially in the euro area. In the United States, technology shocks are also important on some occasions. The decrease in government consumption in the late 1970s and the decrease from the late 1980s to the mid-1990s are mainly due to technology shocks, whereas the increase in government consumption in the early 1980s is mainly due to government-consumption shocks. In Japan, government-consumption shocks explain most of the movements in government consumption in the early part of the sample, whereas both supply-level and government-consumption shocks are responsible for the later part of the sample.

Real-demand shocks explain the largest part of real-exchange-rate movements in the euro area and Japan, but exchange-rate movements in the United States are attributed to more diverse shocks. In the United States, both technology and real-demand shocks play important roles in real-exchange-rate appreciation and depreciation during the 1980s and real depreciation in the 1990s. Government-consumption shocks also explain part of the real depreciation in the late 1980s.

Current-account movements are mostly explained by technology shocks in the United States; the current-account deterioration from the 1990s is mostly explained by technology shocks, whereas the current-account deterioration in the late 1980s is explained by both technology and government-consumption shocks. In the euro area, technology shocks contribute to the deterioration of the current account in the late 1980s and early 1990s and the improvement of the current account in the 2000s. Government-consumption shocks contributed to the improvement of the current account in the late 1990s. In Japan, nominal-demand shocks play an important role in current-account fluctuations, especially in the early sample period, but other shocks also contribute to current-account movements.

There has been much debate on global imbalances in both academic and policy circles, motivated by the large current-account deficits of the United States. One prominent area of debate has been the role of government budget deficits in the current-account deficit [Chinn (2005)]. Blanchard et al. (2005) say that taste shocks have an important role in explaining the current-account deficit of the United States, and highlight the role of changes in asset valuation.[15] From the historical decomposition, however, the deterioration of the current account of the United States since the mid-1990s is mostly due to asymmetry in technology shocks, echoing the interpretation of Engel and Rogers (2006). The improvement in the current account of Europe in the 2000s is also mostly due to (relative) technology shocks. In Japan, technology shocks tend to have positive effects on the current account in the 2000s. Overall, shocks to productivity differential across countries seem to have played a large role in generating recent global imbalances. We note that technology shocks played substantial roles in the recent swing in the U.S. real exchange rate (especially appreciation in the late 1990s and early 2000s), although it played a relatively minor role in exchange-rate fluctuations in Japan and the euro area. Taken together, technology shocks appear to have played an important role in the development of the U.S. real exchange rate and current account in recent years.[16]

4.2. Subsamples and Extended Models

In this section, we examine the robustness of the main results in various ways. First, the full sample periods are relatively long. The economic structure and the role of various structural shocks may change over time. To explore the issue, we estimate the model for subsample periods. We estimate the baseline model for two subsample periods, the first twenty years ("First") and the last twenty years ("Last").[17] Here we focus on the main results, especially the sources of fluctuations in output differential, real exchange rate, and current account.[18]

Second, we consider the labor productivity of each region instead of the relative labor productivity of each region against the rest of the world, as in Enders and Muller (2009), because some theoretical models suggest that relative productivity should be stationary. In this model, we replace the relative labor productivity of each region against the rest of the model with the labor productivity of each region, and use the same identifying assumptions ("Tech").

Third, we extend the baseline model by including other key open-economy macro variables such as inflation differential (CPI), real-interest-rate differential (RIR), and commodity price growth (CMPN). We include each variable one by one in the baseline model. For identifying assumptions, we keep the recursive LR restrictions and order the new variable as the fifth variable as follows:

$$\begin{bmatrix} d(\log \frac{Y_t}{N_t} - \log \frac{Y_t^*}{N_{t*}^*}) \\ d(\log Y_t - \log Y_t^*) \\ d(\log G_t - \log G_t^*) \\ d(\log Q_t) \\ dX_t \\ CA_t \end{bmatrix} = \begin{bmatrix} G_{11}(L) & G_{12}(L) & G_{13}(L) & G_{14}(L) & G_{15}(L) & G_{16}(L) \\ G_{21}(L) & G_{22}(L) & G_{23}(L) & G_{24}(L) & G_{25}(L) & G_{26}(L) \\ G_{31}(L) & G_{32}(L) & G_{33}(L) & G_{34}(L) & G_{35}(L) & G_{36}(L) \\ G_{41}(L) & G_{42}(L) & G_{43}(L) & G_{44}(L) & G_{45}(L) & G_{46}(L) \\ G_{51}(L) & G_{52}(L) & G_{53}(L) & G_{54}(L) & G_{55}(L) & G_{56}(L) \\ G_{61}(L) & G_{62}(L) & G_{63}(L) & G_{64}(L) & G_{65}(L) & G_{66}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{T,t} \\ \varepsilon_{S,t} \\ \varepsilon_{G,t} \\ \varepsilon_{D,t} \\ \varepsilon_{X,t} \\ \varepsilon_{N,t} \end{bmatrix}, \quad (4)$$

$$Gij(1) = 0 \text{ for } ij = 12, 13, 14, 15, 16, 23, 24, 25, 26, 34, 35, 36, 45, 46, 56$$

where dX is the new variable.[19]

Table 10 shows the results for forecast error variance decomposition of output. The contribution of each shock at the 16-quarter horizon is reported for the level of each variable. In almost all cases, two types of supply shocks explain a huge portion of output fluctuations. In particular, the contribution of technology shocks is quite substantial. However, the contribution of each demand shock is relatively small in most cases.

Table 10. Forecast error variance decomposition of output differential (level, 16 quarter horizon): Extended models

	Baseline	First	Second	Tech	CPI	RIR	CMPN
			(1) United States				
Technology	44.4	31.8	64.1	51.3	46.6	56.1	56.0
Supply lev	37.3	40.7	15.9	22.7	29.6	23.3	17.4
Gov cons	8.5	12.0	8.9	16.7	8.6	7.0	5.7
Real dem	5.4	8.3	6.4	4.3	6.0	6.9	4.5
No dem 1	4.4	7.2	4.7	5.0	4.9	2.8	3.6
No dem 2	—	—	—	—	4.2	3.9	12.7
			(2) Euro area				
Technology	30.4	27.3	32.4	21.0	10.3	32.2	26.5
Supply lev	37.5	28.0	41.8	44.4	9.2	33.8	26.7
Gov cons	17.1	24.5	8.8	19.2	34.6	17.4	22.1
Real dem	8.0	9.2	10.2	8.1	28.4	8.3	12.8
No dem 1	7.1	10.9	6.8	7.3	16.8	4.5	3.1
No dem 2	—	—	—	—	0.7	4.0	8.8
			(3) Japan				
Technology	56.4	53.2	68.4	53.3	47.1	37.6	57.3
Supply lev	25.4	35.0	15.6	26.5	30.4	14.2	17.9
Gov cons	7.8	5.9	3.9	8.1	10.1	18.8	11.5
Real dem	3.0	3.2	6.4	3.4	3.2	5.2	3.2
No dem 1	7.4	2.7	5.6	8.7	4.0	7.3	1.9
No dem 2	—	—	—	—	5.1	17.0	8.1

Table 11 reports the results for forecast error variance decomposition of real exchange rate. As in the baseline case, the contribution of real demand shocks is the largest in most cases. Technology shocks play some roles, especially in the United States and Japan. The role of nominal shocks is relatively small in almost all cases.

Table 12 displays the results for forecast error variance decomposition of current account. As in the baseline model, the contribution of technology shocks is the largest in almost all cases, but other shocks also play some role.

5. CONCLUSION

We study international macroeconomic fluctuations using a structural VAR model, identified by long-run zero restrictions that are consistent with a variety of open-economy models. Using data on the United States, the euro area, and Japan—the three largest economies—during the flexible-exchange-rate regime period, we discuss the transmission of a variety of structural shocks and the sources of international macroeconomic fluctuations (including fluctuations in the relative output, real exchange rate, and current account). Despite some differences among the three

TABLE 11. Forecast error variance decomposition of real exchange rate (level, 16 quarter horizon): Extended models

	Baseline	First	Second	Tech	CPI	RIR	CMPN
(1) United States							
Technology	24.5	25.4	46.6	19.9	25.9	25.7	29.5
Supply lev	14.9	18.6	12.8	15.1	14.0	15.5	15.5
Gov cons	10.2	14.0	23.2	13.2	8.7	9.2	8.7
Real dem	44.9	33.6	14.1	46.5	41.1	42.9	25.8
No dem 1	5.4	8.4	3.4	5.2	5.5	2.4	3.6
No dem 2	—	—	—	—	4.8	4.2	17.0
(2) Euro area							
Technology	11.9	18.8	14.6	17.9	17.6	13.6	13.6
Supply lev	10.5	14.9	11.2	13.4	12.2	11.5	10.6
Gov cons	20.1	23.3	16.2	18.6	14.0	19.5	20.7
Real dem	54.4	39.6	54.0	46.1	41.5	50.8	49.2
No dem 1	3.1	3.4	4.0	4.0	11.7	2.6	1.7
No dem 2	—	—	—	—	3.0	2.1	4.1
(3) Japan							
Technology	21.9	24.3	47.3	19.2	23.3	24.7	34.3
Supply lev	13.2	20.0	18.5	18.5	16.5	11.4	14.9
Gov cons	11.1	13.0	7.3	9.9	13.5	22.8	15.2
Real dem	46.1	34.9	21.7	44.5	36.2	12.7	21.9
No dem 1	7.8	7.8	5.2	7.9	5.4	6.4	2.0
No dem 2	—	—	—	—	5.1	21.9	11.8

economies, we find many similarities among them in international macroeconomic fluctuations.

Impulse responses confirm many past findings, adding to the confidence that our VAR captures well various structural shocks. To name a few patterns, positive technology shocks worsen the current account; real-demand shocks cause depreciation of real exchange rate and worsen the current account; and nominal-demand shocks tend to cause depreciation of real exchange rate and improve current account.

There are several novel findings on impulse response: positive supply-level shocks tend to improve current account, and permanent government-consumption shocks tend to appreciate the real exchange rate. Taken together, these results imply several conditional correlations that are noteworthy. Technology and supply-level shocks generate opposite-signed correlations between relative output and current account. Real and nominal demand shocks generate opposite-signed correlations between current account and real exchange rate.

Several novel results emerge on the sources of international macroeconomic fluctuations. First, supply-side shocks, comprising technology shocks and supply-level shocks, explain most fluctuations in cross-country output differentials. Second, real-demand shocks are the most important source of real-exchange-rate fluctuations, although other shocks like technology shocks also play an important

TABLE 12. Forecast error variance decomposition of current account (level, 16 quarter horizon): Extended models

	Baseline	First	Second	Tech	CPI	RIR	CMPN
			(1) United States				
Technology	48.5	25.2	53.9	31.1	31.7	59.2	52.1
Supply lev	18.4	24.2	15.3	24.6	24.4	16.3	11.7
Gov cons	15.6	22.0	12.7	29.8	14.8	12.1	4.9
Real dem	10.2	15.3	9.5	7.4	14.8	5.4	3.4
No dem 1	7.3	13.2	8.6	7.0	7.8	1.6	5.0
No dem 2	—	—	—	—	6.5	5.4	22.8
			(2) Euro area				
Technology	32.3	33.9	40.7	29.1	26.8	31.7	14.5
Supply lev	18.1	19.1	19.2	18.4	13.5	15.7	10.9
Gov cons	25.1	25.4	12.1	25.2	15.6	15.0	30.9
Real dem	9.1	9.5	10.9	8.9	25.1	20.1	22.9
No dem 1	15.3	12.1	17.1	18.4	15.7	8.8	3.5
No dem 2	—	—	—	—	3.3	8.6	17.3
			(3) Japan				
Technology	35.1	27.6	49.1	25.9	39.6	27.5	41.6
Supply lev	16.3	20.6	18.6	26.0	25.7	10.6	14.1
Gov cons	17.2	23.3	12.2	16.2	18.8	22.6	20.1
Real dem	7.7	14.0	10.5	8.0	4.3	6.8	4.6
No dem 1	23.6	14.6	9.6	23.8	4.1	6.5	2.4
No dem 2	—	—	—	—	7.6	25.9	17.2

role. Third, current account is usually influenced by all types of shocks, with technology shocks playing the most important role. In particular, technology shocks appear to have played the dominant role in the large current-account imbalance of the United States from the mid-1990s.

NOTES

1. See Kim and Lee (2008) for a standard open economy DSGE model that is consistent with these restrictions.
2. See the Data Appendix for details on data.
3. We also perform the Johansen cointegration tests. For the United States and the euro area, the null of no cointegrating relation among relative labor productivity, relative real GDP, real government consumption, and real effective exchange rate is not rejected at the 5% level of significance in various specifications, consistent with the theoretical model. However, the cointegration test rejects the null of no cointegrating relation among those variables at the 5% level of significance for Japan, though the test does not reject the null of one or at most one cointegrating relation. Following the results of the cointegration test, we also consider a model that allows one cointegrating relation among the four variables for Japan. We first estimate the cointegrating relation by dynamic ordinary least squares [Stock and Watson (1993)] and then impose the cointegrating relation on the VAR model to construct the vector error correction model. The main findings are consistent with those from the basic model, and the results can be obtained from the authors upon request.

4. The solid line is the median response from bootstrapping, whereas the dotted lines are 68% probability bands.

5. Because, in our empirical results, effects on output and labor productivity last in the long run, we can confirm that technology shocks identified in the model are permanent. In the basic intertemporal model, a permanent technology shock increases investment and decreases savings, leading to the worsening of current account.

6. In Obstfeld and Rogoff (1995), and Kim and Lee (2008), positive technology shocks increase consumption and demand for money, thereby appreciating the nominal and real exchange rates. On the other hand, Corsetti et al. (2006) show that the exchange rate effects of technology shocks change signs, depending on whether the technology shocks fall more on the tradables or nontradables sector.

7. In the intertemporal model, a permanent increase in government consumption does not have any effect on current account as it does not generate any intertemporal smoothing motive. However, if the Ricardian equivalence does not hold, a permanent increase in government consumption may lead to worsening of current account. On the other hand, the new open economy macro model, like the one used by Obstfeld and Rogoff (1995), predicts improvement of current account. Refer to Kim (2013) and Kim and Roubini (2008) for more details on the theoretical predictions.

8. This result coincides with the empirical finding in the study by Lee and Chinn (2006), in which taste shocks were conjectured to drive the shocks that have a long-run effect on real exchange rate.

9. The output and real exchange rate responses for the euro area tend not to be statistically significant, but this may be related to the fact that the true common monetary policy started only from the establishment of EMU in 1999, whereas the data we used were from 1980. More puzzling is the output response in the United States, which may suggest the possibility that nominal shocks include other types of structural shocks besides monetary shocks. However, the output response to monetary shocks produces more intuitive results when the sample is split around the mid-1980s. These results are compatible with the widely reported Great Moderation and the change in the operating procedure of U.S. monetary policy in the early 1980s. See Bernanke (2004) for discussion and references.

10. Mitra and Sinclair (2012) used a multivariate unobserved-component model to examine the relative importance of permanent and temporary movements in explaining output fluctuations in G-7 countries. Gil-Alana and Moreno (2009) employ a model with fractional integration between output and labor. Pesavento and Rossi (2005) reinvestigate the effects of technology shocks on hours using approximations based on local-to-unity asymptotic theory.

11. Although Ahmed et al. (1993) find labor supply shocks playing an important role in explaining the fluctuations in output of the United States (thus within a country), we find that supply-level shocks (including labor-supply shocks) play a substantial role in explaining fluctuations in output differential (that is, the difference between the output of home and foreign countries). One does not necessarily follow from the other, though they are mutually consistent.

12. These results can be obtained from the authors upon request.

13. This difference must be attributable to identification strategies but is not easy to clarify, for the DSGE model-based estimation methods do not admit an immediate comparison with VAR analysis, as structural shocks are identified in different ways. We leave the resolution for future work.

14. We assume that the contribution of the deterministic term is equal to the actual series at the period before the initial data of historical decomposition, for which the contribution of each shock cannot be calculated.

15. In our framework, fiscal and taste shocks are almost equivalent observationally, in the sense that the same long-run restrictions can be used to identify them

16. It is possible that our results may not estimate precisely the role of technology shocks, considering the absence of China from the analysis, although China was an important counterpart to the U.S. current account deficit in recent years. Nevertheless, our results indicate a distinct role played by the strong U.S. productivity growth.

17. For the United States and Japan, we estimate the model for the periods 1973:2–1992:4 and 1987:4–2007:2. For the euro area, we estimate the model for the periods 1980:2–1998:4 and

1986:2–2005:4. We only use 19 years for the first subperiod for the euro area because in that way the sample period includes the pre-EMU period only.

18. Impulse responses of these alternative models are similar to those of the baseline model in many cases.

19. By ordering the variable second to last in the recursive structure, we can keep most identifying assumptions. That is, the first four shocks are identified similarly. For example, only technology shocks can affect the labor productivity differential. Note that the current account should be ordered last because the current account is stationary and no shocks can have a long-run effect on a stationary variable. Also note that the interpretations of the fifth and the sixth shocks (ε_X and $\varepsilon_{Z,}$) are different across models. When the inflation differential is included additionally, ε_X might be interpreted as asymmetric nominal shocks and ε_N might be interpreted as other nominal shocks, including temporary or symmetric nominal shocks. When the commodity price growth is included, ε_X might be interpreted as global nominal shocks. When the real interest rate differential is included, it may be hard to distinguish between ε_N and ε_X because all nominal shocks are not likely to affect the real interest rate in the long run.

REFERENCES

Ahmed, Shangil, Barry W. Ickes, Ping Wang, and Byung Sam Yoo (1993) International business cycles. *American Economic Review* 83, 335–359.

Bergin, Paul R. (2003) Putting the "New Open Economy Macroeconomics" to a test. *Journal of International Economics* 60, 3–34.

Bergin, Paul R. (2006) How well can the New Open Economy Macroeconomics explain the exchange rate and current account? *Journal of International Money and Finance* 25(5), 1–27.

Bernanke, Ben S. (2004) The Great Moderation. Remarks at the meetings of the Eastern Economic Association, Washington, DC, February 20, 2004, available at http://www.federalreserve.gov/BOARDDOCS/SPEECHES/2004/20040220/default.htm.

Blanchard, Olivier J. (2004) The economic future of Europe. *Journal of Economic Perspectives* 18 (4), 3–26.

Blanchard, Olivier J., Francesco Giavazzi, and Filipa Sa (2005) The U.S. Current Account and the Dollar. NBER working paper 11137.

Blanchard, Olivier J. and Danny Quah (1989) The dynamic effects of aggregate demand and supply disturbances. *American Economic Review* 79, 655–673.

Chinn, Menzie D. (2005) Getting Serious about the Twin Deficits. Special council report 10, Council on Foreign Relations.

Christiano, Lawrence J., Martin Eichenbaum, and Robert Vigfusson (2007) Assessing structural VARs. *NBER Macroeconomic Annual* 2006, 1–102.

Clarida, Richard and Jordi Gali (1994) Sources of real exchange rate fluctuations: How important are nominal shocks. *Carnegie-Rochester Series on Public Policy* 41, 1–56.

Corsetti, Giancarlo, Luca Dedola, and Sylvain Leduc (2006) Productivity, External Balance and Exchange Rates: Evidence on the Transmission Mechanism among G7 Countries. Working paper, European University Institute.

Corsetti, Giancarlo and Gernot J. Muller (2006) Twin deficits: Squaring theory, evidence and common sense. *Economic Policy* 21(48), 597–638.

Eichenbaum, Martin and Charles L. Evans (1995) Some empirical evidence on the effects of shocks to monetary policy on exchange rates. *Quarterly Journal of Economics* 110(4), 975–1009.

Enders, Zeno and Gernot J. Muller (2009) On the international transmission of technology shocks. *Journal of International Economics* 78, 45–59.

Enders, Zeno, Gernot J. Muller, and Almuth Scholl (2011) How do fiscal and technology shocks affect real exchange rates? New evidence for the United States. *Journal of International Economics* 83(1), 53–69.

Engel, Charles and John H. Rogers (2006) The U.S. current account deficit and the expected share of world output. *Journal of Monetary Economics* 53, 1063–1093.

Faruqee, Hamid and Jaewoo Lee (2009) Global dispersion of current accounts: Is the universe expanding? *IMF Staff Papers* 56(3), 574–595.

Francis, Neville and Valerie A. Ramey (2005) Is the technology-driven real business cycle hypothesis dead? Shocks and aggregate fluctuations revisited. *Journal of Money, Credit and Banking* 52(8), 1379–1399.

Gali, Jordi (1999) Technology, employment and the business cycle: Do technology shocks explain aggregate fluctuations? *American Economic Review* 89, 249–271.

Gil-Alana, Luis Alberiko and Antonio Moreno (2009) Technology shocks and hours worked: A fractional integration perspective. *Macroeconomic Dynamics* 13(5), 580–604.

Glick, Reuven and Kenneth Rogoff (1995) Global versus country-specific productivity shocks and the current account. *Journal of Monetary Economics* 35, 159–192.

Kim, Soyoung (2001) International transmission of U.S. monetary policy shocks: Evidence from VAR's. *Journal of Monetary Economics* 48 (2), 339–372.

Kim, Soyoung (2013) Country Characteristics and the Effects of Government Consumption Shocks on the Current Account and Real Exchange Rate. Working paper, Seoul National University.

Kim, Soyoung and Jaewoo Lee (2008) International Macroeconomic Fluctuations: A New Open Economy Macroeconomics Interpretation. HKIMR working paper 23.

Kim, Soyoung and Nouriel Roubini (2000) Exchange rate anomalies in the industrial countries: A solution with a structural VAR Approach. *Journal of Monetary Economics* 45, 561–586.

Kim, Soyoung and Nouriel Roubini (2008) Twin deficit or twin divergence? Effects of government budget deficit on the current account and the exchange rate. *Journal of International Economics* 74 (2), 362–387.

Lee, Jaewoo and Menzie D. Chinn (2006) Current account and real exchange rate dynamics in the G7 countries. *Journal of International Money and Finance* 25, 257–274.

Lee, Jaewoo and Man-Keung Tang (2007) Does productivity growth lead to appreciation of the real exchange rate? *Review of International Economics* 15(1), 164–187.

Lubik, Thomas A. and Frank Schorfheide (2005) A Bayesian look at New Open Economy macroeconomics. *NBER Macroeconomics Annual* 2005(20), 313–382.

Mitra, Sinchan and Tara M. Sinclair (2012) Output fluctuations in the G-7: An unobserved components approach. *Macroeconomic Dynamics* 16(3), 396–422.

Obstfeld, Maurice and Kenneth Rogoff (1995) Exchange rate dynamics redux. *Journal of Political Economy* 103, 624–660.

Pesavento, Elena and Barbara Rossi (2005) Do technology shocks drive hours up or down? *Macroeconomic Dynamics* 9(4), 478–488.

Sachs, Jeffrey D. (1981) The Current Account in the Macroeconomic Adjustment Process. NBER working paper 0796.

Scholl, Almuth and Harald Uhlig (2008) New evidence on the puzzles: Results from agnostic identification on monetary policy and exchange rates. *Journal of International Economics* 76(1), 1–13.

Shapiro, Matthew and Mark Watson (1988) Sources of business cycle fluctuation. In Stanley Fischer (ed.), *NBER Macroeconomics Annual 1988,* Vol. 3, pp. 111–156. Cambridge, MA: MIT Press.

Stock, James H. and Mark W. Watson (1993) A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* 61(4), 783–820.

Stockman, Alan C. (1980) A theory of exchange rate determination. *Journal of Political Economy* 88(4), 673–698.

Stockman, Alan C. and Linda L. Tesar (1995) Tastes and technology in a two-country model of the business cycle: Explaining international comovements. *American Economic Review* 85, 168–185.

DATA APPENDIX

The real effective exchange rate based on CPI (..RECZF. . .), from International Financial Statistics (IFS), is used. However, the data are available only from 1980. To construct the change (or log-difference) of series before 1980 for the United States and Japan, we constructed the real exchange rate of each country against the other six G-7 countries. Then the weighted average of the changes of the six bilateral real exchange rates against other G-7 countries was used. The weights for the six other G-7 countries were taken from the weights used to construct the IFS series for the 1980s, and were normalized to sum to 1.

The growth rate of the rest of the world's real GDP, for each country, is constructed by using the weighted average of the growth rate of other G-7 countries' real GDP. That is, G-7 countries excluding the United States are considered for the case of the United States, G-7 countries excluding Japan are considered for the case of Japan, and the United States, Japan, the United Kingdom, and Canada are considered for the case of the euro area. The weights for other G-7 countries were taken from the weights used to construct the real effective exchange rate, and were normalized to sum to 1. The same method is used to construct the growth rate of the rest of the world's real government consumption, the inflation rate of the rest of the world, and the real interest rate of the rest of the world.

Real GDP and real government consumption for G-7 countries are obtained by deflating nominal GDP and nominal government consumption (in domestic currency term) with GDP deflator. Nominal GDP, nominal government consumption, and the GDP deflator for G-7 countries are obtained from IFS (Japan, United States, United Kingdom, France, and Canada) and OECD Quarterly National Accounts (Germany and Italy). For the GDP deflator of Japan, strong seasonality is found for the data before 1979 (although the data are claimed to have been seasonally adjusted), and the data before 1979 are seasonally adjusted by the X11 method. For Germany, the growth rate of West Germany is used to estimate the data before 1991. For the euro area, data on real GDP, nominal government consumption, and GDP deflator are obtained from EABCN (Euro Area Business Cycle Network).

Labor productivity is constructed as the ratio of real GDP to civilian employment. The growth rate of the rest of the world's labor productivity for each country is constructed by applying the same procedure that is used for the rest of the world's real GDP growth rate. Civilian employment data for G-7 countries are obtained from OECD Main Economic Indicators. For France, civilian employment data were only available from 1978. The data before 1978 are recovered using the growth rate of total employment data from OECD Economic Outlook. For the period from 1978 to 2007:2, two data series are highly correlated. For the euro area, employment data from EABCN are used.

Current account data in domestic currency terms for G-7 countries are obtained from OECD Economic Outlook. For France, the new version of the OECD Economic Outlook database only has data from 1975, and the old version of the OECD Outlook database is used to obtain the values for 1973 and 1974. For the United States, the Gulf War transfers from 1990:4 to 1992:2 were taken out from the original data series. For Germany, unified German data are used from 1991, whereas West German data are used up to 1989. A linear trend in the log of nominal GDP is estimated, and then the current account data are divided by the trend of nominal GDP. For Germany, linear trends are estimated separately for the periods before and after 1991.

To measure the price level and the inflation rate, the Consumer Price Index is used. The data for G-7 countries are obtained from IFS, whereas the data for the euro area are obtained from EABCN. The (ex post) real interest rate is calculated based on short-term (mostly three-month) monthly interest rate and CPI inflation rate. The three-month treasury bill rate, obtained from IFS, is used for France, the United States, the United Kingdom, and Canada. The call money rate, obtained from IFS, is used for Japan. The short-term interest rate, obtained from OECD Statistics, is used for Germany. For Italy, the three-month treasury bill rate from IFS is used for the period from the second quarter of 1977 and the short-term interest rate from Euro Stat is used for the period before the second quarter of 1977. For the commodity price index, the average of price indices of food, beverages, agricultural raw materials, and metals is used.