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## A Small Quarterly Multi-Country Projection Model

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**IMF Working Paper**

Research Department

**A Small Quarterly Multi-Country Projection Model<sup>1</sup>**

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**Abstract**

**This Working Paper should not be reported as representing the views of the IMF.**

The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

This is the second of a series of papers that are being written as part of a larger project to estimate a small quarterly Global Projection Model (GPM). The GPM project is designed to improve the toolkit for studying both own-country and cross-country linkages. In this paper, we estimate a small quarterly projection model of the US, Euro Area, and Japanese economies. The model is estimated with Bayesian techniques, which provide a very efficient way of imposing restrictions to produce both plausible dynamics and sensible forecasting properties. We show how the model can be used to construct efficient baseline forecasts that incorporate judgment imposed on the near-term outlook.

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## I. Introduction

This study is the second of a series of studies designed to develop a full global projection model. The first study in the series, "A small quarterly projection model of the US economy," (Carabenciov and other, 2008) set out a closed economy version of the model and applied it to the US economy using Bayesian estimation techniques. The current paper, the second in the series, extends the model to an open economy. It sets out a small quarterly projection model of the US, euro area, and Japanese economies to illustrate the way that such models can be used to understand past economic developments and to forecast future developments in a multi-country setting. This initial version of the model incorporates a financial variable for the US economy and enables us to see the effects of changes in this variable on the US and the other economies. Future versions of the model will incorporate financial variables in the other economies as well. We also show how the model can be used to construct efficient baseline forecasts that incorporate judgment imposed on the near-term outlook.<sup>2</sup> The model will eventually be used to assess the relative importance of the cross-border effects of real shocks and financial shocks.<sup>3</sup>

## II. Benchmark Model

### A. Background

In recent years, the IMF has developed two types of macroeconomic models – dynamic stochastic general equilibrium (DSGE) models and small quarterly projection models (QPMs) – that it has used to analyze economic behavior and to forecast future developments. The DSGE models are based on theoretical underpinnings and have been found to be very useful in analyzing the effects of structural changes in the economy, as well as the effects of longer-term developments such as persistent fiscal deficits and current account deficits.<sup>4</sup> And multi-country variants of these models have allowed researchers to analyze the effects of shocks in one country on economic variables in

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<sup>2</sup>The forecast is for illustrative purposes only, and is not the official forecast of the IMF. The latter, which is based on the work of desk economists at the Fund, is published twice a year in the IMF's World Economic Outlook (WEO).

<sup>3</sup>Bayoumi and Swiston (2007) use VARs to try to achieve the same objective.

<sup>4</sup>See Botman and others (2007) for a summary of the applications using these models.

other countries. The small quarterly projection models use four or five behavioral equations to characterize the macroeconomic structure of an economy in a way that is both easy to use by modelers and comprehensible to policymakers. They focus on the key macroeconomic variables in the economy – typically output, inflation, a short-term interest rate, and sometimes the exchange rate and/or the unemployment rate. By virtue of their relatively simple and readily understandable structure, they have been used for forecasting and policy analysis purposes in central banks and by country desks in the IMF.<sup>5</sup> In the past, the parameters of such models have been calibrated on the basis of the knowledge of country experts of the economic structure of the country being studied and that of similar countries.

In the series of papers that we are preparing, three important extensions will be made to the basic model. First, in all the papers in the series, Bayesian techniques are used to estimate the parameters of the model. Bayesian methods allow researchers to input their priors into the model and then to confront them with the data, in order to determine whether their priors are more or less consistent with the data. Although regime shifts in recent years (most notably, the anchoring of inflation expectations to a formal or informal target in many countries) limit the time series to relatively short periods, the approach taken in these papers will be increasingly useful over time as the lengths of usable time series are extended.

Second, in this paper, we are expanding the model to three economies – United States, the Euro area, and Japan. In a future paper, the small quarterly models of a number of countries (United States, the Euro area, Japan, emerging Asia, oil-exporting countries, Canada, Russia, other industrialized, other major oil producers, and the rest of the world) will be integrated into a small quarterly Global Projection Model (GPM), which will enable researchers to analyze the effects on a number of countries of shocks in one country and of global shocks. Moreover, the model will be programmed in such way that researchers will be able to add other countries to the model in a relatively straightforward manner. Such models will give forecasters a new tool to assist them in preparing worldwide forecasts and in carrying out alternative policy simulations in the global context. There is strong demand for such an empirically based multi-country model, both for IMF surveillance work and for helping central bank forecasters to assess the external environment in

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<sup>5</sup>See Berg, Karam, and Laxton (2006a,b) for a description of the basic model as well as Epstein and others (2006) and Argov and others (2007) for examples of applications and extensions. Currently, there are several country desks at the Fund using the model to support forecasting and policy analysis and to better structure their dialogue with member countries. A number of inflation-targeting central banks have used similar models as an integral part of their Forecasting and Policy Analysis Systems—see Coats, Laxton and Rose (2003) for a discussion about how models are used in inflation-targeting countries,

preparing their projections. Large-scale DSGE models show promise in this regard, but we are years away from developing empirically-based multi-country versions of these models. While global VARs (GVARs) have been developed for forecasting exercises, they are not very useful for policy analysis because they lack the identification restrictions necessary to obtain plausible impulse response functions.

Third, given the importance in recent years of financial-real linkages, we have been experimenting both in the previous paper and in this paper with financial variables that might be helpful in explaining economic developments and in forecasting future movements of the economy. In the earlier paper, we used a single financial variable, a US bank lending tightening measure (BLT), which contributed importantly to the explanation of movements of the US economy over the sample period and also improved out-of-sample forecasting. We continue to use the BLT variable in this paper. In future papers we will broaden the use of financial variables to include a number of financial measures of risk in the United States and other countries.

## **B. The Specification of The Model**

We now consider a small generic open economy model that describes the joint determination of output, unemployment, inflation, a short-term interest rate and the exchange rate for the three economies. The model is fundamentally a gap model, in which the gaps of the variables from their equilibrium values play the crucial role in the functioning of the system. A number of definitions and identities are used to complete the model. We present the model specification for a single country labelled  $i$ . The specification for other countries will be very similar, although the priors for the coefficient estimates and for the standard deviations of the structural shocks will differ across economies on the basis of expert knowledge of those economies. In the next section of the paper, we will expand the model to include the US BLT variable.

## B.1 Observable variables and data definitions

The benchmark model has 5 observable variables for each economy.<sup>6</sup> These are real GDP, the unemployment rate, CPI inflation, a short-term interest rate, and the exchange rate.<sup>7</sup> We use capital letters for the variables themselves and small letters for the gaps between the variables and their equilibrium values. Thus, we define  $Y$  as 100 times the log of real GDP,  $\bar{Y}$  as 100 times the log of potential output and lowercase  $y$  as the output gap in percentage terms ( $y = Y - \bar{Y}$ ). Similarly, we define the unemployment gap,  $u$ , as the difference between the actual unemployment rate ( $U$ ) and the equilibrium unemployment rate or NAIRU,  $\bar{U}$ . We define the quarterly rate of inflation at annual rates ( $\pi$ ) as 400 times the first difference of the log of the CPI. In addition, we define the year-on-year measure of inflation ( $\pi_4$ ) as 100 times the difference of the log of the CPI in the current quarter from its value four quarters earlier. The nominal interest rate is  $I$ , the real interest rate is  $R$ , the log of the nominal exchange rate vis-à-vis the US dollar is  $S$ , and the log of the real exchange rate vis-à-vis the US dollar is  $Z$ . The gap between the real exchange rate,  $Z$ , and its equilibrium value,  $\bar{Z}$ , is denoted as  $z$ .

## B.2 Stochastic processes and model definitions

A major advantage of Bayesian methods is that it is possible to specify and estimate fairly flexible stochastic processes. In addition, unlike classical estimation approaches, it is possible to specify more stochastic shocks than observable variables, which is usually necessary to prevent the model from making large and systematic forecast errors over long periods of time. For example, an important ingredient in specifying a forecasting model, as we will see in this section, is allowing for permanent changes in the underlying estimates of the equilibrium values for potential output and the equilibrium unemployment rate.

We assume that there can be shocks to both the level and growth rate of potential output. The shocks to the level of potential output can be permanent, while the shocks to the growth rate can result in highly persistent deviations in potential growth from long-run steady-state growth. In equation 1  $\bar{Y}$  is equal to its own lagged value plus the quarterly growth rate ( $\bar{g}^Y/4$ ) plus a

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<sup>6</sup>Data definitions are provided in the appendix to this paper.

<sup>7</sup>More accurately, each non-American economy has an exchange rate vis-à-vis the US dollar. So if there are  $N$  economies in the model, there will be  $N-1$  exchange rates.

disturbance term ( $\varepsilon^{\bar{Y}}$ ) that can cause permanent level shifts in potential GDP.

$$\bar{Y}_{i,t} = \bar{Y}_{i,t-1} + g_{i,t}^{\bar{Y}}/4 + \varepsilon_{i,t}^{\bar{Y}} \quad (1)$$

As shown in equation 2, in the long run the growth rate of potential GDP,  $g^{\bar{Y}}$ , is equal to its steady-state rate of growth,  $g^{\bar{Y}ss}$ . But it can diverge from this steady-state growth following a positive or negative value of the disturbance term ( $\varepsilon^{g^{\bar{Y}}}$ ), and will return to  $g^{\bar{Y}ss}$  gradually, with the speed of return based on the value of  $\tau$ .

$$g_{i,t}^{\bar{Y}} = \tau_i g_i^{\bar{Y}ss} + (1 - \tau_i) g_{i,t-1}^{\bar{Y}} + \varepsilon_{i,t}^{g^{\bar{Y}}} \quad (2)$$

A similar set of relationships holds for the equilibrium or NAIRU rate of unemployment.  $\bar{U}$  is defined in equation 3 as its own past value plus a growth term  $g^{\bar{U}}$  and a disturbance term ( $\varepsilon^{\bar{U}}$ ). And in equation 4,  $g^{\bar{U}}$  is a function of its own lagged value and the disturbance term ( $\varepsilon^{g^{\bar{U}}}$ ). Thus, the NAIRU can be affected by both level shocks and persistent growth shocks.

$$\bar{U}_{i,t} = \bar{U}_{i,t-1} + g_{i,t}^{\bar{U}} + \varepsilon_{i,t}^{\bar{U}} \quad (3)$$

$$g_{i,t}^{\bar{U}} = (1 - \alpha_{i,3}) g_{i,t-1}^{\bar{U}} + \varepsilon_{i,t}^{g^{\bar{U}}} \quad (4)$$

Equation 5 defines the real interest rate,  $R$ , as the difference between the nominal interest rate,  $I$ , and the expected rate of inflation for the subsequent quarter.

$$R_{i,t} = I_{i,t} - \pi_{i,t+1} \quad (5)$$

Equation 6 defines  $r$ , the real interest rate gap, as the difference between  $R$  and its equilibrium value,  $\bar{R}$ .

$$r_{i,t} = R_{i,t} - \bar{R}_{i,t} \quad (6)$$

Equation 7 defines  $\bar{R}$ , the equilibrium real interest rate, as a function of the steady-state real interest rate,  $\bar{R}^{ss}$ . It has the ability to diverge from the steady state in response to a stochastic shock ( $\varepsilon^{\bar{R}}$ ).

$$\bar{R}_{i,t} = \rho_i \bar{R}_i^{ss} + (1 - \rho_i) \bar{R}_{i,t-1} + \varepsilon_{i,t}^{\bar{R}} \quad (7)$$

Equation 8 defines  $Z_i$ , the log of the real exchange rate in country  $i$ , as equal to 100 times the log of the nominal exchange rate,  $S_i$  (defined as the number of units of local currency in country  $i$  vis-à-vis the US dollar), times the CPI ( $P_{us}$ ) in the United States, divided by the CPI in country  $i$  ( $P_i$ ). An increase in  $Z_i$  is thus a real depreciation of currency  $i$  vis-à-vis the US dollar.

$$Z_{i,t} = 100 * \log(S_{i,t} P_{us,t} / P_{i,t}) \quad (8)$$

The change in the log of the real exchange rate is shown in equation 9 as 100 times the change in the log of the nominal exchange rate less the difference between the quarterly inflation rates in country  $i$  and the United States. It is therefore approximately equal to the change in percentage terms for small changes.

$$\Delta Z_{i,t} = 100 \Delta \log(S_{i,t}) - (\pi_{i,t} - \pi_{us,t}) / 4 \quad (9)$$

Equation 10 defines the expected real exchange rate for the next period,  $Z^e$ , as a weighted average of the lagged real exchange rate and the 1-period model-consistent solution of the real exchange rate.

$$Z_{i,t+1}^e = \phi_i Z_{i,t+1} + (1 - \phi_i) Z_{i,t-1} \quad (10)$$

Equation 11 defines the real exchange rate gap,  $z$ , as equal to the log of the real exchange rate minus the log of the equilibrium real exchange rate,  $\bar{Z}$ .

$$z_{i,t} = Z_{i,t} - \bar{Z}_{i,t} \quad (11)$$

Equation 12 defines the equilibrium real exchange rate,  $\bar{Z}$ , as equal to its lagged value plus a disturbance term,  $\varepsilon^{\bar{z}}$ .

$$\bar{Z}_{i,t} = \bar{Z}_{i,t-1} + \varepsilon_{i,t}^{\bar{z}} \quad (12)$$

### B.3 Behavioral equations

Equation 13 is a behavioral equation that relates the output gap ( $y$ ) to its own lead and lagged values, the lagged value of the gap in the short-term real interest rate ( $r$ ), the output gaps in its trading partners, an effective real exchange rate gap, and a disturbance term ( $\varepsilon^y$ ). The foreign output gap term is defined as a weighted average of the lagged foreign output gaps,<sup>8</sup> where the weights ( $\omega_{i,j,5}$ ) are the ratios of the exports of country  $i$  to country  $j$  to total exports of country  $i$  to all the countries in the model. This weighted foreign output gap variable is thus a form of activity variable, with the weights imposed on the basis of past data. The effective real exchange rate gap variable in the equation is a weighted average of the real exchange rate gaps of the foreign countries with which economy  $i$  trades. In this case, the weights ( $\omega_{i,j,4}$ ) are the ratio of the sum of exports and imports of country  $i$  with country  $j$  to the sum of exports and imports with all the countries in the model and are also imposed on the basis of the data.

$$y_{i,t} = \beta_{i,1}y_{i,t-1} + \beta_{i,2}y_{i,t+1} - \beta_{i,3}r_{i,t-1} + \beta_{i,4} \sum_j \omega_{i,j,4}z_{i,j,t-1} + \beta_{i,5} \sum_j \omega_{i,j,5}y_{j,t-1} + \varepsilon_{i,t}^y \quad (13)$$

All variables in this equation are expressed as deviations from their equilibrium values. The own-lag term allows for the inertia in the system, and permits shocks to have persistent effects. The lead term allows more complex dynamics and forward-looking elements in aggregate demand. The real interest rate term and the real exchange rate term provide the crucial direct and indirect links between monetary policy actions and the real economy. And the activity variable allows for the direct trade links among the various economies.

The specification of the real exchange rate gap variables ( $z$ ) is somewhat complex in a multi-country model. Since all the exchange rate variables are defined in terms of the US dollar, the bilateral real exchange rate gaps for all country pairs except those involving the United States should be in relative terms. Consider, for example, the euro area output gap equation. If the euro area exchange rate were overvalued by 5% (that is, its  $z$  is minus 5%) and if the yen exchange rate were undervalued by 10% (that is, its  $z$  is plus 10%), then the euro is overvalued by 15% vis-à-vis the yen, and the  $z_{eu,ja}$  enters the euro area output gap equation as  $z_{eu} - z_{ja}$ , or -15%. In contrast, only  $z_{eu}$  has to be inserted in the euro area output gap equation as the real exchange rate gap vis-à-vis the US dollar. In the US output gap equation, one can either use the simple  $z$  variables

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<sup>8</sup>In a future version of the model, we plan to use a weighted average of lagged and contemporaneous foreign output gaps in the domestic output gap equation.

and expect  $\beta_{us,4}$  to be negative, or, alternatively, use the negatives of the z variables and expect  $\beta_{us,4}$  to have the same positive sign as all the other  $\beta_{i,4}$  coefficients. For simplicity, we have chosen to do the latter.

Equation 14 is the inflation equation, which links inflation to its past value and its future value, the lagged output gap, the change in the effective exchange rate of the country, and a disturbance term ( $\varepsilon^\pi$ ).<sup>9</sup> The size of  $\lambda_1$  measures the relative weight of forward-looking elements and backward-looking elements in the inflation process. The backward-looking elements include direct and indirect indexation to past inflation and the proportion of price setters who base their expectations of future inflation on actual past rates of inflation. The forward-looking element relates to the proportion of price setters who base their expectations on model-consistent estimates of future inflation. The output gap is the crucial variable linking the real side of the economy to the rate of inflation.

The rate of inflation is also influenced by the change in the effective real exchange rate of country i. As in the case of the output gap equation, the treatment of exchange rate movements is somewhat complex. Since the real exchange rates are all based on the US dollar, the change in the bilateral real rate of exchange of currency i relative to currency j (where neither i nor j is the United States) is defined as the change of currency i relative to the US dollar minus the change of currency j relative to the US dollar, or  $\Delta Z_i - \Delta Z_j$ , with a positive value being a real depreciation of currency i vis-à-vis currency j. Where j is the United States, the relevant variable is  $\Delta Z_i$ . The weights on the changes in the bilateral real exchange rates are based on imports of country i from country j and the coefficient  $\lambda_{i,3}$  is expected to be positive. For the US inflation equation, the change in the real exchange rate variables can be entered as  $\Delta Z_i$  and  $\lambda_{us,3}$  would be expected to be negative, or as  $-\Delta Z_i$ , with  $\lambda_{us,3}$  expected to be positive. We have chosen to do the latter.

$$\pi_{i,t} = \lambda_{i,1}\pi_{i,t+4} + (1 - \lambda_{i,1})\pi_{i,t-1} + \lambda_{i,2}y_{i,t-1} + \lambda_{i,3} \sum_j \omega_{i,j,3} \Delta Z_{i,j,t} - \varepsilon_{i,t}^\pi \quad (14)$$

Equation 15 is a Taylor-type equation that determines the short-term nominal interest rate (which can be interpreted either as the policy rate, as we do in this paper for the United States, or as a short-term market interest rate that is closely linked to the policy rate, as we do for the other two economies). It is a function of its own lag (a smoothing device for the movement of short-term

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<sup>9</sup>The disturbance term is entered with a negative sign to simplify the cross correlation relationships that will be discussed later.

rates) and of the central bank's responses to movements of the output gap and to the deviation of the expected inflation rate from its target. More precisely, the central bank aims at achieving a measure of the equilibrium nominal interest rate over the long run (the sum of the equilibrium real interest rate and expected inflation over the four quarters starting the previous quarter), but adjusts its rate in response to deviations of the expected year-on-year rate of inflation three quarters in the future from the inflation target  $\pi^{tar}$  and to the current output gap.<sup>10</sup> The equation also includes a disturbance term ( $\varepsilon^I$ ) to allow for central bank interest rate actions that are not exactly equal to those indicated by the equation.

$$I_{i,t} = (1 - \gamma_{i,1}) [\bar{R}_{i,t} + \pi 4_{i,t+3} + \gamma_{i,2}(\pi 4_{i,t+3} - \pi_i^{tar}) + \gamma_{i,4} y_{i,t}] + \gamma_{i,1} I_{i,t-1} + \varepsilon_{i,t}^I \quad (15)$$

Equation 16 is a version of uncovered interest parity (or UIP), in which the difference between the real exchange rate of currency  $i$  and its expected value the following quarter (multiplied by 4 to transform the quarterly rate of change to an annual rate of change in order to make it comparable to the interest rate differentials) is equal to the difference between the real rate in country  $i$  and its counterpart in the United States less the difference in the equilibrium real interest rates in the two countries. The latter is equivalent to the equilibrium risk premium. Thus, if the real interest rate in country  $i$  is greater than that in the United States, this would be a reflection of one of two possibilities or a combination of the two—either the currency  $i$  real exchange rate is expected to depreciate over the coming period ( $Z^e$  is higher than  $Z$ ), or the equilibrium real interest rates in the two countries differ because of a risk premium on yields of country  $i$  assets denominated in the  $i$  currency. There is also a disturbance term,  $\varepsilon^{Z-Z^e}$ , in the equation. The model differs from Dornbusch's (1976) overshooting model insofar as  $Z^e$  is not fully model consistent, being partly a function of the past levels of the real exchange rate (as shown in equation 10). Note that there are  $i-1$  UIP equations in the model, with no such equation necessary in the US block of equations.<sup>11</sup>

$$4(Z_{i,t+1}^e - Z_{i,t}) = (R_{i,t} - R_{us,t}) - (\bar{R}_{i,t} - \bar{R}_{us,t}) + \varepsilon_{i,t}^{Z-Z^e} \quad (16)$$

<sup>10</sup>The use of the rate of inflation three quarters in the future follows Orphanides (2003).

<sup>11</sup>While the economics of the UIP equation is most easily understood as expressed in the text, the coding of the model is as follows:  $(R_{i,t} - R_{us,t}) = 4(Z_{i,t+1}^e - Z_{i,t}) + (\bar{R}_{i,t} - \bar{R}_{us,t}) + \varepsilon_{i,t}^{R_i - R_{US}}$ . The only difference between the two versions is that the impulse response function for shocks to this equation would reflect the form of the disturbance shown in this footnote, which is the negative of the disturbance shown in the text.

Equation 17 provides a dynamic version of Okun's law where the unemployment gap is a function of its lagged value, the contemporaneous output gap and a disturbance term ( $\varepsilon^u$ ).

$$u_{i,t} = \alpha_{i,1}u_{i,t-1} + \alpha_{i,2}y_{i,t} + \varepsilon_{i,t}^u \quad (17)$$

This last equation does not play a very important role in the model but is used to help measure the output gap in real time by exploiting the correlation between changes in the output gap and contemporaneous and future changes in the unemployment gap.

#### B.4 Cross correlations of disturbances

The model is also able to incorporate cross correlations of error terms. There are three types of cross correlation specified in this version of the model. Other cross correlations can be entered into the model by researchers investigating certain types of shocks. The first of the cross correlations, which is used in each country model, involves a correlation between  $\varepsilon^{\bar{Y}}$  and  $\varepsilon^{\pi}$ . This implements in the model the notion that a positive supply shock to the level of potential output puts downward pressure on costs and prices. This correlation structure is used to roughly mimic the impulse response functions (IRFs) that have been estimated in DSGE models of the US economy and provides an example of how the dynamics of smaller semi-structural models can embody some of the insights from our deeper structural models—see Juillard and others (2007, 2008).

The second of the cross correlations is applied to the Japanese and euro area economies and involves a positive correlation between  $\varepsilon^{g^{\bar{Y}}}$  and  $\varepsilon^y$ . The basic idea is that a positive shock to potential output growth that is expected to persist for a considerable period of time will be associated with an increase in expected permanent income, which will raise spending by households even before the level of potential output increases. Similarly, businesses will be motivated to increase their investment spending on the basis of the expected faster growth in potential output. Thus, aggregate demand and actual output will rise before potential output and there will be an increase in the output gap as a result of the shock to the growth rate of potential output.

The third of the cross correlations is applied to the US economy and involves a correlation between  $\varepsilon^{g^{\bar{Y}}}$  and  $\varepsilon_{US}^{BLT}$ . The latter is the residual from the equation for the US bank lending

tightening variable that will be discussed in detail in the next section of the paper. The intuition is that a sustained increase in asset prices (which are not explicitly specified in the model) that is based upon expectations of an increase in potential output growth in the United States will result in an easing of bank lending conditions in the United States (over and above what would normally be associated with near-term expectations of the output gap). By correlating the two disturbance terms, the model may be able to capture significant shifts in market expectations of potential output growth through their effects on asset prices and BLT. And through the effect of BLT on the output gap (to be discussed shortly), such developments would result in an increase in the output gap.<sup>12</sup>

Other possible cross correlations are based on shocks that may or may not be correlated across countries. Thus, for example, if one believes that aggregate demand shocks tend to be country specific, there would be no correlation of the shocks in the output gap equations across countries and one can examine the impulse response functions across borders of a shock to aggregate demand in a given country by shocking the residual in the output gap equation for that country. If, on the contrary, it is believed that aggregate demand shocks are correlated across countries, one can introduce such correlations into the aggregate demand disturbances across the countries in the model. Confronting the priors with the data will allow us to determine whether the priors with respect to such correlations are consistent with the evidence, and to the extent that it is consistent, will be helpful in determining impulse response functions of shocks to aggregate demand that are common across countries. Similar cross correlations across countries are potentially relevant for shocks to interest rates, exchange rates, and other financial variables that will be discussed in future papers.

### **III. Extending the Model to Include Financial-Real Linkages**

#### **A. Background**

For much of the postwar period, downturns in business cycles were precipitated mainly by increases in interest rates initiated by central banks in response to periods of excess demand that

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<sup>12</sup>In future versions of the model that will introduce financial variables for all the economies in the model, consideration will be given to specifying similar cross correlations for economies other than the United States.

gave rise to inflation pressures. Indeed, in some countries (the United Kingdom being a prominent example), actions of the fiscal and monetary authorities were considered to have brought about a stop-go economy, in which policy switched periodically back and forth between an emphasis on unemployment and economic growth, on the one hand, and an emphasis on inflation, on the other. When the economy was weak, policy eased, giving rise to expansionary pressures. When these pressures were sufficiently strong and inflation became the overriding concern, policy was tightened so that the slowing or contraction of the economy would put downward pressure on inflation and prevent it from getting out of hand.

Such policy-induced slowdowns of the economy persisted from the 1950s into the 1990s, with virtually every downturn preceded by inflationary pressures and a resulting tightening of monetary policy. However, this central bank tightening explanation cannot account for the economic slowdown of the early part of this decade, or of the current slowing of the US and other economies, since inflation pressures and interest rate increases were evidently not the main reason for these downturns. In the context of the apparent linkages between financial developments and the real economy, driven in part through asset price movements, attention has increasingly turned to the ways in which financial developments can affect the real economy. This interest has been aided by the development of theoretical models to describe and explain these linkages, in particular the financial accelerator mechanism.<sup>13</sup>

In our view, the more traditional types of models that allow central bank actions to play a major role in business cycle developments are still needed to explain much of the postwar period. However, the developments over the last decade or so require an extension to those models that have placed central bank actions at the center of the business cycle (and particularly in the downturns). The key factors in these most recent developments, and to a much lesser extent in earlier developments, are the financial developments that have interacted with the real side of the economy in what has come to be called financial-real linkages.

There are many different variants of financial-real linkages. Some refer to developments in financial institutions, while others focus on developments in financial markets. Within the financial institution sector, some relate to the behavior of banks and other financial institutions in dealing with perceptions of the changing risk situation facing their customers or changing

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<sup>13</sup>See, for example, Bernanke and Gertler (1995). Interestingly, the perceived structural change in the way the economy operates has given rise to renewed interest in models of the business cycle from the interwar period in which real factors and financial factors other than central bank actions played a key role. See Laidler (2003).

attitudes to risk on their own part, while others relate to situations in which banks' capital positions have deteriorated. In the case of financial markets, there have been cases in which liquidity has seized up and prevented potential borrowers from issuing debt, and other cases in which actual or perceived pressures on the balance sheets of lenders and/or borrowers have been the origin of the inability of the financial markets to carry out their normal intermediation functions.

These different variants can be seen in economic episodes in which the financial-real linkages made themselves felt. In normal times financial accelerators may help to explain movements in spending, but interest rate movements can typically capture most of the effects of the accelerators. It may only be in "abnormal" times that the behavior on the financial side is such as to require special treatment to pick up its effects.

What are the episodes that require special treatment? If one goes back sufficiently far into the past, one can find a number of cases. For example, the Federal Reserve Board's MPS model included a specification of financial institution behavior relating to Regulation Q in the United States, where the ceiling on deposit rates meant that financial institutions were unable to meet the demand for mortgage loans at times of high market interest rates because they were unable to raise the needed funds, and this resulted in fluctuations in the supply of mortgages and in expenditures on housing. In the case of Canada, in the early years before banks were able to raise funds through the wholesale deposit market, the Bank of Canada operated on "credit conditions". The ability of banks to extend loans was influenced by the amount of liquid assets on their balance sheet, which they could use to fund loans. The Bank of Canada's RDX2 model attempted to specify the driving factors behind these credit conditions.

Over the years, with regulatory changes (such as the elimination of regulation Q in the United States) and with the increased sophistication of ways in which banks could raise funds, banks became much less constrained in their ability to extend credit, and macro models focused on the role of interest rates and other factors in determining the demand for credit. But, from time to time, there were episodes in which the normal functioning of financial institutions was disrupted for some reason and the supply of bank credit (not just its demand) became an important factor in private sector expenditures. At the same time, financial markets became increasingly important both in the direct provision of credit to business and in the development of mechanisms (such as the securitization of loans) that facilitated even further the ability of financial institutions to originate the extension of credit to households and businesses. At times, there were also unusual

circumstances that affected the functioning of financial markets and influenced consumption and investment expenditures on goods and services.

A listing of some of the episodes in the relatively recent past in which behavior was affected by the supply of funds to households and businesses illustrates the nature of the issue and perhaps the difficulty of finding a simple specification that would cover all the types. In the early 1990s, in the United States, banks became reluctant to provide loans following a period in which they had suffered severe losses that impaired their capital position. Chairman Greenspan referred to this as the “financial headwinds” period and the Federal Reserve responded by reducing interest rates to levels well below what would normally be needed in the circumstances.

A second episode occurred in 1998, when the near failure of LTCM and the Russian debt default caused financial markets to seize up for a short period of time, and prevented borrowers from carrying out their planned funding. For example, there were cases of real estate developers, which had been funding their activities by short-term construction loans from banks, who were unable for a short period of time to transfer these obligations into longer-term mortgages, as the typical purchasers of such mortgages were either unwilling or unable to extend such credit at a time of market difficulties.

A third episode relates to the rise and fall of the subprime mortgage market in the United States and the associated developments in derivative markets that were associated with this market. With the spread of subprime mortgages (fueled in part by unusually low interest rates and the apparent ability of lenders to transfer their exposure to others via asset-backed securities), expenditures on housing expanded. At the same time, housing prices rose sharply, and the new financial environment in which households were able to draw on the increased value of their homes via bank loans collateralized by home equity values allowed households to increase their consumption expenditures. As interest rates returned towards neutral levels, the default of many subprime mortgage borrowers, the freezing of liquidity in the asset-backed commercial paper market, and the associated recognition of the necessity to write down the value of many structured financial instruments (well beyond those based on subprime mortgages) resulted in a situation in which both financial institutions and financial markets faced serious problems. Many financial institutions suffered significant losses (in some cases requiring recapitalization), and in such circumstances their ability and willingness to extend loans was curtailed. And financial markets were faced with considerable uncertainty about the valuation of certain kinds of financial instruments. As well, there were lingering liquidity difficulties in certain segments of the market.

The difficulties in financial markets and financial institutions showed up in the increased risk spread on issues by private sector borrowers in financial markets and in the tightening of terms and conditions on loans extended by financial institutions, as shown in the Federal Reserve's quarterly survey of senior loan officers. As a result, investment projects had more difficulty being funded than would normally have been the case.

What does this imply for macro modeling? Consider first financial accelerators. As far as financial accelerator models are concerned, there can be an endogenous element in which the business cycle leads to increases and decreases of collateral values and hence to the ability to access funding, and an exogenous element in which exogenous shocks to asset values result in changes in the ability of borrowers to obtain financing. While the former can typically be captured to a considerable extent by interest rate movements, it will be important to try to model the latter. One issue that requires careful attention in structural DSGE models is whether financial institutions ration credit on the basis of collateral values (such as maximum loan-to-value ratios) or simply tighten terms and conditions on the loans that they are prepared to extend. A second type of financial-real linkage relates to the capital position of financial institutions (most importantly banks) and how it affects the willingness of financial institutions to extend loans. A third type of linkage relates to whether financial markets are functioning normally or are facing either liquidity difficulties or problems in evaluating risks. All the episodes that were listed above and the economic behavior patterns underlying them raise the question of whether financial-real linkages should be part of the central macro model or should be modeled via satellite models. Should they feed into the forecast in normal circumstances or only in unusual episodes? And, if the latter, can they be treated as a form of regime shift?

In this and future papers, we will attempt to integrate financial-real linkages into the type of model described earlier.<sup>14</sup> There are a number of advantages to using a small model in trying to understand and model the role of the linkages for macro economic behavior. First of all, the insights that have been developed in more complex DSGE and other models can be added to a well understood macro model to see whether they aid in the explanation of macroeconomic developments and forecasting. Second, different measures can be used to see which type of proxy is most helpful in capturing the linkages. Third, the small size of the model allows for experimentation of various types. For example, should a proxy for financial-real linkages be

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<sup>14</sup>See Lown, Morgan, and Rohatgi (2000), Lown and Morgan (2002), Lown and Morgan (2006), Swiston (2008), and Bayoumi and Melander (2008) for earlier attempts to assess the effects of financial-real linkages.

introduced as simply an extra variable in the model that functions continuously or should it only be allowed to affect behavior when it reaches critical threshold levels of the sort that were seen in the episodes discussed above? Fourth, by allowing for persistence in real and financial shocks and in their effects on the real economy, judgmental near-term forecasts of these shocks can play an important role in model-based, medium-term projections through the setting of initial conditions. Fifth, multi-country models with financial-real linkages will allow us to see whether cross-border financial effects have played an important role in transmitting the business cycle internationally, and to assess the relative importance of real linkages and financial linkages in transmitting shocks across countries.

In this paper, we use only one financial variable (over and above interest rates and exchange rates), the bank lending tightening variable for the United States ( $BLT_{US}$ ). In future papers, we plan to examine the potential role of BLT variables in other countries and a variety of spread measures, such as bond spreads, swap spreads, and credit default swap spreads.

## **B. Model Specification Incorporating the US Bank Lending Tightening Variable**

The financial variable  $BLT_{US}$  is an unweighted average of the responses to four questions with respect to tightening terms and conditions in the Federal Reserve Board's quarterly Senior Loan Officer Opinion Survey on Bank Lending Practices. More precisely, for each of four questions on bank credit standards on loan applications,<sup>15</sup> net tightening is equal to the sum of the percentage of banks responding "tightened considerably" and "tightened somewhat" less the sum of the percentage of banks responding "eased somewhat" and "eased considerably". These net tightening variables are each weighted by one quarter to give the overall BLT variable. It is worth noting that the net tightening responses from the survey outweigh the net easing responses on average over the sample period, indicating a bias of about 5% in the variable. See figure 1 for a comparison of the base case US output gap from the US model without  $BLT_{US}$  (Carabenciov and others, 2008a) with the results of a regression of that output gap on  $BLT_{US}$  five quarters earlier.

The model with financial-real linkages makes two substantive changes to the benchmark model

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<sup>15</sup>Question 1a on C&I loans or credit lines to large and middle-market firms, question 1b on C&I loans or credit lines to small firms, question 8 on commercial real estate loans, and question 10 on mortgage loans to purchase homes.

set out earlier. In equation 18,  $BLT_{US}$  is a function of  $\overline{BLT}_{US}$ , the equilibrium level of  $BLT_{US}$ , which itself is a random walk (equation 19), and a disturbance term,  $\varepsilon_{US,t}^{BLT}$ .<sup>16</sup>

$$BLT_{US,t} = \overline{BLT}_{US,t} - \kappa_{US}y_{US,t+4} - \varepsilon_{US,t}^{BLT} \quad (18)$$

$$\overline{BLT}_{US} = \overline{BLT}_{US,t-1} + \varepsilon_{US,t}^{\overline{BLT}} \quad (19)$$

As shown in equation 18, banks are assumed to tighten or ease their lending practices in part depending on their view of the expected behavior of the economy 4 quarters ahead. That is, if the output gap is assumed to be positive (a strong economy), there will be a tendency to ease lending conditions, while if it is assumed to be negative (a weak economy), there will be a tendency to tighten lending conditions.

In equation 20, the output gap is explained by the same variables as in the US version of equation 13 (a lead and lag of the output gap, the real interest rate gap, the foreign activity gap and the effective exchange rate gap), as well as by  $\eta_{US}$ , a distributed lag of  $\varepsilon_{US}^{BLT}$ . Thus, if lending conditions are easier than might have been anticipated on the basis of expectations of future economic behavior (positive  $\varepsilon_{US}^{BLT}$ ), the effect will be a larger output gap and a stronger economy.

$$y_{US,t} = \beta_{US,1}y_{US,t-1} + \beta_{US,2}y_{US,t+1} - \beta_{US,3}r_{US,t-1} + \beta_{US,4} \sum_j \omega_{US,4,j}z_{US,j,t-1} \quad (20)$$

$$+ \beta_{US,5} \sum_j \omega_{US,j,5}y_{j,t-1} + \theta_{US}\eta_{US,t} + \varepsilon_{US,t}^y$$

$$\eta_{US,t} = 0.04\varepsilon_{US,t-1}^{BLT} + 0.08\varepsilon_{US,t-2}^{BLT} + 0.12\varepsilon_{US,t-3}^{BLT} + 0.16\varepsilon_{US,t-4}^{BLT} + 0.20\varepsilon_{US,t-5}^{BLT} + 0.16\varepsilon_{US,t-6}^{BLT} \quad (21)$$

$$+ 0.12\varepsilon_{US,t-7}^{BLT} + 0.08\varepsilon_{US,t-8}^{BLT} + 0.04\varepsilon_{US,t-9}^{BLT}$$

The values of the coefficients imposed in equation 21 are intended to reflect a pattern in which an increase of  $\varepsilon_{US}^{BLT}$  (an easing of the bank lending conditions variable) is expected to positively affect spending by firms and households in a hump-shaped fashion, with an initial buildup and then a gradual rundown of the effects.

<sup>16</sup>The disturbance term is entered with a negative sign to simplify the cross correlations.

There are two ways of thinking about the way that the  $\varepsilon_{US}^{BLT}$  variables function in the model. In the first, this proxy variable for financial tightening can be thought of as capturing the exogenous element in bank lending that has the potential to set in motion a weakening or strengthening economic situation. That is, those responsible for bank lending look forward to economic conditions about a year in the future and tighten or loosen in part on the basis of their expectations. If their actions are typical for the stage of the cycle, the interest rate variable itself may pick up the normal tightening and easing of terms and conditions on bank lending, and BLT would play little role in driving future economic developments. If, on the other hand, their actions are greater or less than is typical in light of the expected economic situation, this could have a direct effect on the ability of borrowers to access funds and to make expenditures. A second interpretation puts less emphasis on the direct effects on expenditures of the tightening or easing of bank lending conditions. Rather, from this perspective, one can consider the  $\varepsilon_{US}^{BLT}$  variable as reflecting the views of experts on the lending side of the economy with respect to future economic and financial conditions and thereby functioning as a very useful leading indicator of economic developments.

There are a number of issues surrounding this variable. First, in the interpretation that focuses on the exogenous part of this variable, it is assumed that the part of financial-real linkages that propagates other typical shocks to the system is captured by the interest rate. This is not an unreasonable assumption, since the endogenous part of the financial accelerator mechanism intensifies the effects on the economy of other shocks and, in a macro sense, could be thought of as simply increasing the coefficient on the interest rate variable. Second, there could be an asymmetry between positive and negative shocks to  $BLT_{US}$ . While financial conditions that are tighter than typical will have the effect of preventing liquidity-constrained households and businesses from achieving their desired expenditures, beyond a certain point the easing of financial conditions may be less powerful in leading to increased spending. That is, once there is sufficient collateral to satisfy lenders of the safety of their loans, a further increase in the value of the collateral may not affect their behavior very much.<sup>17</sup> Third, it is possible that small changes in financial conditions will have relatively minor effects, and only changes beyond a certain critical threshold will have the capacity to bring about economically significant changes. Fourth, given the complexity of the financial-real linkages in the economy,  $BLT_{US}$  may not be able to capture all of these types of linkages, and other variables (such as risk spreads) will be introduced into the

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<sup>17</sup>It could, however, affect borrower behavior.

output gap equations in future papers to try to pick up some of the other effects.

## **IV. Confronting The Model with The Data**

### **A. Bayesian Estimation**

Bayesian estimation provides a middle ground between classical estimation and the calibration of macro models. The use of classical estimation in a situation of a relatively small sample size (which is almost always the case for time series data) often gives model results that are strange, and are inconsistent with the views of macroeconomists as to the functioning of the economy. This problem is accentuated by the simultaneity challenges to macro models, which are not handled well by simultaneous equation methods in small samples. For example, because an aggregate demand shock can lead to persistent inflationary pressures and to central bank actions to raise interest rates to offset the shock, classically estimated models using time series data will sometimes show an increase in interest rates leading to an increase in inflation. This is particularly problematic when the model is to be used for policy simulations, since it may well indicate the need for an interest rate decline to slow the rate of inflation.

Models with calibrated parameters avoid this problem, but are often criticized as representing no more than the modelers' judgment, which may or may not be consistent with the data. While calibration is typically based on the understanding of experts of the functioning of the economy, the desire to confront the model with the data in a statistical sense has led researchers to use Bayesian estimation techniques to estimate models.

The Bayesian approach has the benefit of putting some weight on the priors of the researchers and some weight on the data over the sample period. By changing the specification of the tightness (e.g., the standard deviation) of the distribution on the priors, the researcher can change the relative weights on the priors and the data in determining the posterior distribution for the parameters. In the limit, a diffuse or noninformative distribution puts more weight on the data while a distribution with a very tight prior distribution (e.g., a small standard deviation) puts more weight on the priors.

There are a number of criteria by which researchers evaluate the success of Bayesian estimated

models and decide between models with different weights placed on priors and the data. First, if an estimated model yields coefficients that are close to the priors in spite of allowing considerable weight to be placed on the data, this indicates that the priors are not inconsistent with the data. A second criterion involves seeing whether the impulse response functions (IRFs) from the model estimated with Bayesian techniques are compatible with the views of the researchers (and in the case of models built at central banks with the views of the management of the central bank) with respect to the functioning of the economy in response to shocks. Third, in comparing different variants of a given macro model (for example, one that treats shocks to output as largely demand determined and another that treats shocks as largely supply determined), researchers can use the relative magnitudes of the log data density and root mean squared errors (RMSEs) as indications of which model is more consistent with the data. And, fourth, the plausibility of the variance decomposition of the variables in the model can help to indicate whether the model is sensible.<sup>18</sup>

Bayesian estimated models are likely to have better model properties than classically estimated models, but may sometimes not fit the data as well as simple VAR models, since the sole purpose of the latter is to maximize fit. It is the combination of reasonable fit, appropriate structural results from a theoretical perspective, and the ability to give sensible results for policy simulations that gives estimated Bayesian models their strength. Also, the use of such models along with judgmental inputs for the first two quarters of the forecast period is likely to give better and more sensible forecasting results than most other models. A comparison of Bayesian-estimated Global Projection Models with competitor global models will be presented in one of the future papers.

## **B. Results**

### **B.1 Estimates of coefficients**

The model is estimated over the sample period 1994Q1 to 2008Q1. Tables 1 through 3 set out estimation results for the parameters for the three countries in this version of the model, showing the distribution used in the estimation, the prior mean, the prior standard deviation, the posterior mode, and the posterior standard deviation.

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<sup>18</sup>For example, in a two country model, if the variance decomposition showed that a shock to the output gap equation of the large country had a smaller effect on the output gap of the small country than the reverse, considerable doubt would be thrown on the validity or usefulness of the model results.

Beginning with the output gap equations, we find that while all three economies have much more weight on the backward-looking component,  $\beta_1$ , than on the forward-looking component,  $\beta_2$ , the euro area economy has considerably more weight on the backward-looking component than do the other two economies. Also, the sum of the coefficients on the backward-looking component and the forward-looking component is appreciably lower in the US economy than in the other two economies. The Japanese economy has a somewhat weaker coefficient on the real interest rate gap,  $\beta_3$ , than the other two economies. The posterior estimates of the coefficient on the real exchange rate gap,  $\beta_4$ , are about the same for all three economies, a very different outcome than would have been expected on the basis of the prior estimates. In contrast, the coefficients on the activity variable,  $\beta_5$ , are roughly in line with the priors, with the US coefficient being smaller than the Japanese coefficient, which in turn is smaller than that of the euro area. This result is consistent with the relative openness of the respective economies. The response of US output gap to unexpected tightening in BLT,  $\theta_{us}$ , is a little higher than anticipated.

Turning to the inflation equations, we see that all three economies are more forward looking than assumed by the priors,  $\lambda_1$ , while the effect of the output gap on inflation in each country,  $\lambda_2$ , is somewhat smaller than assumed by the priors. And the effect of exchange rate changes on inflation,  $\lambda_3$ , is much smaller than anticipated in all three economies.

In the interest rate reaction functions, the smoothing coefficient,  $\gamma_1$ , is larger than anticipated in all three economies. The response to deviations of inflation from target,  $\gamma_2$ , is lower than anticipated in all three economies.<sup>19</sup> The coefficients on the output gap,  $\gamma_4$ , are about as expected for all three economies.

There are a number of other results of interest. In all three economies, the response of the unemployment gap to the output gap, or the Okun coefficient,  $\alpha_2$ , is much smaller than anticipated. Also, in all three economies, the persistence of growth in the NAIRU to shocks,  $(1 - \alpha_3)$ , is greater than anticipated. This is also the case for persistence of growth in potential output to shocks,  $(1 - \tau)$ . Indeed, in all three economies the latter coefficient is close to unity. Similarly, the persistence of the equilibrium real interest rate to shocks,  $(1 - \rho)$ , is much higher than anticipated in the United States, although not in the other two economies. Finally, the expected real exchange rate is very forward looking,  $\phi$ , for both the euro and the yen.

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<sup>19</sup>Note, however, that because of the specification of the equation, the response of interest rates to an increase in forecast inflation,  $\pi_{4,i,t+3}$ , is  $\gamma_2$  plus 1. The stability requirement that the response of the rate of interest to an increase in the rate of inflation must exceed unity is easily met in all three economies.

## B.2 Estimates of standard deviation of structural shocks and cross correlations

Table 4 presents the same information for the standard deviation of the structural shocks, making use of more diffuse priors. Table 5 does the same for the cross correlations in the model. Given that the priors for the estimates of the standard deviation of the structural shocks and for the cross correlations are held with much less confidence than the priors for the coefficients, it is not surprising that the posterior results differ more from the priors than was the case for the coefficients. Particularly worth noting are the much higher posteriors than expected for the standard deviations of the  $BLT_{US}$  shock, the equilibrium real exchange rate shocks, the inflation shocks for all three economies, and the shock to equilibrium real interest rates in the United States. There were also a number of much lower than expected posteriors for the standard deviations of shocks, including the shocks in the two UIP equations, and the shocks to the equations for the unemployment rate gap, NAIRU, and NAIRU growth in all three economies. These results indicate that, compared to prior expectations, there is considerably less uncertainty about the shock terms pertaining to unemployment and UIP, and considerably more about the shock terms pertaining to real exchange rates and inflation.

As shown in Table 5, the posterior results for the three types of cross correlations are mostly in line with their priors.

## B.3 RMSEs

Table 6 presents the model's RMSEs for the United States, the euro area, and Japan, which are based on the intra-sample forecasts without any judgmental input. By and large, the euro area shows the greatest stability (smallest RMSE) of the three economies.

## B.4 Impulse response functions

Figures 2 through 16 present a selection of the model's most important impulse response functions, which show reasonable and expected patterns. The first set of figures – 2 through 10 – show the effects of demand shocks in the United States, the euro area, and Japan. Demand shocks to the US economy result in the expected increase in US output, inflation and nominal and real interest rates, declines in US unemployment and in the effective real exchange rate (i.e., an initial

appreciation in the US dollar), and an initial easing of the bank lending tightening variable in the United States. By and large, the shock to US demand has qualitatively similar, but quantitatively smaller, effects in the euro area and Japan, with one obvious exception, i.e., that the effective real exchange rate depreciates in Japan. It should also be noted that, quantitatively, the effects of the US demand shock on the euro area economy are typically somewhat larger than those on the Japanese economy, and that the relative size of the effects in Japan and especially in the euro area compared to those in the United States are larger for financial variables than for non-financial variables.

Demand shocks in the euro area have similar effects on output and unemployment in the euro area economy as the corresponding shocks in the United States have on the US economy. However, the inflation effects and the interest rate response are larger in the euro area than in the United States. In the case of a Japanese demand shock, the effects on output, inflation and interest rates in Japan tend to be somewhat larger than those in the United States from a US demand shock, while the effects on unemployment are smaller. For the most part, the spillover effects from a euro area shock to the United States and Japan are very similar to those from the United States to the euro area and Japan. Similar responses can be seen in the spillover effects of demand shocks in Japan.

Figures 11 through 13 show the effect of a shock to the  $BLT_{US}$  variable on the key variables in the three economies. An easing in bank lending tightening in the United States results in a considerably stronger US economy and qualitatively similar effects in the euro area and Japan that are about one fourth the size of those in the United States for the output gap and a somewhat higher ratio for inflation.

Figures 14 through 16 set out the results of a shock to potential output growth in the United States. The shock to potential output growth is accompanied by an increase in the output gap because of the cross correlation between the shock to potential output growth and that to the bank lending tightening variable. As discussed earlier, a positive shock to potential output growth that is expected to persist for a considerable period of time may be associated with an easing in bank lending tightening (along with an increase in implicit increase in asset prices). The easing in bank lending tightening results in an increase in the output gap and output growth, a reduction in the unemployment gap, a rise in inflation, an increase in nominal and real interest rates, and an appreciation of the real exchange rate. The spillover to the euro area and Japan involves qualitatively similar, but quantitatively smaller, effects, with the exception of the depreciation of the exchange rate in the two overseas economies. Comparing the effects of the shock to potential

output with the shocks to the output gap, one sees that the former gives rise to more persistence, more cumulative output growth and inflation, and larger movements in interest rates and the exchange rate.

### **C. Forecasting with Bayesian Estimates**

There are various ways in which models can be used for out-of-sample forecasting in central banks. The simplest, but least useful, way involves allowing the model to forecast the next few quarters by itself, without any judgmental input. These are typically called unconditional forecasts. A much more sophisticated approach to forecasting, of the sort that is used in central banks and the IMF, makes use of the judgment of country experts to forecast the endogenous variables in the model for the first two quarters or so, and are called conditional forecasts. The basic notion is that these very short-term forecasts (or “nowcasts” as they are sometimes called) are dependent not only on the basic driving forces of the economy but also on many special factors. The influence of such factors is typically not included in basic macro models but is part of the knowledge base of the specialists working in such institutions. As a result, it is very likely that these experts can outperform any model in near-term forecasting, and in this way they can establish a good starting point for the model in forecasting over the medium term, the period when the underlying driving forces of the economy become more important than special factors. In the rest of this section, we provide an illustrative example of a conditional forecast to show the way in which judgmental information can be introduced into the first two or three quarters of the projection (by “tuning” the model in those quarters), following which the model is allowed to determine the forecast for the rest of the projection period.<sup>20</sup> We also compare the results of this conditional forecast with those of an unconditional forecast, in which all the endogenous variables are determined by the model.

Figure 17 presents the summary results of the conditional forecast and a comparison with the unconditional forecast, while figures 18, 19 and 20 provide more detailed information for the United States, the euro area, and Japan. All the actual data for the unconditional forecasts are based on information available for 2008Q1. The same is true for the actual data for the conditional forecasts, with the following exceptions. Actual data for 2008Q2 are used for the

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<sup>20</sup>Note that this forecast is not an official forecast of the IMF or of the Bank of Russia, but rather is provided solely for illustrative purposes.

short-term interest rates in all three countries, the two bilateral exchange rates, the US unemployment rate, and the bank lending tightening variable. All the figures in the tables present the central forecast along with 30%, 50%, 70% and 95% confidence intervals, the latter reflecting two standard deviations from the central case.<sup>21</sup> These confidence intervals give some indication of the degree of confidence that can be placed in the forecast of the different variables and the range within which one would expect the different variables to fall. The figures also show the unconditional forecasts (the dashed line), thereby allowing us to assess the effect of using actual data (where available) and judgmental inputs for two or three quarters in the conditional forecasts. Similar information with respect to the difference between the conditional and unconditional forecasts is provided in square brackets in the bottom half of each table.

Let us begin our analysis of the conditional forecast with the US economy. Judgment is provided for quarterly real GDP growth for 2008Q2 and Q3. The strength in Q2 is largely a result of the effect of the rebate cheques on household expenditures, along with some unexpected strength in nonresidential construction, the combination of which helped to offset the weakness in residential construction. The relatively weak real output growth in the subsequent three quarters suggests that the strength in Q2 involved some borrowing from future spending. There is no judgmental input into potential GDP growth, which declines through much of 2008 and 2009 because of the impact of tightening in the BLT variable on potential output growth, as both respond to the sustained decrease in asset prices. Potential output growth returns to its steady-state rate of about 2.5% in 2010 and thereafter. Judgment was used to increase total CPI inflation in Q2, Q3, and Q4. The strong positive judgment in the conditional forecast for CPI inflation is partly related to the sharp increase in oil prices over the preceding period in two ways. First, margins in the retail price of oil had declined over the earlier period as it takes some time to pass on increases in the price of crude oil, and they were likely to be restored in the rest of 2008. Second, there has been a tendency to underestimate the response of retail energy prices to increases in crude oil prices, based on a historical relationship in which specific taxes on energy were a much higher proportion of total retail prices than is the case at present. Moreover, sharp increases in producers prices in food, energy and other commodities indicated significant upward pressure on the total CPI. The output gap, which involves no judgmental input, troughs in 2009 and remains negative

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<sup>21</sup>The standard production version of the model that has been used in preparing this paper is linear and does not put any non-negativity restrictions on nominal interest rates, with the result that the forecast nominal interest rate does at times become negative in the lower confidence intervals. An alternative, non-linear procedure has been developed that prevents interest rates from becoming negative, but use of this procedure is very time consuming.

in 2010, thereby providing downward pressure on the rate of inflation. Finally, the increase in the short-term interest rate in the United States in Q3 is based on market sentiment that anticipates a one-time increase in the policy interest rate. Interest rates remain below equilibrium for a couple of years, as the monetary authorities provide stimulus to a relatively weak economy in the context of forecast declining inflation.

Turning to the euro area and Japan, there is a sharper decline in quarterly real GDP growth in Q2 than in the United States, partly because of the fiscal support in the United States in Q2, and perhaps partly because of the leap year effect in Q1 in Japan. While euro area inflation is high through 2008 (although less than in the United States), Japanese inflation remains considerably lower. This difference is related to the negative output gap in Japan, although partly offset by the greater appreciation of the currency in the euro area. Euro area interest rates remain high in 2008 in the face of continuing relatively high inflation, while Japanese interest rates remain low. The cyclical movements of the euro area economy and especially those of the Japanese economy are somewhat more muted than those of the US economy.

Actual forecasts in policymaking institutions reflect a combination of judgment by experts, particularly for the near term, and the model dynamics for the medium term. The results of this section of the paper indicate how such forecasts can be affected by the judgmental projection of the exogenous variables and the tuning of endogenous variables. Typically, this judgment reflects a much more detailed understanding of the various sectors of the economy based on earlier empirical work, recent data, and anecdotal information than can be captured in a small macro model. And the difference between the conditional forecast and the unconditional forecast shows the extent to which the judgments are affecting the forecast results. The model itself imposes consistency on the forecast in the medium term and long term.

## **V. Concluding Remarks**

This is the second of a series of papers that are being written as part of a larger project to estimate a small quarterly Global Projection Model (GPM). The GPM project is designed to improve the toolkit to which economists have access for studying both own-country and cross-country macro linkages and financial-real linkages. In this paper, we developed a small quarterly projection model of three economies (United States, euro area, and Japan) in which the key variables were

output gaps, unemployment gaps, inflation rates, short-term interest rates, and exchange rates. We also introduced a financial variable (in the form of a US bank lending tightening variable) into the model to allow for financial-real linkages. The model was estimated with Bayesian techniques, which provide a very efficient way of imposing restrictions to produce both plausible dynamics and sensible forecasting properties. An important advantage of these techniques is that they allow researchers to estimate models with flexible stochastic processes, which can provide timely and more efficient model-consistent measures of potential output and other latent variables in the system. After presenting the posterior estimates, impulse response functions, and RMSEs for intra-sample forecasts, we showed how the model can be used to construct efficient baseline out-of-sample forecasts that incorporate judgment imposed on the near-term outlook.

The next phases of the project will be to expand the model to include financial variables in other countries and to build a global version of the model (with several countries and a residual economy) and use it to assess whether spillovers across countries are generated more through financial linkages than through conventional trade linkages. It can also be used to compare forecasting results with those of competitor models of the global economy.

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## Appendix: GPM Data Definitions

United States	
GDP U.S.:	Gross Domestic Product (SAAR, Bil.Chn.2000.Dollars)
Interest rates	Federal Open Market Committee: Fed Funds Target Rate (percent) (period average)
CPI U.S.:	Consumer Price Index (SA, 1982-84=100)
Core CPI	U.S.: CPI-U: All Items Less Food and Energy (SA, 1982-84=100)
Unemployment	U.S.: Civilian Unemployment Rate (SA, percent)
Bank lending tightening (BLT)	Average of: FRB Sr Officers Survey: Banks Tightening C.I Loans to Large Firms (percent) FRB Sr Officers Survey: Banks Tightening C.I Loans to Small Firms (percent) FRB Sr Loan Off Survey: Tightening Standards for Commercial Real Estate (percent) FRB Sr Loan Survey: Res Mortgages: Net Share, Banks Tightening (Haver Est, percent)
Euro Area	
GDP Euro	Area15: Gross Domestic Product (SA/WDA, Mil.Chn.00.Euros)
Interest rates	Euro Area11-15: 3-Month EURIBOR Rate (AVG, percent)
CPI Euro	Area15: Monetary Union Index of Consumer Prices (SA, 2005=100)
Core CPI	Euro Area15: MUICP: Total excl Energy, Food, Alcohol and Tobacco(SA, 2005=100)
Unemployment	Euro Area15: Unemployment Rate (SA,percent)
Exchange Rates	Period averages; increase is depreciation
Japan	
GDP Japan:	Gross Domestic Product (SAAR, Bil.Chn.2000.Yen)
Interest rates	Japan: Call Rate: Uncollateralized 3-Month (EOP, percent)
CPI Japan:	Consumer Price Index (SA, 2005=100)
Core CPI	Japan: CPI: All Items excluding Food and Energy (SA, 2005=100)
Unemployment	Japan: Unemployment Rate (SA, percent)
Exchange Rates	Period averages; increase is depreciation
Real Effective	
Exchange Rates	Weighted averages of the bilateral exchange rates. Weights are based on bilateral trade data from IMF Direction of Trade database (2006). The rates in the inflation equations are defined with import weights, while the rates in the output gap equations use total trade (imports+exports) weights.
Foreign Outp. Gaps	Weighted averages of the lagged foreign output gaps. Weights are based on bilateral trade data (exports) from IMF Direction of Trade db (2006).

Figure 1: Comparison between Output Gap and BLT indicator

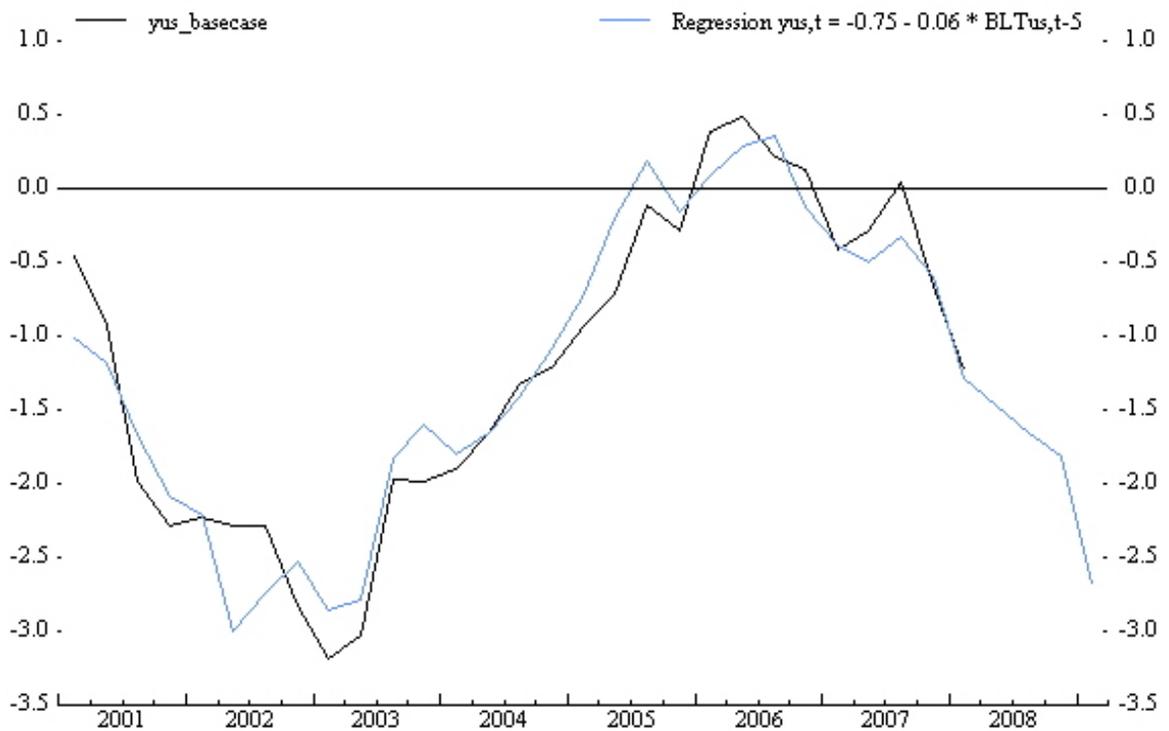


Table 1: Results from posterior maximization [1]

	Prior distribution	Prior mean	Prior s.d.	Posterior mode	s.d.
$\alpha_{eu,1}$	beta	0.750	0.1000	0.7170	0.0685
$\alpha_{ja,1}$	beta	0.750	0.1000	0.7589	0.1168
$\alpha_{us,1}$	beta	0.750	0.1000	0.8235	0.0514
$\alpha_{eu,2}$	gamm	0.300	0.1000	0.1401	0.0279
$\alpha_{ja,2}$	gamm	0.100	0.0500	0.0599	0.0305
$\alpha_{us,2}$	gamm	0.300	0.1000	0.1823	0.0260
$\alpha_{eu,3}$	beta	0.500	0.2000	0.1010	0.0452
$\alpha_{ja,3}$	beta	0.500	0.2000	0.2214	0.1052
$\alpha_{us,3}$	beta	0.500	0.2000	0.3649	0.2627
$\beta_{eu,1}$	gamm	0.750	0.1000	0.9544	0.0670
$\beta_{ja,1}$	gamm	0.750	0.1000	0.9649	0.0598
$\beta_{us,1}$	gamm	0.750	0.1000	0.6549	0.0545
$\beta_{eu,2}$	beta	0.100	0.0500	0.1478	0.0638
$\beta_{ja,2}$	beta	0.100	0.0500	0.0726	0.0406
$\beta_{us,2}$	beta	0.100	0.0500	0.0694	0.0410
$\beta_{eu,3}$	gamm	0.200	0.0500	0.2009	0.0438
$\beta_{ja,3}$	gamm	0.200	0.0500	0.1478	0.0399
$\beta_{us,3}$	gamm	0.200	0.0500	0.1866	0.0455
$\beta_{eu,4}$	gamm	0.104	0.0400	0.0516	0.0206
$\beta_{ja,4}$	gamm	0.090	0.0400	0.0302	0.0157
$\beta_{us,4}$	gamm	0.060	0.0200	0.0423	0.0144
$\beta_{eu,5}$	gamm	0.052	0.0100	0.0514	0.0099
$\beta_{ja,5}$	gamm	0.045	0.0100	0.0398	0.0090
$\beta_{us,5}$	gamm	0.030	0.0100	0.0241	0.0085

Table 2: Results from posterior maximization [2]

	Prior distribution	Prior mean	Prior s.d.	Posterior mode	s.d.
$\gamma_{eu,1}$	beta	0.500	0.0500	0.6859	0.0359
$\gamma_{ja,1}$	beta	0.500	0.0500	0.7497	0.0356
$\gamma_{us,1}$	beta	0.500	0.0500	0.7107	0.0350
$\gamma_{eu,2}$	gamm	1.500	0.2000	1.3061	0.1658
$\gamma_{ja,2}$	gamm	1.500	0.2000	1.0579	0.1424
$\gamma_{us,2}$	gamm	1.500	0.3000	0.9104	0.1884
$\gamma_{eu,4}$	gamm	0.200	0.0500	0.2012	0.0511
$\gamma_{ja,4}$	gamm	0.200	0.0500	0.1693	0.0433
$\gamma_{us,4}$	gamm	0.200	0.0500	0.2052	0.0522
$g_{eu}^{\bar{Y}^{ss}}$	norm	2.000	0.0500	2.2614	0.3189
$g_{ja}^{\bar{Y}^{ss}}$	norm	1.700	0.0500	1.4444	0.3053
$g_{us}^{\bar{Y}^{ss}}$	norm	2.200	0.0500	2.2729	0.2451
$\kappa_{us}$	gamm	20.000	0.5000	20.0773	0.4957
$\lambda_{eu,1}$	beta	0.500	0.1000	0.7867	0.0704
$\lambda_{ja,1}$	beta	0.500	0.1000	0.8967	0.0421
$\lambda_{us,1}$	beta	0.500	0.1000	0.8480	0.0551
$\lambda_{eu,2}$	gamm	0.250	0.0500	0.2223	0.0407
$\lambda_{ja,2}$	gamm	0.250	0.0500	0.1836	0.0405
$\lambda_{us,2}$	gamm	0.200	0.0500	0.1801	0.0381
$\lambda_{eu,3}$	gamm	0.208	0.0500	0.1061	0.0233
$\lambda_{ja,3}$	gamm	0.180	0.0500	0.0756	0.0203
$\lambda_{us,3}$	gamm	0.120	0.0500	0.0707	0.0264

Table 3: Results from posterior maximization [3]

	Prior distribution	Prior mean	Prior s.d.	Posterior mode	s.d.
$\phi_{eu}$	beta	0.500	0.2000	0.8342	0.0670
$\phi_{ja}$	beta	0.500	0.2000	0.8562	0.0677
$\rho_{eu}$	beta	0.500	0.1000	0.4673	0.1189
$\rho_{ja}$	beta	0.500	0.1000	0.4968	0.1072
$\rho_{us}$	beta	0.500	0.1000	0.2901	0.0667
$\overline{r}r_{eu}$	norm	2.000	0.3000	1.9837	0.1904
$\overline{r}r_{ja}$	norm	2.000	0.3000	1.3791	0.2546
$\overline{r}r_{us}$	norm	2.000	0.3000	1.7285	0.2465
$\tau_{eu}$	beta	0.050	0.0300	0.0289	0.0185
$\tau_{ja}$	beta	0.050	0.0300	0.0375	0.0254
$\tau_{us}$	beta	0.050	0.0300	0.0274	0.0160
$\theta_{us}$	gamm	1.000	0.5000	1.0708	0.5567

Table 4: Results from posterior parameters (standard deviation of structural shocks)

	Prior distribution	Prior mean	Prior s.d.	Posterior mode	s.d.
$\varepsilon_{us}^{\overline{BLT}}$	invg	0.200	Inf	0.0922	0.0377
$\varepsilon_{us}^{\overline{BLT}}$	invg	0.400	Inf	0.9487	0.4592
$\varepsilon_{eu}^{g\overline{Y}}$	invg	0.100	0.0500	0.1142	0.0351
$\varepsilon_{ja}^{g\overline{Y}}$	invg	0.100	0.0500	0.0714	0.0217
$\varepsilon_{us}^{g\overline{Y}}$	invg	0.100	Inf	0.2931	0.0672
$\varepsilon_{eu}^{\overline{Y}}$	invg	0.200	0.0500	0.1821	0.0342
$\varepsilon_{ja}^{\overline{Y}}$	invg	0.200	0.0500	0.6033	0.0736
$\varepsilon_{us}^{\overline{Y}}$	invg	0.050	0.0500	0.0291	0.0112
$\varepsilon_{eu}^{\overline{Z}}$	invg	1.000	Inf	4.3529	0.5711
$\varepsilon_{ja}^{\overline{Z}}$	invg	4.000	Inf	5.7984	0.8056
$\varepsilon_{eu}^{\pi}$	invg	0.500	Inf	1.0736	0.1222
$\varepsilon_{ja}^{\pi}$	invg	1.000	Inf	1.3525	0.1418
$\varepsilon_{us}^{\pi}$	invg	0.700	Inf	1.2532	0.1212
$\varepsilon_{eu}^{\overline{R}}$	invg	0.200	0.0400	0.1885	0.0355
$\varepsilon_{ja}^{\overline{R}}$	invg	0.100	0.0400	0.0795	0.0232
$\varepsilon_{us}^{\overline{R}}$	invg	0.200	Inf	0.9454	0.1599
$\varepsilon_{R_{eu}-R_{us}}$	invg	1.000	Inf	0.4616	0.1892
$\varepsilon_{R_{ja}-R_{us}}$	invg	0.500	Inf	0.2303	0.0939
$\varepsilon_{eu}^{rs}$	invg	0.250	Inf	0.2514	0.0325
$\varepsilon_{ja}^{rs}$	invg	0.250	Inf	0.2336	0.0341
$\varepsilon_{us}^{rs}$	invg	0.700	Inf	0.2408	0.0439
$\varepsilon_{eu}^{\overline{U}}$	invg	0.100	Inf	0.0304	0.0065
$\varepsilon_{ja}^{\overline{U}}$	invg	0.100	Inf	0.0533	0.0323
$\varepsilon_{us}^{\overline{U}}$	invg	0.100	Inf	0.0475	0.0203
$\varepsilon_{eu}^{g\overline{U}}$	invg	0.100	Inf	0.0398	0.0074
$\varepsilon_{ja}^{g\overline{U}}$	invg	0.100	Inf	0.0516	0.0148
$\varepsilon_{us}^{g\overline{U}}$	invg	0.100	Inf	0.0472	0.0175
$\varepsilon_{eu}^u$	invg	0.200	Inf	0.0433	0.0061
$\varepsilon_{ja}^u$	invg	0.100	Inf	0.0724	0.0230
$\varepsilon_{us}^u$	invg	0.200	Inf	0.0967	0.0157
$\varepsilon_{eu}^y$	invg	0.300	0.0500	0.2591	0.0324
$\varepsilon_{ja}^y$	invg	0.500	0.1000	0.3923	0.0569
$\varepsilon_{us}^y$	invg	0.250	Inf	0.3525	0.0410

Table 5: Results from posterior parameters (correlation of structural shocks)

	Prior distribution	Prior mean	Prior s.d.	Posterior mode	s.d.
$\varepsilon_{us}^{\bar{Y}}, \varepsilon_{us}^{\pi}$	beta	0.100	0.0300	0.0915	0.0292
$\varepsilon_{us}^{BLT}, \varepsilon_{us}^{g\bar{Y}}$	beta	0.650	0.0500	0.8759	0.0563
$\varepsilon_{eu}^{\bar{Y}}, \varepsilon_{eu}^{\pi}$	beta	0.100	0.0300	0.0961	0.0304
$\varepsilon_{eu}^y, \varepsilon_{eu}^{g\bar{Y}}$	beta	0.250	0.1000	0.2476	0.1135
$\varepsilon_{ja}^{\bar{Y}}, \varepsilon_{ja}^{\pi}$	beta	0.100	0.0300	0.0917	0.0287
$\varepsilon_{ja}^y, \varepsilon_{ja}^{g\bar{Y}}$	beta	0.250	0.1000	0.2156	0.1026

Table 6: Root Mean Squared Errors

	1 Q Ahead	4 Q Ahead	8 Q Ahead	12 Q Ahead
Output Gap US $y_{us}$	0.5	0.632	0.874	0.994
GDP Quarterly Growth at annual rates US $4(Y_{us} - Y_{us,-1})$	1.89	2.04	2.28	2.17
GDP Year-on-Year Growth US $Y_{us} - Y_{us,-4}$	0.601	1.29	1.64	1.6
Unemployment Rate US $U_{us}$	0.147	0.424	0.819	1.11
CPI Year-on-Year Inflation US $\pi_{4us}$	0.335	0.758	0.724	0.753
Short-term Interest Rate (RS) US $rs_{us}$	0.339	1.06	1.55	1.78
Bank Lending Tightening US $BLT_{us}$	7.55	13	15.8	16.7
Output Gap EU $y_{eu}$	0.379	0.743	0.71	0.871
GDP Quarterly Growth at annual rates EU $4(Y_{eu} - Y_{eu,-1})$	1.56	1.77	1.45	1.38
GDP Year-on-Year Growth EU $Y_{eu} - Y_{eu,-4}$	0.436	1.17	1.06	1.11
Unemployment Rate EU $U_{eu}$	0.0707	0.307	0.704	1.18
CPI Year-on-Year Inflation EU $\pi_{4eu}$	0.267	0.762	0.643	0.477
Short-term Interest Rate (RS) EU $rs_{eu}$	0.27	0.79	0.8	0.953
Output Gap JA $y_{ja}$	0.563	1.22	1.69	1.84
GDP Quarterly Growth at annual rates JA $4(Y_{ja} - Y_{ja,-1})$	2.89	2.94	2.92	2.85
GDP Year-on-Year Growth JA $Y_{ja} - Y_{ja,-4}$	0.724	1.88	1.84	1.69
Unemployment Rate JA $U_{ja}$	0.122	0.373	0.732	1
CPI Year-on-Year Inflation JA $\pi_{4ja}$	0.323	0.898	1.21	1.37
Short-term Interest Rate (RS) JA $rs_{ja}$	0.287	0.973	1.69	2.06

Figure 2: Demand shock in the US (1)

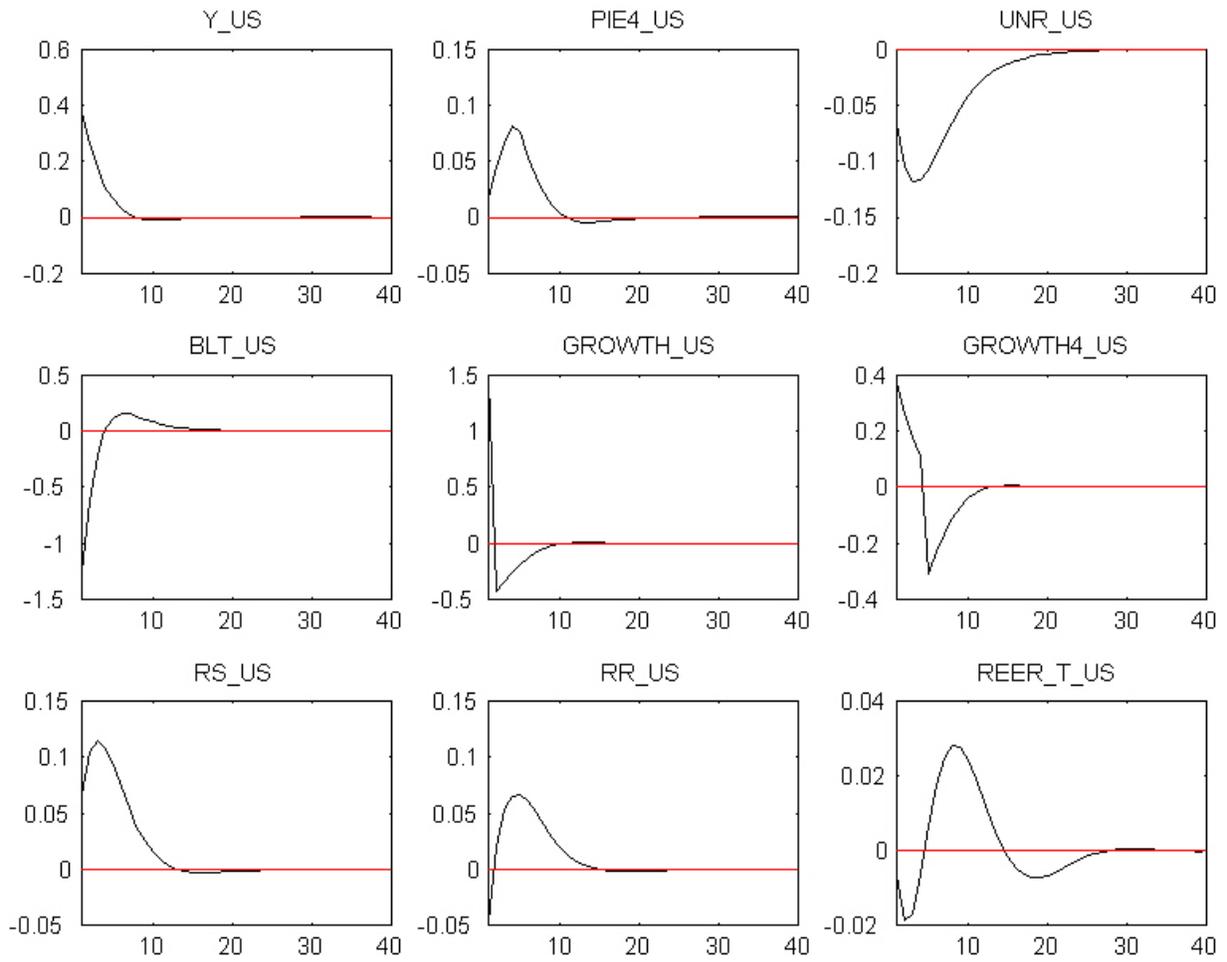


Figure 3: Demand shock in the US (2)

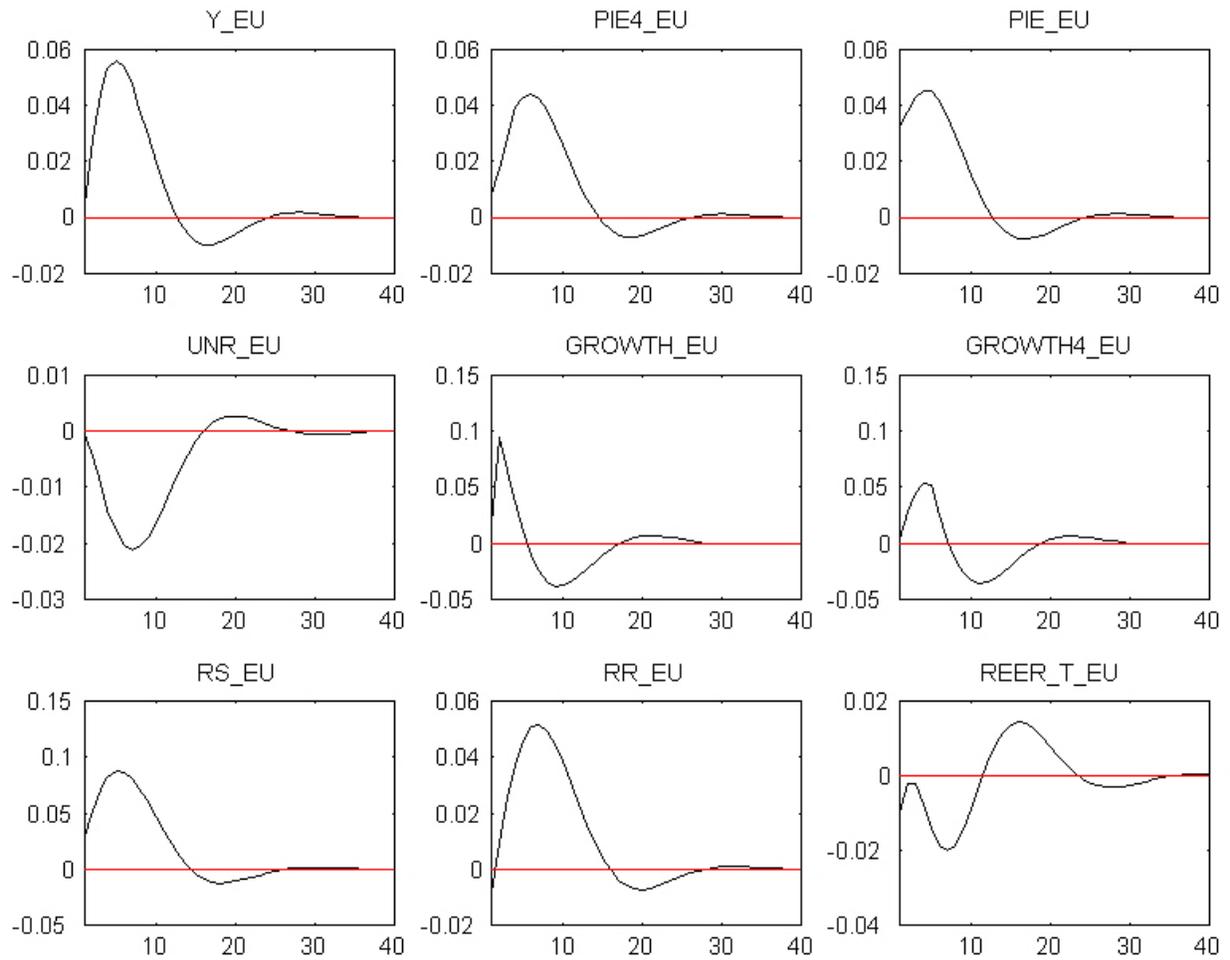


Figure 4: Demand shock in the US (3)

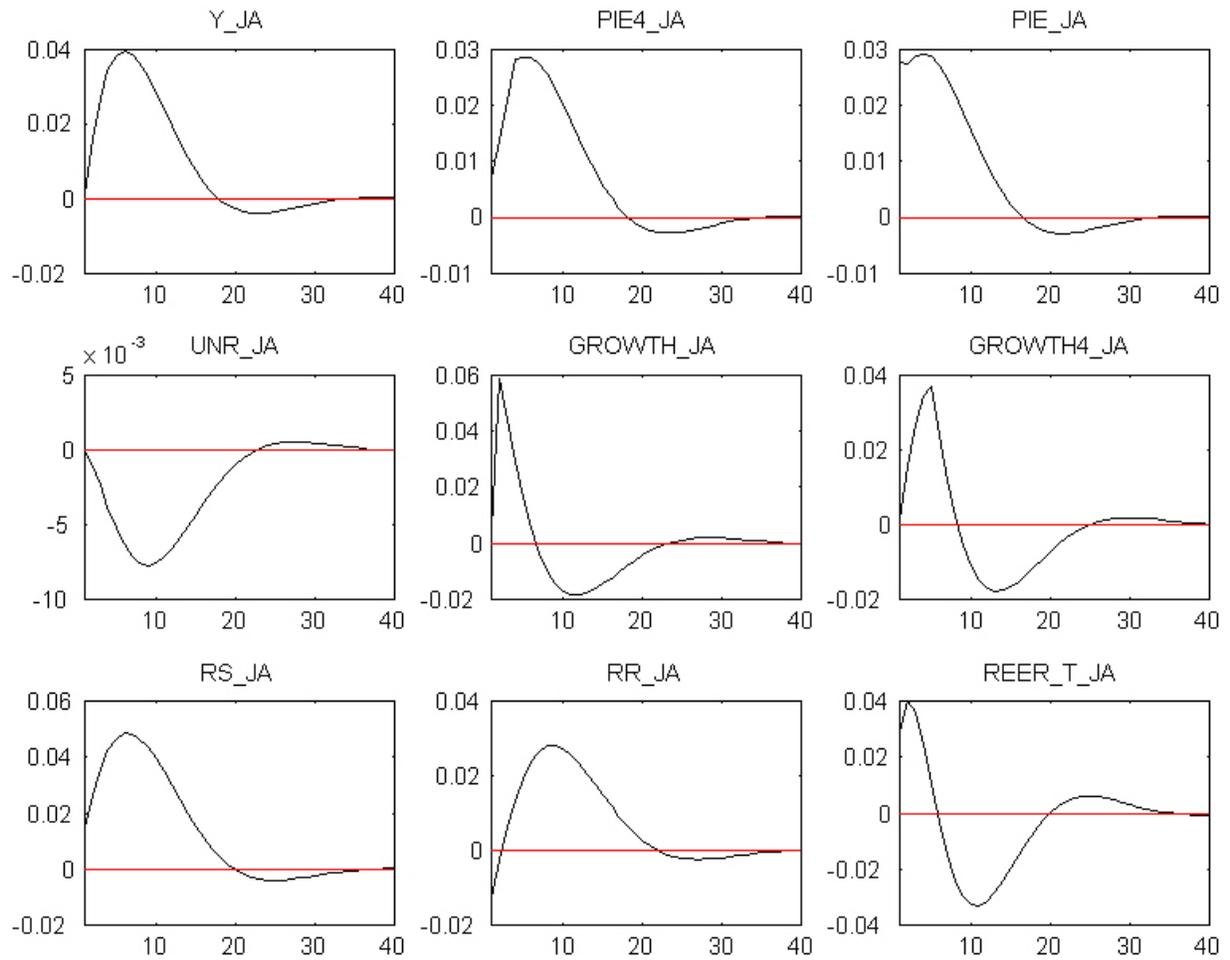


Figure 5: Demand shock in Europe (1)

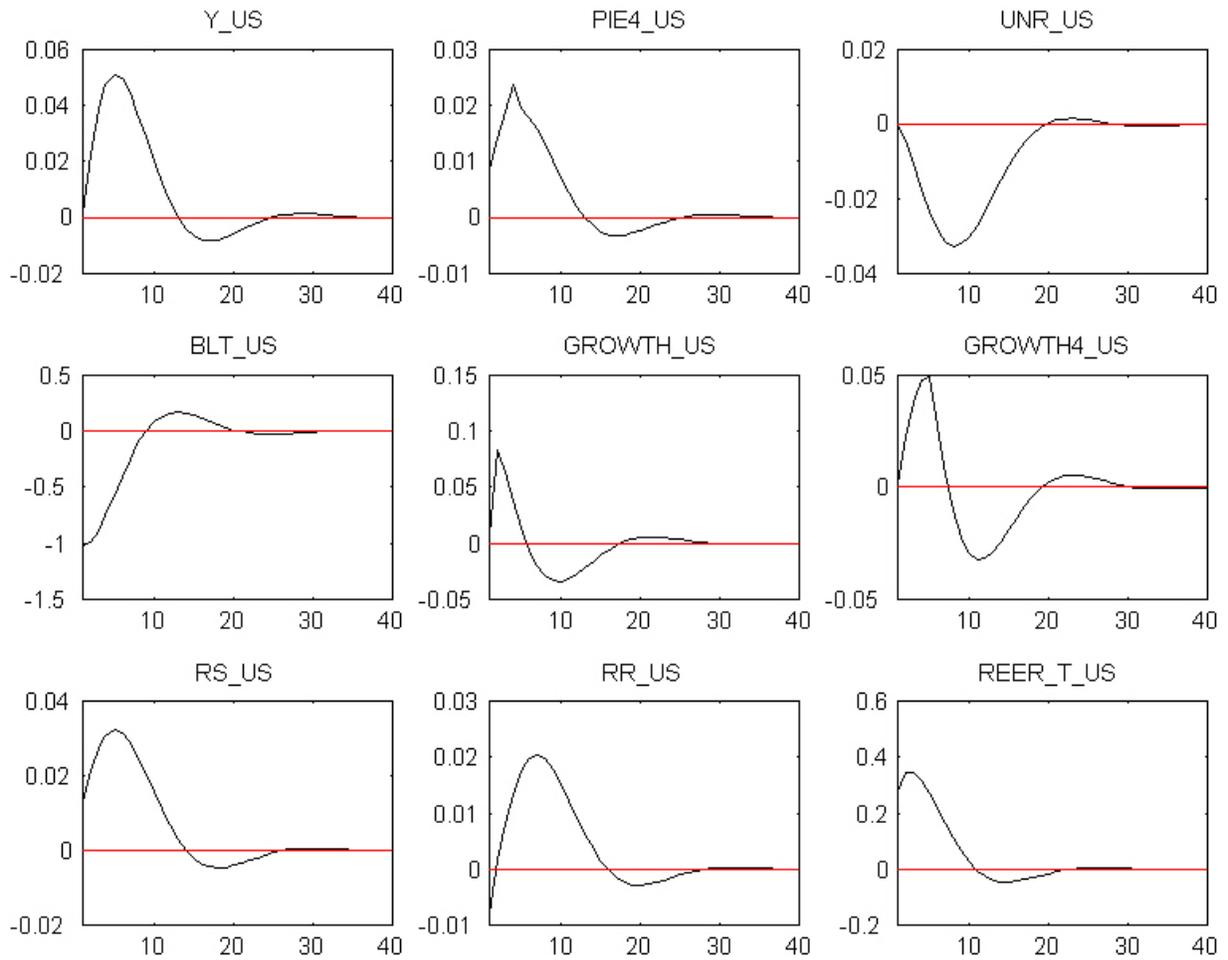


Figure 6: Demand shock in Europe (2)

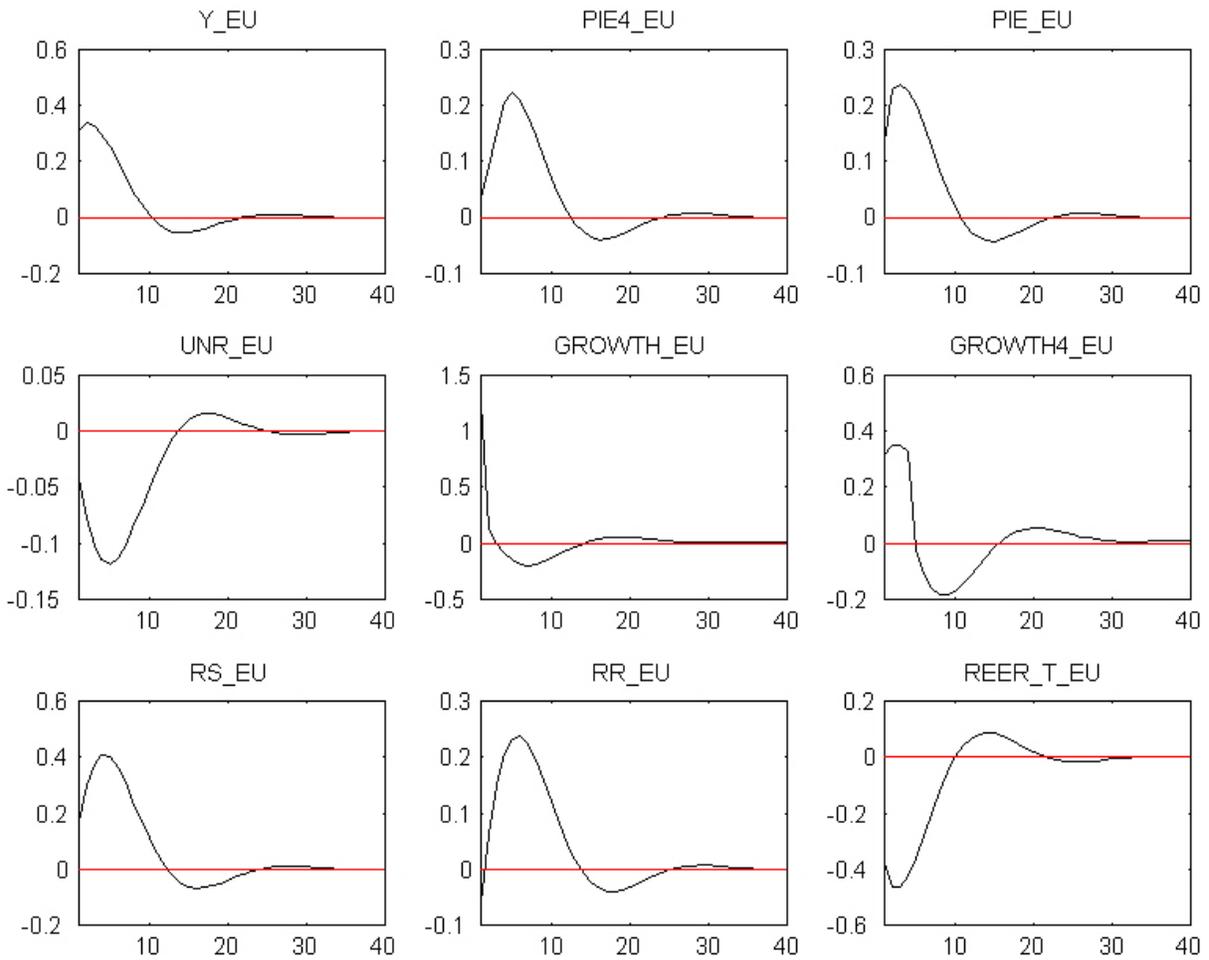


Figure 7: Demand shock in Europe (3)

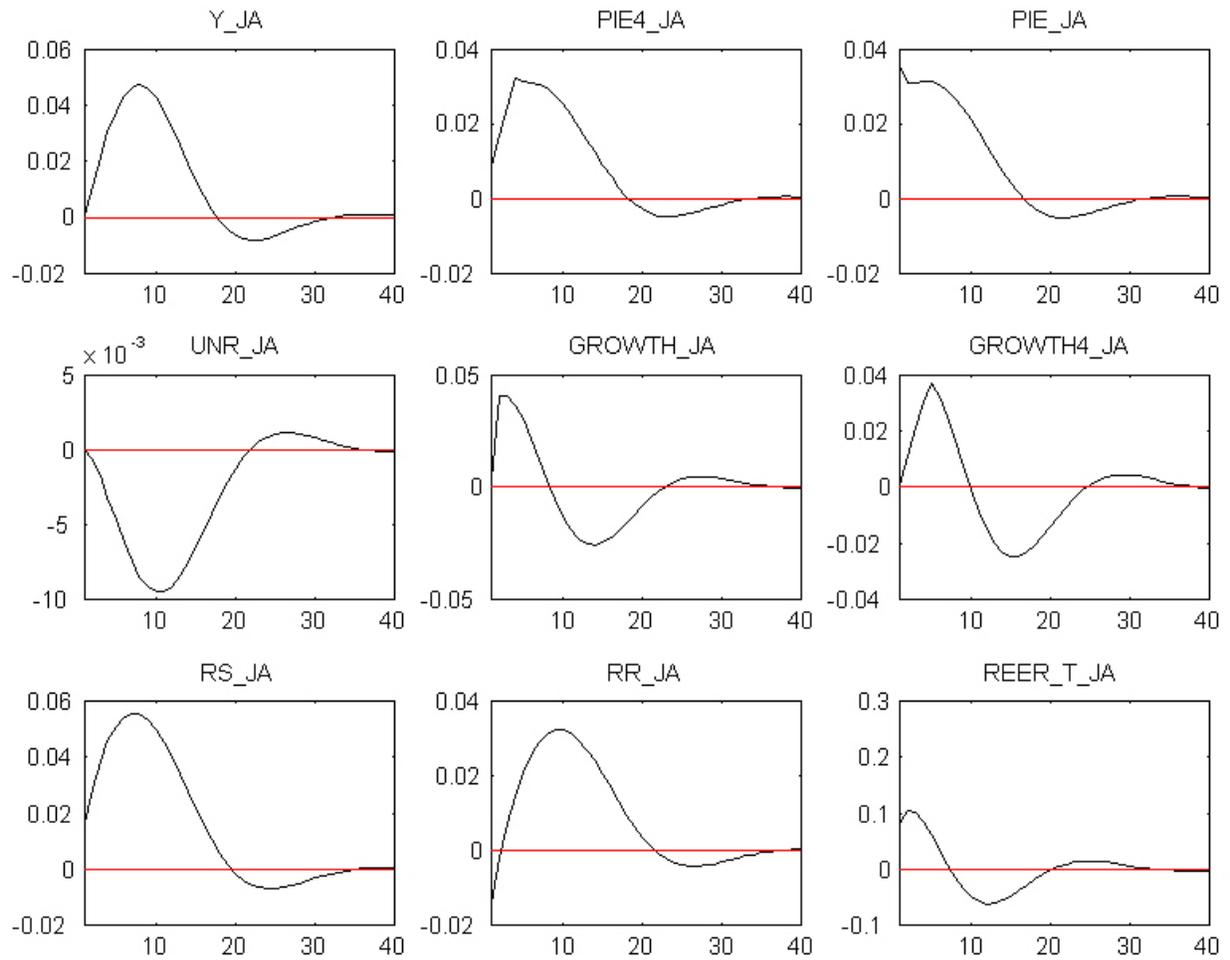


Figure 8: Demand shock in Japan (1)

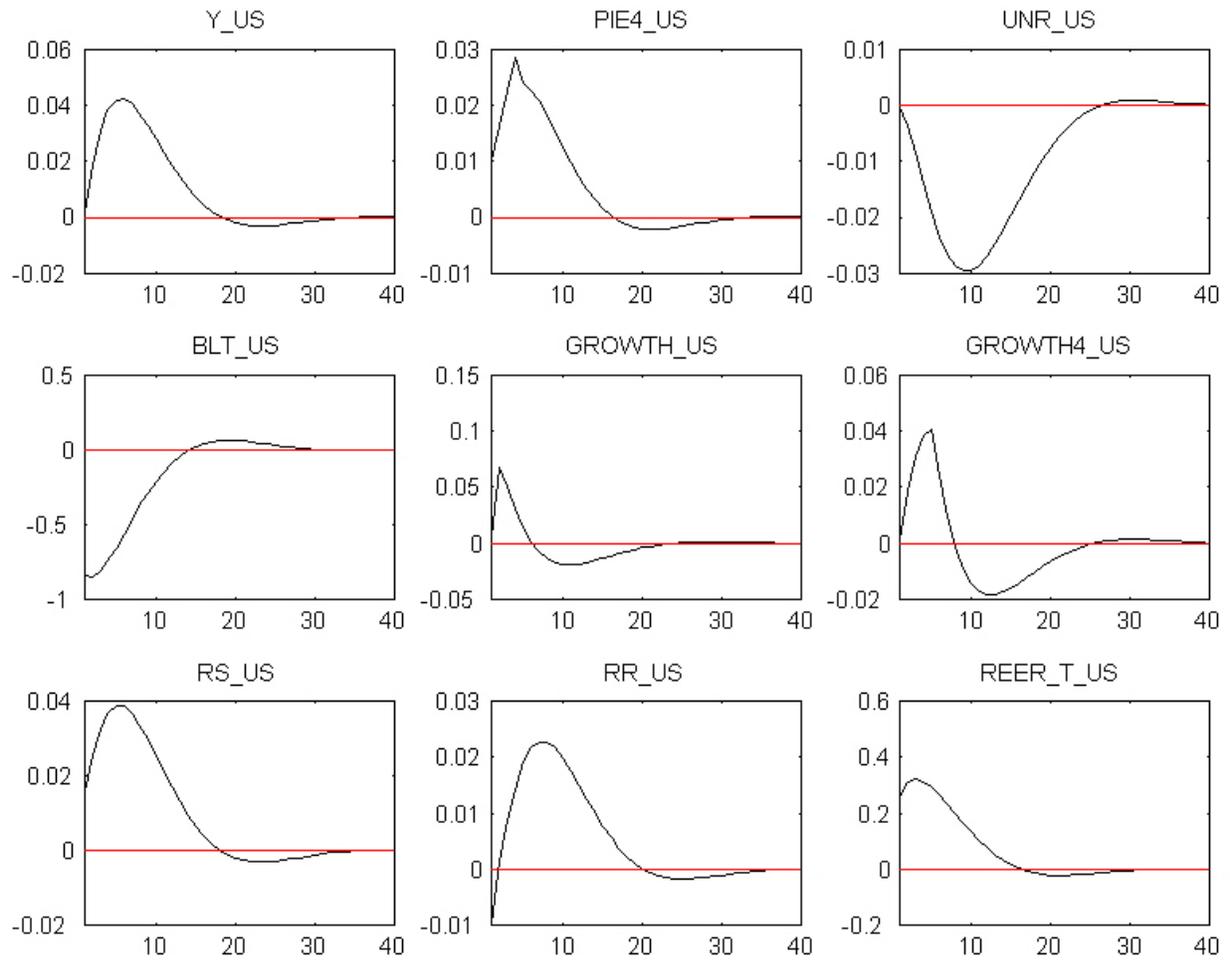


Figure 9: Demand shock in Japan (2)

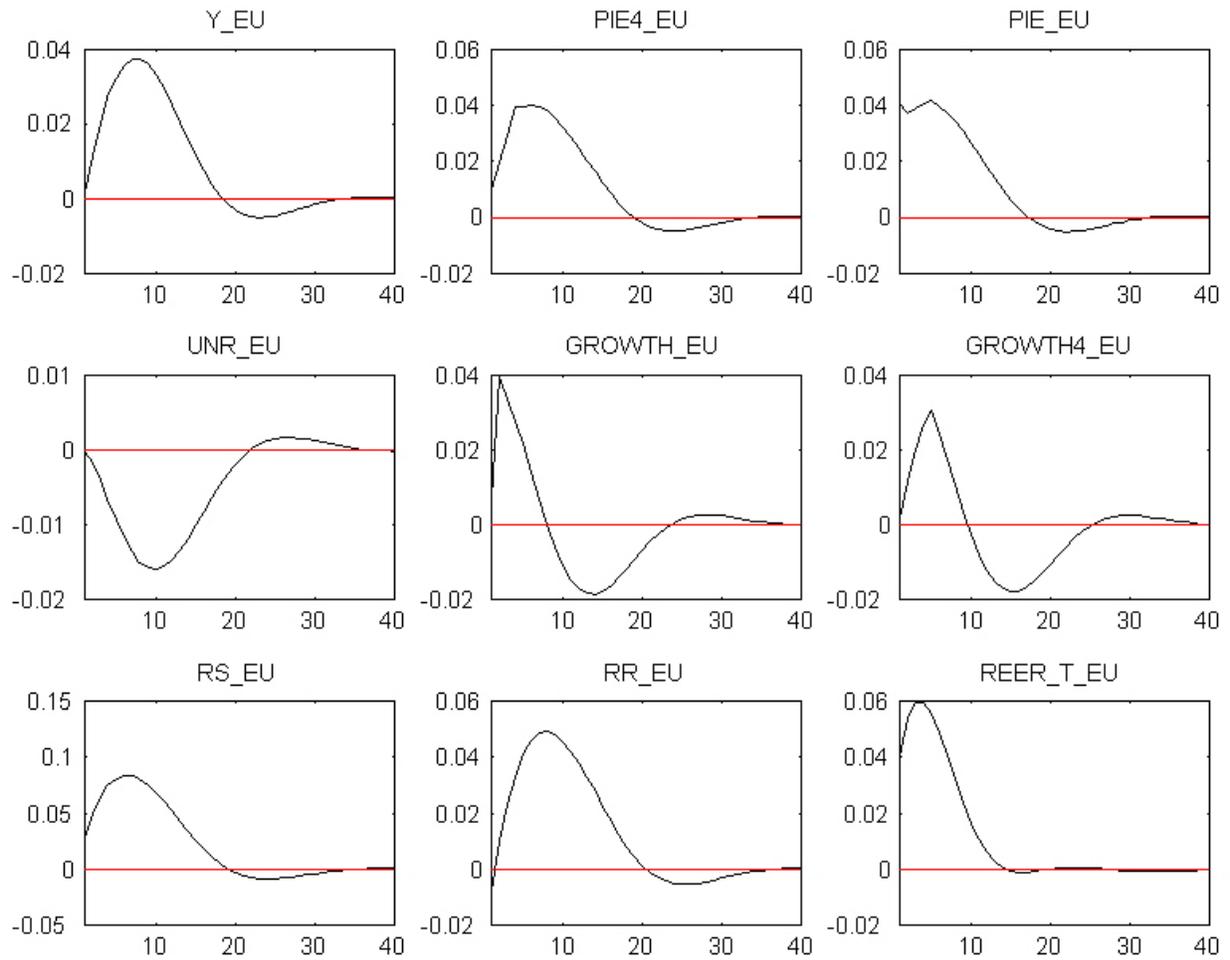


Figure 10: Demand shock in Japan (3)

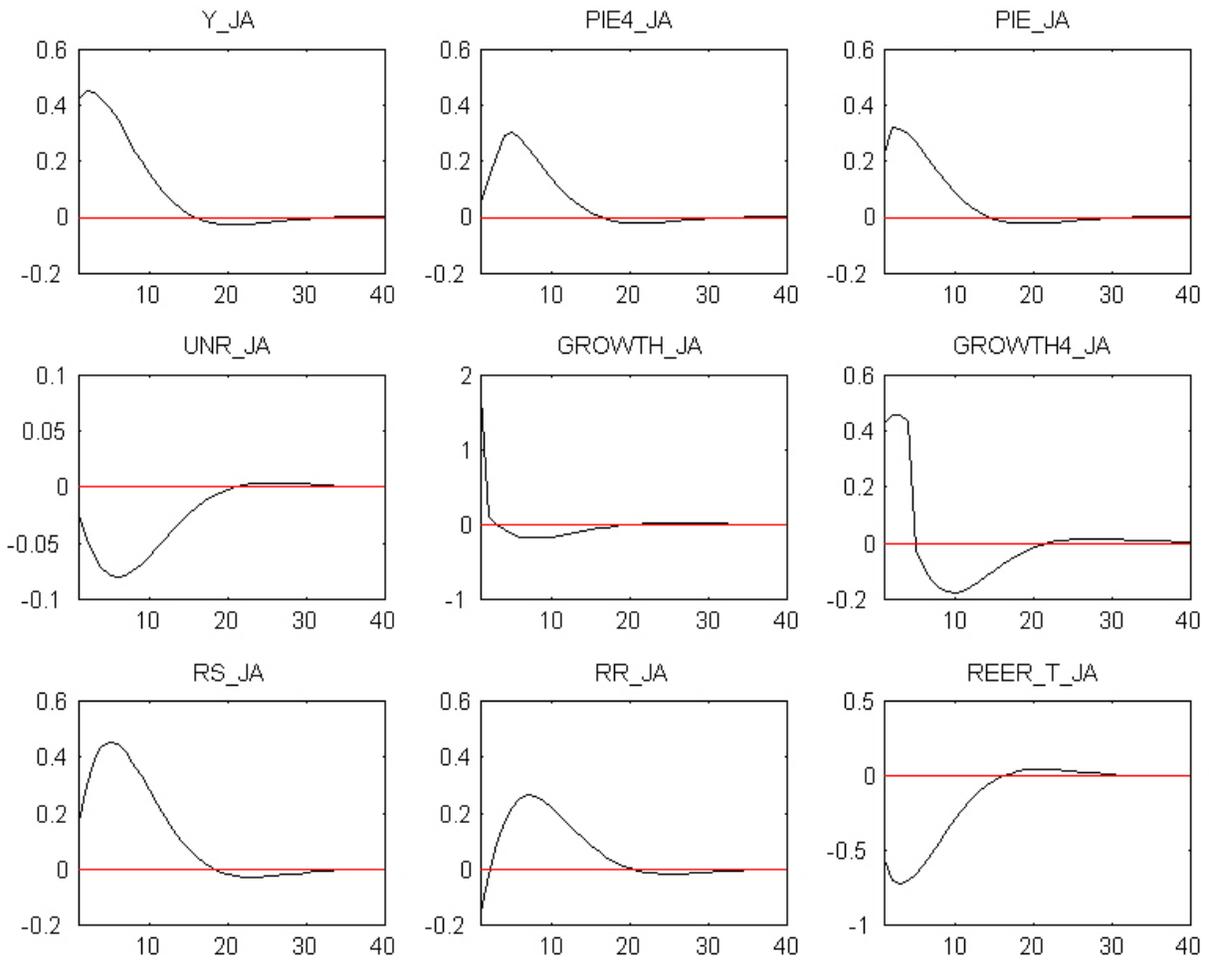


Figure 11: Financial (BLT) shock in the US (1)

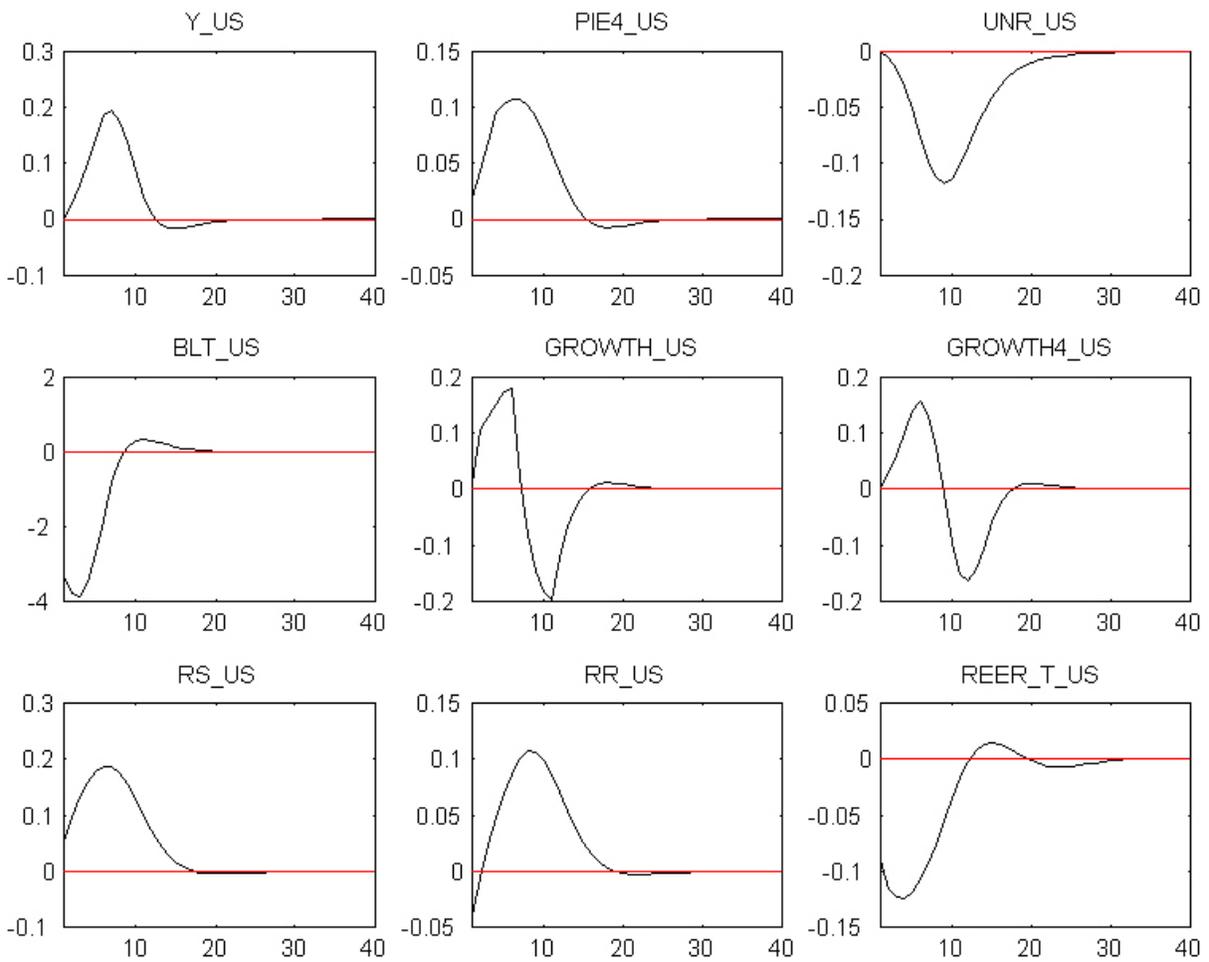


Figure 12: Financial (BLT) shock in the US (2)

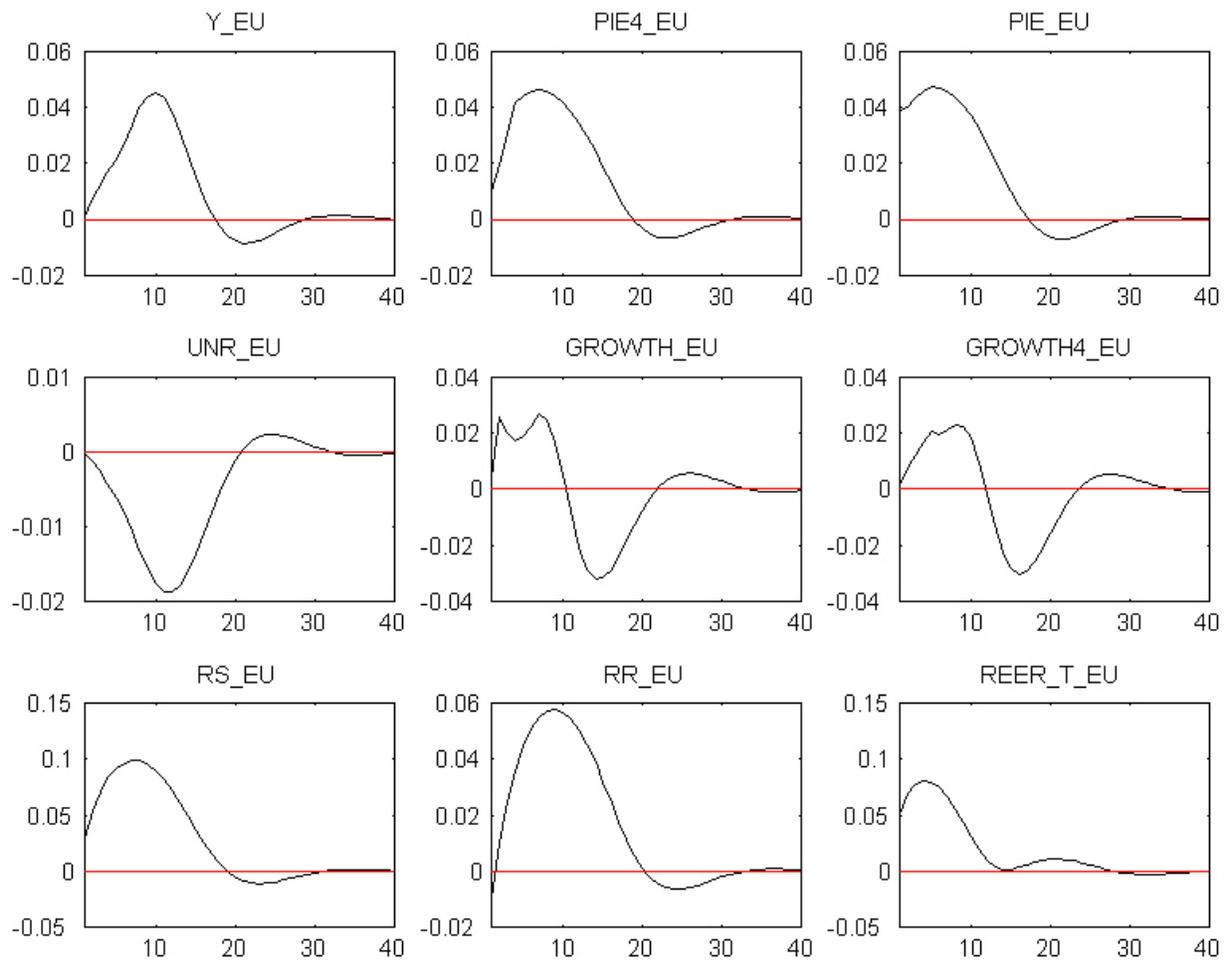


Figure 13: Financial (BLT) shock in the US (3)

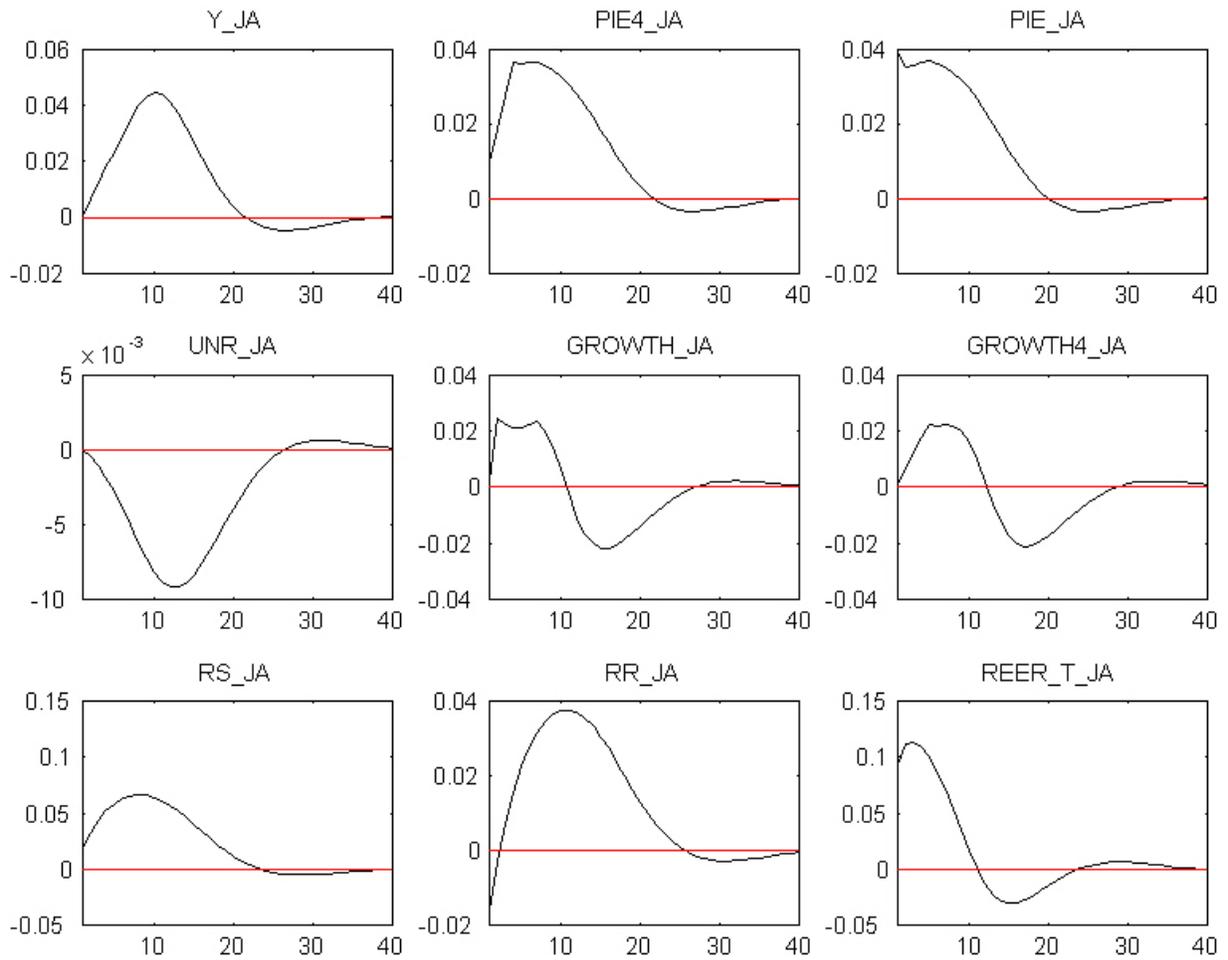


Figure 14: Growth rate shock in the US (1)

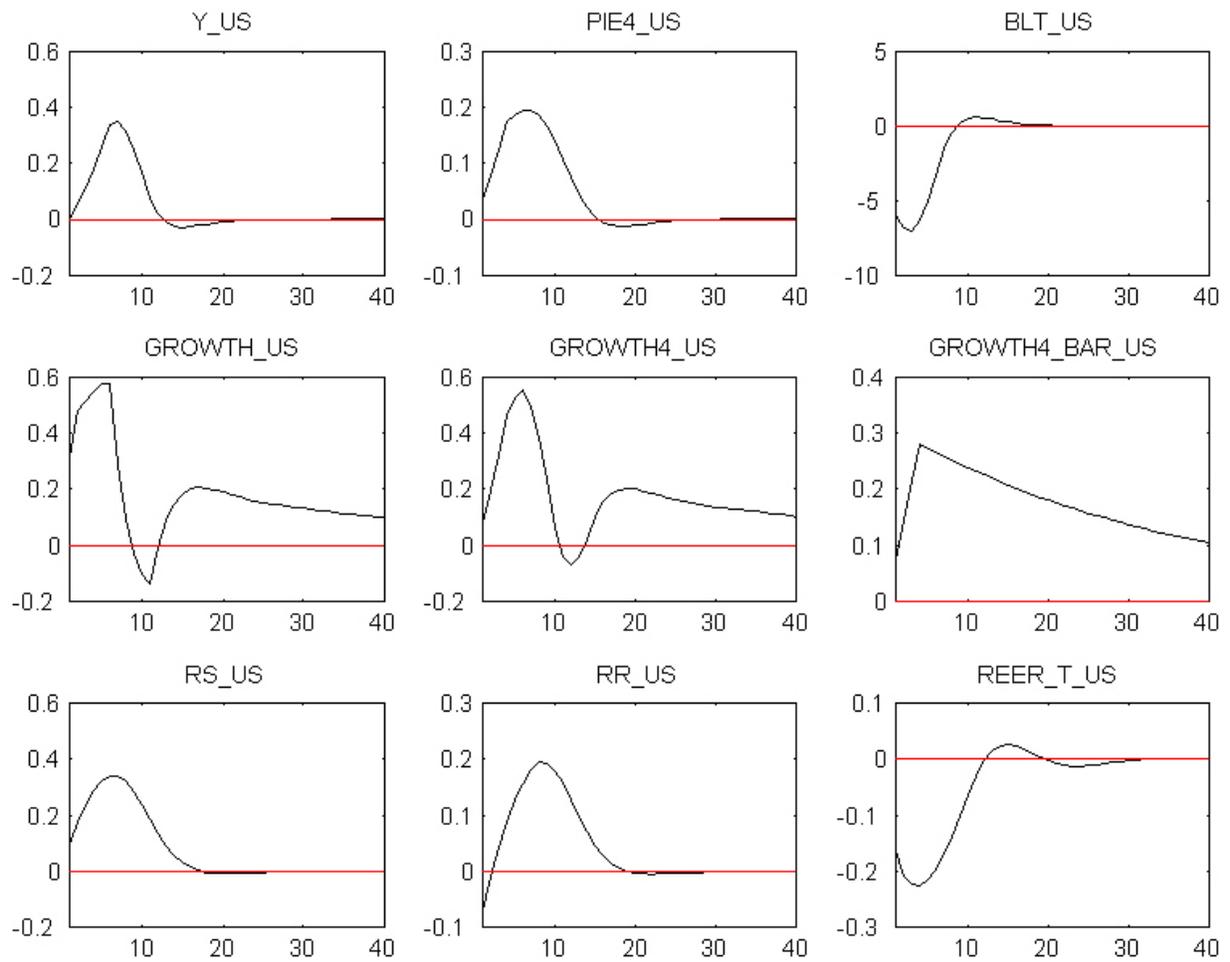


Figure 15: Growth rate shock in the US (2)

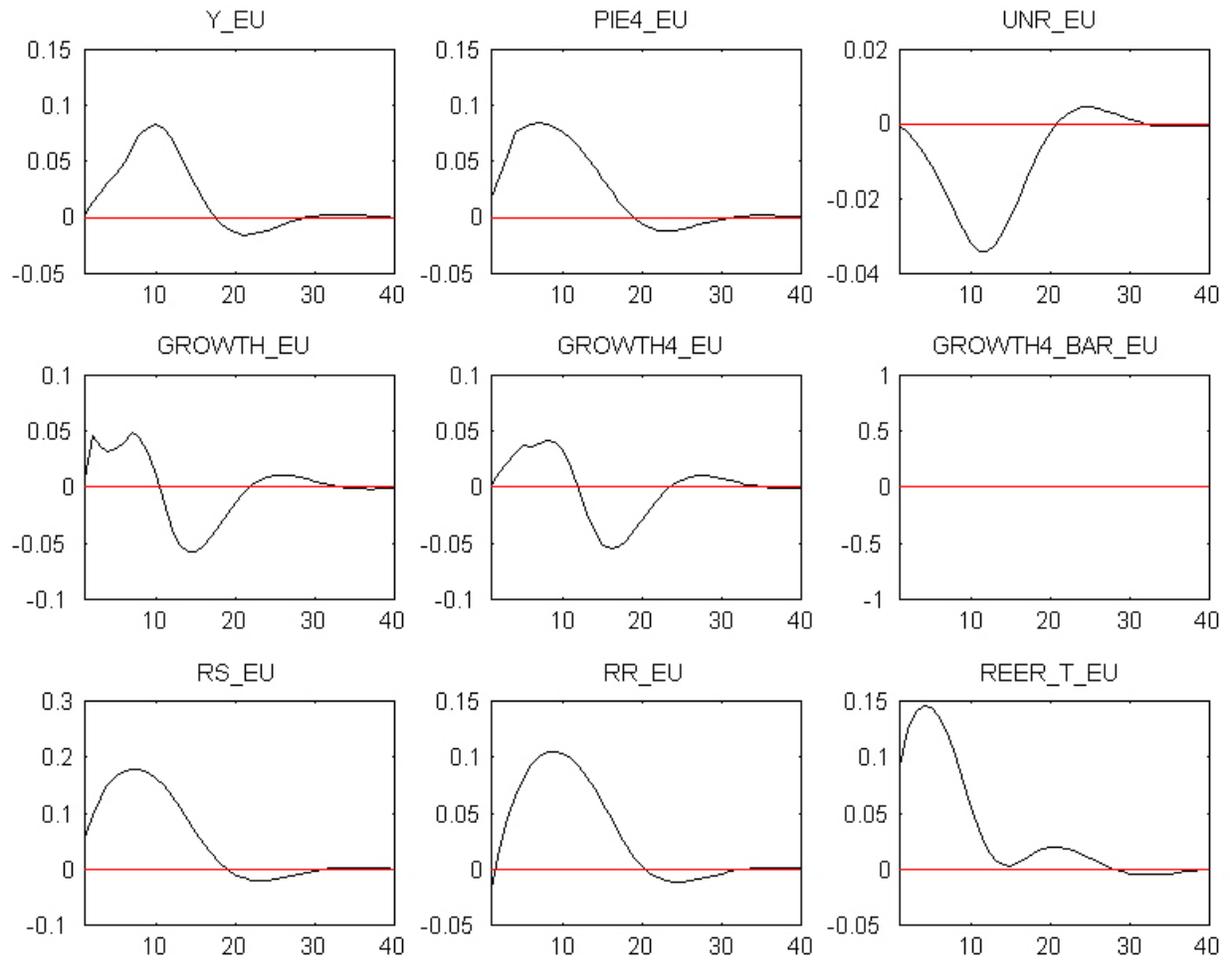


Figure 16: Growth rate shock in the US (3)

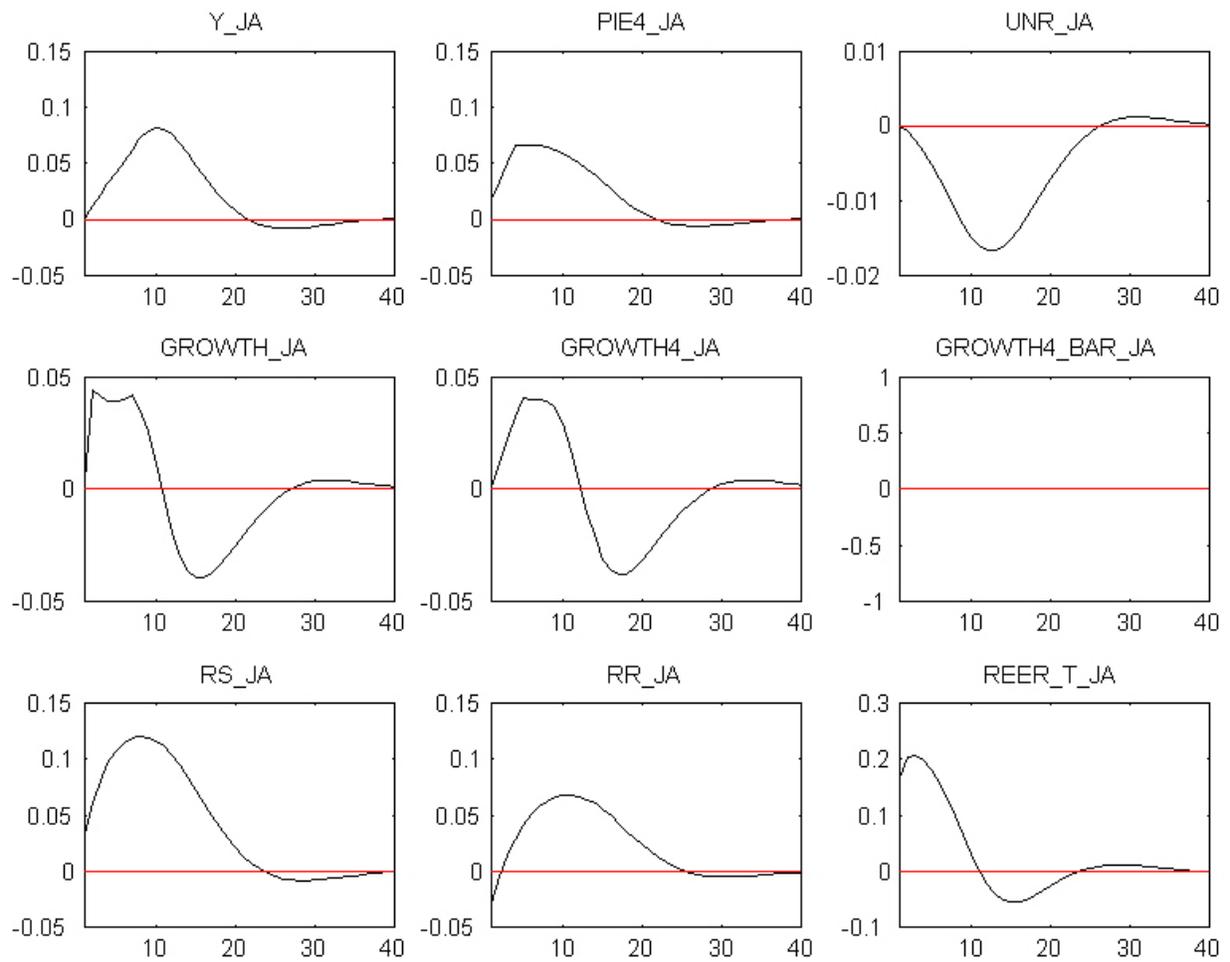
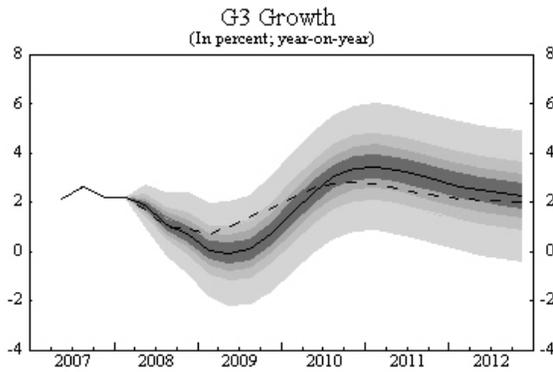


Figure 17: Forecast Results [1]

**Summary: July 18 2008 Conditional Compared to July 18 2008 Unconditional**

(Solid line=July 18 2008 Conditional with 30%, 50%, 70% and 95% confidence bands; dashed line=July 18 2008 Unconditional)



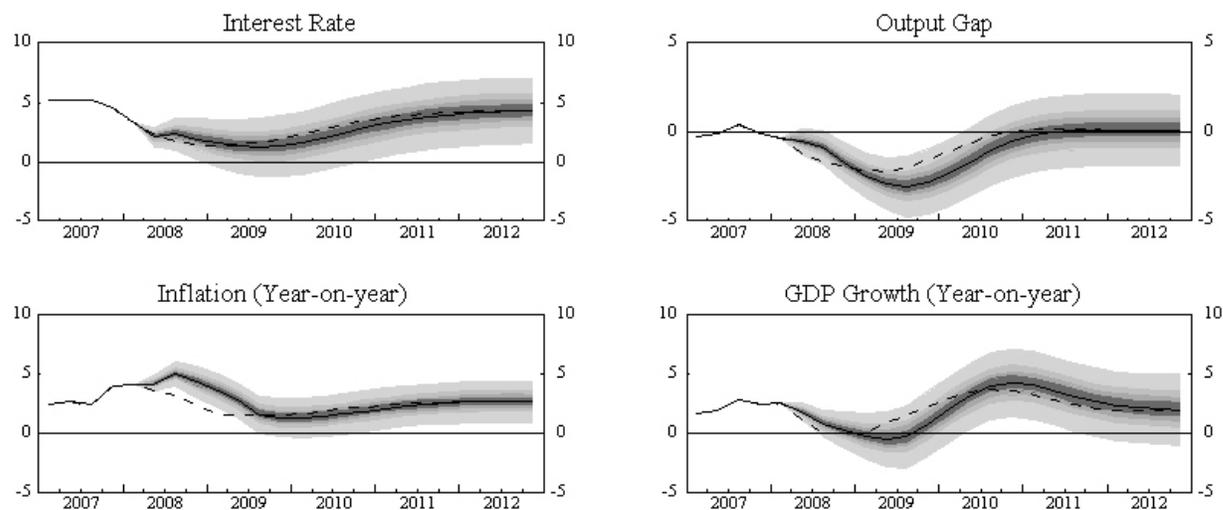
	Quarterly								Annual					
	2007		2008				2009		2007	2008	2009	2010	2011	2012
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2						
<b>Real GDP Growth (% y-o-y)</b>														
G3 Growth	2.6	2.2	2.2	1.9	1.1	0.7	0.1	-0.1	2.3	1.5	0.2	2.6	3.2	2.4
	[+0.0]	[+0.0]	[+0.0]	[+0.2]	[+0.1]	[-0.2]	[-0.6]	[-1.1]	[+0.0]	[+0.0]	[-1.0]	[+0.0]	[+0.7]	[+0.4]
United States	2.8	2.5	2.5	1.8	0.7	0.2	-0.3	-0.6	2.2	1.3	-0.1	3.4	3.4	2.1
	[-0.0]	[+0.0]	[-0.0]	[+0.7]	[+0.8]	[+0.2]	[-0.3]	[-1.4]	[-0.0]	[+0.4]	[-1.3]	[-0.1]	[+0.7]	[+0.2]
Euro Area	2.7	2.1	2.2	2.0	1.5	1.3	0.3	0.1	2.6	1.7	0.3	1.9	3.4	3.0
	[-0.0]	[+0.0]	[-0.0]	[-0.1]	[-0.3]	[-0.4]	[-0.8]	[-0.9]	[-0.0]	[-0.2]	[-0.9]	[+0.0]	[+0.7]	[+0.5]
Japan	1.9	1.4	1.1	1.6	1.5	1.0	0.5	0.9	2.0	1.3	1.0	1.7	2.1	2.1
	[+0.0]	[+0.0]	[+0.0]	[-0.6]	[-1.0]	[-1.2]	[-1.3]	[-0.7]	[+0.0]	[-0.7]	[-0.6]	[+0.2]	[+0.5]	[+0.5]
<b>CPI Inflation (% y-o-y)</b>														
United States	2.4	4.0	4.2	4.2	5.1	4.4	3.6	2.8	2.9	4.5	2.3	1.5	2.3	2.6
	[+0.0]	[-0.0]	[+0.0]	[+0.7]	[+1.9]	[+2.1]	[+2.0]	[+1.3]	[-0.0]	[+1.2]	[+0.8]	[-0.4]	[-0.2]	[+0.0]
Euro Area	1.9	2.9	3.4	3.6	3.9	3.6	2.8	2.1	2.1	3.6	1.7	0.3	1.0	1.9
	[+0.0]	[-0.0]	[+0.0]	[+0.4]	[+0.7]	[+1.2]	[+1.0]	[+0.4]	[-0.0]	[+0.6]	[+0.1]	[-1.0]	[-0.6]	[-0.0]
Japan	-0.1	0.5	1.0	1.4	1.6	1.7	1.3	0.6	0.1	1.4	0.4	-0.3	0.3	0.8
	[+0.0]	[+0.0]	[+0.0]	[+0.5]	[+0.8]	[+1.2]	[+1.0]	[+0.2]	[+0.0]	[+0.6]	[-0.0]	[-0.9]	[-0.5]	[-0.2]

Note: July 18 Conditional as a deviation from July 18 Unconditional: (percent deviation) or [percentage point deviation]

Figure 18: Forecast Results [2]

**United States: July 18 2008 Conditional Compared to July 18 2008 Unconditional**

(Solid line=July 18 Conditional with 30%, 50%, 70% and 95% confidence bands; dashed line=July 18 Unconditional)



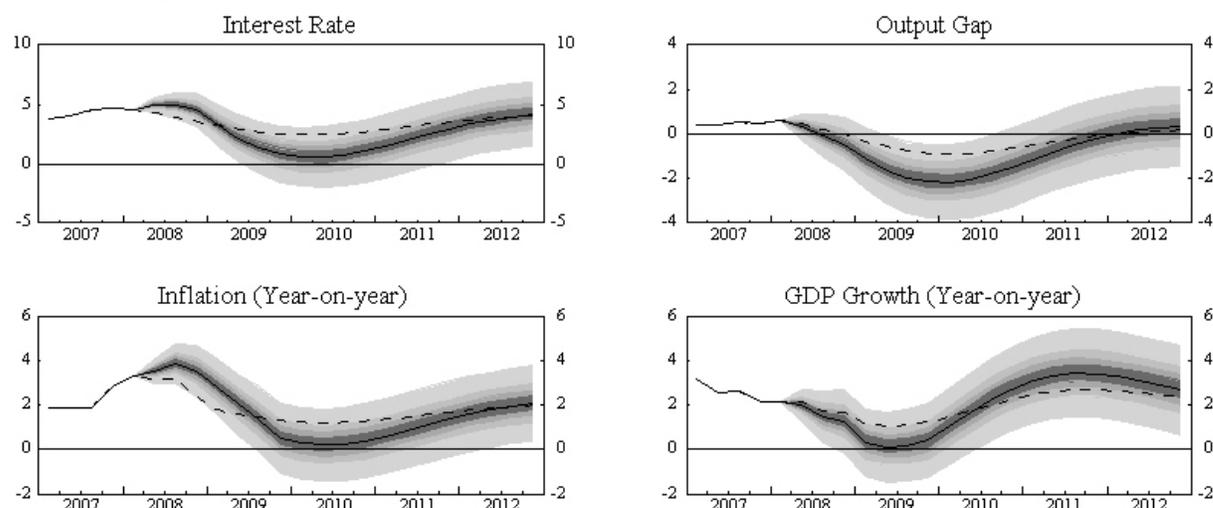
	Quarterly								Annual					
	2007		2008		2009		2009		2007	2008	2009	2010	2011	2012
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2						
Short-term Interest Rate	5.2 [+0.0]	4.5 [+0.0]	3.2 [+0.0]	2.1 [-0.2]	2.3 [+0.5]	1.9 [+0.4]	1.5 [+0.2]	1.3 [-0.1]	5.0 [+0.0]	2.4 [+0.2]	1.3 [-0.3]	2.2 [-0.7]	3.6 [-0.3]	4.2 [-0.1]
Bank Lending Tightening	17.7 [-0.0]	32.2 [+0.0]	52.4 [+0.0]	63.6 [-13.1]	67.3 [-21.1]	63.5 [-25.1]	53.4 [-24.3]	40.4 [-21.2]	19.4 [-0.0]	61.7 [-14.9]	34.4 [-18.3]	6.9 [+3.9]	4.3 [-0.4]	5.1 [-0.9]
Real GDP Growth														
% y-o-y	2.8 [-0.0]	2.5 [+0.0]	2.5 [-0.0]	1.8 [+0.7]	0.7 [+0.8]	0.2 [+0.2]	-0.3 [-0.3]	-0.6 [-1.4]	2.2 [-0.0]	1.3 [+0.4]	-0.1 [-1.3]	3.4 [-0.1]	3.4 [+0.7]	2.1 [+0.2]
% q@ar	4.9 [+0.0]	0.6 [+0.0]	0.9 [+0.0]	1.0 [+2.6]	0.5 [+0.5]	-1.6 [-2.3]	-1.0 [-2.1]	-0.1 [-1.8]						
Potential GDP Growth														
% y-o-y	2.9 [+0.0]	2.8 [-0.0]	2.6 [+0.0]	2.3 [+0.0]	2.0 [+0.0]	1.8 [+0.0]	1.8 [+0.0]	1.9 [+0.0]	2.9 [+0.0]	2.2 [+0.0]	1.9 [+0.0]	1.9 [+0.0]	1.9 [+0.0]	2.0 [+0.0]
% q@ar	3.0 [-0.0]	2.6 [+0.0]	1.8 [-0.0]	1.8 [+0.0]	1.8 [+0.0]	1.8 [+0.0]	1.9 [+0.0]	1.9 [+0.0]						
CPI Inflation														
% y-o-y	2.4 [+0.0]	4.0 [-0.0]	4.2 [+0.0]	4.2 [+0.7]	5.1 [+1.9]	4.4 [+2.1]	3.6 [+2.0]	2.8 [+1.3]	2.9 [-0.0]	4.5 [+1.2]	2.3 [+0.8]	1.5 [-0.4]	2.3 [-0.2]	2.6 [+0.0]
% q@ar	2.8 [+0.0]	5.0 [+0.0]	4.3 [-0.0]	4.7 [+2.8]	6.2 [+4.6]	2.3 [+0.8]	1.4 [-0.0]	1.2 [-0.2]						
Real Effective Exchange Rate														
Depreciation (y-o-y)	3.6	7.6	12.4	14.3 [+1.3]	11.1 [-0.6]	5.7 [-1.2]	0.8 [-1.5]	-2.2 [-2.7]	4.2	10.9 [-0.2]	-1.0 [-1.4]	-0.4 [+0.6]	0.7 [+0.9]	0.8 [+0.6]
Bilateral Exchange Rate														
vs. Euro Area	0.73 (+0.0)	0.69 (+0.0)	0.67 (+0.0)	0.64 (-2.8)	0.64 (-3.2)	0.64 (-2.6)	0.64 (-2.4)	0.64 (-2.4)	0.73 (+0.0)	0.65 (-2.2)	0.64 (-2.5)	0.64 (-3.5)	0.63 (-4.8)	0.62 (-5.4)
vs. Japan	117.76 (+0.0)	113.04 (+0.0)	105.19 (+0.0)	104.38 (+1.7)	106.68 (+5.3)	107.28 (+6.6)	106.83 (+6.6)	106.37 (+6.4)	117.72 (+0.0)	105.89 (+3.4)	106.17 (+6.2)	104.46 (+5.0)	102.12 (+4.0)	99.57 (+3.2)
Output Gap	0.4 [+0.0]	-0.1 [+0.0]	-0.3 [+0.0]	-0.5 [+0.7]	-0.9 [+0.8]	-1.7 [+0.2]	-2.4 [-0.3]	-2.9 [-0.7]	-0.0 [+0.0]	-0.9 [+0.4]	-2.8 [-0.8]	-1.4 [-0.9]	-0.0 [-0.2]	0.1 [+0.0]

Note: July 18 Conditional as a deviation from July 18 Unconditional: (percent deviation) or [percentage point deviation]

Figure 19: Forecast Results [3]

**Euro Area: July 18 2008 Conditional Compared to July 18 2008 Unconditional**

(Solid line=July 18 Conditional with 30%, 50%, 70% and 95% confidence bands; dashed line=July 18 Unconditional)



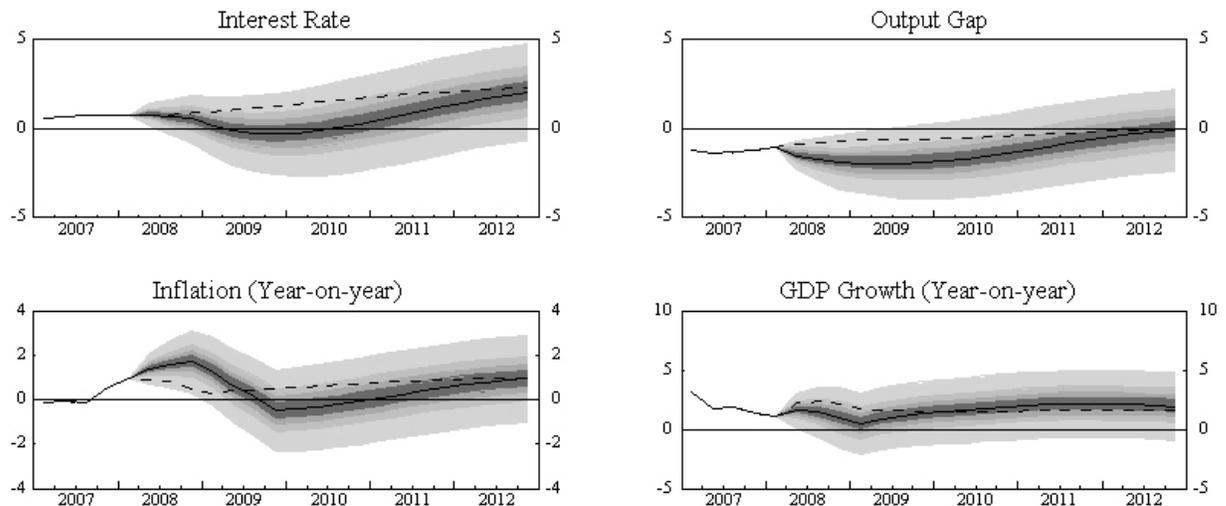
	Quarterly								Annual					
	2007		2008		2009									
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	2007	2008	2009	2010	2011	2012
Short-term Interest Rate	4.5 [+0.0]	4.7 [+0.0]	4.5 [+0.0]	4.9 [+0.7]	4.9 [+1.0]	4.5 [+0.9]	3.2 [-0.0]	2.2 [-0.8]	4.3 [+0.0]	4.7 [+0.6]	1.9 [-1.0]	0.7 [-1.8]	2.2 [-1.0]	3.8 [-0.1]
Real GDP Growth														
% y-o-y	2.7 [-0.0]	2.1 [+0.0]	2.2 [-0.0]	2.0 [-0.1]	1.5 [-0.3]	1.3 [-0.4]	0.3 [-0.8]	0.1 [-0.9]	2.6 [-0.0]	1.7 [-0.2]	0.3 [-0.9]	1.9 [+0.0]	3.4 [+0.7]	3.0 [+0.5]
% q@ar	2.7 [+0.0]	1.3 [+0.0]	3.2 [-0.0]	0.9 [-0.5]	0.5 [-0.6]	0.5 [-0.6]	-0.6 [-1.6]	0.1 [-1.0]						
Potential GDP Growth														
% y-o-y	1.8 [-0.0]	1.8 [+0.0]	2.0 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.2 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	1.7 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.1 [+0.0]
% q@ar	2.0 [+0.0]	1.6 [+0.0]	2.7 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.1 [+0.0]	2.1 [+0.0]						
CPI Inflation														
% y-o-y	1.9 [+0.0]	2.9 [-0.0]	3.4 [+0.0]	3.6 [+0.4]	3.9 [+0.7]	3.6 [+1.2]	2.8 [+1.0]	2.1 [+0.4]	2.1 [-0.0]	3.6 [+0.6]	1.7 [+0.1]	0.3 [-1.0]	1.0 [-0.6]	1.9 [-0.0]
% q@ar	1.8 [+0.0]	5.0 [+0.0]	4.0 [+0.0]	3.6 [+1.5]	3.3 [+1.3]	3.6 [+1.8]	0.9 [-0.6]	0.6 [-0.7]						
Real Effective Exchange Rate Depreciation (y-o-y)	-7.6	-9.9	-10.1	-11.0 [-2.7]	-10.5 [-3.2]	-6.1 [-3.2]	-3.8 [-3.0]	0.5 [+0.1]	-8.5	-9.4 [-3.1]	0.0 [-0.4]	0.5 [-0.4]	-0.8 [-0.8]	-0.7 [-0.4]
Bilateral Exchange Rate														
vs. United States	1.37 (+0.0)	1.45 (+0.0)	1.50 (+0.0)	1.56 (+2.9)	1.57 (+3.3)	1.56 (+2.7)	1.56 (+2.5)	1.55 (+2.4)	1.37 (+0.0)	1.55 (+2.2)	1.55 (+2.5)	1.56 (+3.7)	1.60 (+5.0)	1.62 (+5.7)
vs. Japan	161.84 (+0.0)	163.87 (+0.0)	157.73 (+0.0)	163.07 (+4.7)	167.91 (+8.8)	167.85 (+9.5)	166.37 (+9.3)	165.06 (+9.0)	161.26 (+0.0)	164.16 (+5.8)	164.78 (+8.9)	163.26 (+8.9)	163.15 (+9.2)	161.66 (+9.0)
Output Gap	0.6 [+0.0]	0.5 [+0.0]	0.6 [+0.0]	0.3 [-0.1]	-0.1 [-0.3]	-0.5 [-0.4]	-1.1 [-0.8]	-1.6 [-1.1]	0.5 [+0.0]	0.1 [-0.2]	-1.7 [-1.1]	-1.9 [-1.1]	-0.7 [-0.4]	0.2 [+0.1]

Note: July 18 Conditional as a deviation from July 18 Unconditional: (percent deviation) or [percentage point deviation]

Figure 20: Forecast Results [4]

**Japan: July 18 2008 Conditional Compared to July 18 2008 Unconditional**

(Solid line=July 18 Conditional with 30%, 50%, 70% and 95% confidence bands; dashed line=July 18 Unconditional)



	Quarterly								Annual					
	2007		2008		2009									
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	2007	2008	2009	2010	2011	2012
Short-term Interest Rate	0.8 [+0.0]	0.8 [+0.0]	0.8 [+0.0]	0.8 [+0.0]	0.6 [-0.2]	0.5 [-0.3]	0.2 [-0.8]	-0.1 [-1.2]	0.7 [+0.0]	0.7 [-0.1]	-0.1 [-1.3]	-0.0 [-1.6]	0.9 [-1.1]	1.8 [-0.5]
Real GDP Growth														
% y-o-y	1.9 [+0.0]	1.4 [+0.0]	1.1 [+0.0]	1.6 [-0.6]	1.5 [-1.0]	1.0 [-1.2]	0.5 [-1.3]	0.9 [-0.7]	2.0 [+0.0]	1.3 [-0.7]	1.0 [-0.6]	1.7 [+0.2]	2.1 [+0.5]	2.1 [+0.5]
% q@ar	1.1 [+0.0]	2.6 [+0.0]	3.3 [+0.0]	-0.5 [-2.5]	0.5 [-1.3]	0.7 [-1.0]	1.2 [-0.4]	1.3 [-0.2]						
Potential GDP Growth														
% y-o-y	1.5 [+0.0]	1.1 [+0.0]	0.9 [+0.0]	1.7 [+0.0]	1.9 [+0.0]	1.7 [+0.0]	1.4 [+0.0]	1.4 [+0.0]	1.6 [+0.0]	1.6 [+0.0]	1.4 [+0.0]	1.4 [+0.0]	1.4 [+0.0]	1.4 [+0.0]
% q@ar	0.9 [+0.0]	2.0 [-0.0]	2.7 [+0.0]	1.4 [+0.0]	1.4 [+0.0]	1.4 [+0.0]	1.4 [+0.0]	1.4 [+0.0]						
CPI Inflation														
% y-o-y	-0.1 [+0.0]	0.5 [+0.0]	1.0 [+0.0]	1.4 [+0.5]	1.6 [+0.8]	1.7 [+1.2]	1.3 [+1.0]	0.6 [+0.2]	0.1 [+0.0]	1.4 [+0.6]	0.4 [-0.0]	-0.3 [-0.9]	0.3 [-0.5]	0.8 [-0.2]
% q@ar	0.7 [+0.0]	1.6 [-0.0]	1.2 [+0.0]	2.1 [+2.0]	1.5 [+1.2]	2.1 [+1.8]	-0.6 [-1.0]	-0.5 [-1.0]						
Real Effective Exchange Rate Depreciation (y-o-y)	6.5	3.0	-5.0	-6.6 [+2.6]	-2.1 [+6.5]	-0.2 [+7.5]	5.0 [+8.0]	3.6 [+5.1]	7.1	-3.5 [+5.6]	2.0 [+3.4]	-0.0 [-0.4]	0.0 [-0.4]	-0.4 [-0.4]
Bilateral Exchange Rate														
vs. United States	0.0085 (+0.0)	0.0088 (+0.0)	0.0095 (+0.0)	0.0096 (-1.7)	0.0094 (-5.0)	0.0093 (-6.2)	0.0094 (-6.2)	0.0094 (-6.0)	0.0085 (+0.0)	0.0094 (-3.2)	0.0094 (-5.9)	0.0096 (-4.8)	0.0098 (-3.8)	0.0100 (-3.1)
vs. Euro Area	0.0062 (+0.0)	0.0061 (+0.0)	0.0063 (+0.0)	0.0061 (-4.5)	0.0060 (-8.1)	0.0060 (-8.7)	0.0060 (-8.5)	0.0061 (-8.2)	0.0062 (+0.0)	0.0061 (-5.3)	0.0061 (-8.2)	0.0061 (-8.2)	0.0061 (-8.4)	0.0062 (-8.3)
Output Gap	-1.3 [-0.0]	-1.2 [+0.0]	-1.0 [-0.0]	-1.5 [-0.6]	-1.7 [-0.9]	-1.9 [-1.2]	-1.9 [-1.3]	-1.9 [-1.3]	-1.3 [-0.0]	-1.5 [-0.7]	-1.9 [-1.3]	-1.6 [-1.1]	-0.9 [-0.6]	-0.3 [-0.2]

Note: July 18 Conditional as a deviation from July 18 Unconditional: (percent deviation) or [percentage point deviation]