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A First Look on the New Halle Economic Projection Model

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A First Look on the New Halle Economic Projection Model*

Abstract

In this paper we develop a small open economy model explaining the joint determination of output, inflation, interest rates, unemployment and the exchange rate in a multi-country framework. Our model – the Halle Economic Projection Model (HEPM) – is closely related to studies recently published by the International Monetary Fund (global projection model). Our main contribution is that we model the Euro area countries separately. In this version we consider Germany and France, which represent together about 50 percent of Euro area GDP. The model allows for country specific heterogeneity in the sense that we capture different adjustment patterns to economic shocks. The model is estimated using Bayesian techniques. Out-of-sample and pseudo out-of-sample forecasts are presented.

Keywords: Multi-country model, Forecasting, Bayesian estimation

JEL classification: C32, C53, E37

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A First Look on the New Halle Economic Projection Model

Zusammenfassung

In diesem Diskussionspapier wird ein Modell vorgestellt, das die jeweilige gesamtwirtschaftliche Entwicklung in den größten Ländern des Euro-Währungsgebietes im Kontext der weltwirtschaftlichen Lage abbildet. Dabei wird an entsprechende Arbeiten des Internationalen Währungsfonds (global projection model) angeknüpft. In der hier dargelegten Basisvariante werden zunächst drei Länder modelliert, nämlich die USA und aus dem Euro-Währungsgebiet Deutschland und Frankreich, die zusammen etwa 50 Prozent des Bruttoinlandsproduktes des Euro-Währungsgebietes ausmachen. Das Modell berücksichtigt länderspezifische Anpassungsprozesse bei ökonomischen Schocks. Das Modell wird mit Bayesianischen Methoden geschätzt, und Prognosen zu unterschiedlichen Zeitpunkten werden präsentiert und diskutiert.

Schlagworte: Mehrländermodell, Prognose, Bayesianische Ökonometrie

JEL-Klassifikation: C32, C53, E37

1 Introduction

Recently, in a series of papers, Carabenciov et al. (2008a, 2008b, and 2008c) have developed a new type of macroeconomic projection model. The aim of that project is to develop a *global projection model* (GPM) that is easy to use and that is comprehensible to policy makers. By now it comprises the United States, the Euro Area, Japan, Latin America, and Indonesia, see Andrle et al. (2009). The model is designed to study both national and international economic fluctuations. Following this approach, we build a New Keynesian macroeconomic model, which can be used for forecasting purposes, simulation of different policy scenarios, and identification of unobservable variables. It allows us to track various types of shocks in a multi-country framework. The model is estimated using Bayesian techniques. While Carabenciov and coauthors model the Euro area as a homogeneous economic block, we disaggregate the Euro area into individual member countries. In this paper we present a basic version of the new Halle Economic Projection model (HEPM), which comprises the United States, Germany, and France. The latter two countries are modeled with a common monetary policy, and, in the basic model, the Euro area consists only of Germany and France. To pick up the recent debate concerning the importance of financial markets for business cycle dynamics[1] we follow Carabenciov et al. (2008b) and include a financial variable for the United States in order to capture movements in bank lending.[2]

Many institutions use traditional macroeconometric models for short-term forecasting.[3] While these models perform well in terms of statistical fit and forecasting, they may be prone to the Lucas critique, as the estimated parameters may not be constant. Therefore, dynamic stochastic general equilibrium (DSGE) models, see for instance Smets & Wouters (2007) or Christiano et al. (2005, 1999) have been developed as an additional tool for business cycle analysis and forecasting. These models are derived from the optimizing behavior of firms and households, and the dynamic behavior of the endogenous variables depends on a set of *deep* economic parameters, which are supposed to be more stable over time than estimated coefficients

1 See Christiano, Trabant & Walentin (2007) or Brunnermeier & Sannikov (2009), for example.

2 The development of a corresponding financial variable for Euro area countries is subject to ongoing research.

3 Examples are the macroeconometric model of the Halle Institute for Economic Research, see Scheufele (2008), or the ECB's area wide model, see Fagan et al. (2005).

in traditional macroeconometric models. The rigid structure of DSGE models, however, makes it difficult to estimate them in a reasonable way. As a result, the most commonly encountered problem when estimating DSGE models is a flat objective function, which in turn may lead to serious biases. Our model, like the models developed by Carabenciov et al., is less demanding in this respect. It combines the core equations of the New-Keynesian standard DSGE model with empirically useful ad-hoc equations. While the implicit microfoundation of the core equations facilitates the structural interpretation of economic fluctuations and of adjustment processes to economic shocks, the ad-hoc extensions improve the statistical fit and the forecasting performance of the model (compared to pure DSGE models), which makes this type of model attractive for applied business cycles researchers and forecasters. The remainder of the paper is structured as follows. Section 2 outlines the underlying theoretical concepts and describes the model in detail. Section 3 introduces the dataset and the applied estimation method. Section 4 presents the estimation results and the forecasting results. Section 5 concludes.

2 Model specification

The projection model explains the joint evolution of output, inflation, interest rates, unemployment and the exchange rate in a multi-country framework. It follows a basic structure, which – according to Blanchard (2008), for example – is widely accepted among macroeconomists: technological progress goes through waves, perceptions of the future affect the demand for goods today, and, demand for goods can affect output in the short run because of nominal rigidities. In our model, these joint beliefs are represented in the form of three basic relations. An aggregate demand (IS) relation, a Phillips curve, and a monetary policy rule. Our starting point is a three country model compromising two main blocks: the U.S. economy and the Euro area economy. The main contribution of this paper is that we model the Euro area as a composition of several member countries. In this version, we consider two countries, which together account for about 50 percent of Euro area GDP, namely Germany and France.[4] This approach allows for country specific heterogeneity in the sense that coefficients and shocks are country-specific. Besides the individual

[4] From this point, the model can easily be extended by including more member countries. This is subject to ongoing research.

Euro area member countries, we also construct a model block of the aggregate Euro area, in particular for modeling monetary policy. Below, i indicates individual countries (United States, Germany, and France); for the Euro area equations we use the label EU.

2.1 Observable variables and definitions

In principle, we use five observable variables per country. These are real GDP, CPI inflation, the short-term interest rate, the unemployment rate and the U.S. dollar exchange rate. However, for the Euro area member countries there are no country-specific short-term interest rates and nominal U.S. dollar exchange rates but only the corresponding Euro area variables. In line with Carabenciov et al. (2008b) we use capital letters for the observable variables and small letters for the gaps between the variables and their equilibrium values. Y is defined as 100 times the log of GDP, $\bar{Y}$ is 100 times the log of potential output and y is the output gap defined in percentage terms ($y = Y - \bar{Y}$). The definitions for the unemployment rate correspond to the GDP definition. U is the actual unemployment rate, $\bar{U}$ the steady state unemployment rate, which can be interpreted as NAIRU (non-accelerating inflation rate of unemployment), and u is the unemployment gap which is defined as $u = U - \bar{U}$. Furthermore, the annualized quarterly inflation rate π is defined as 400 times the log difference of the CPI. The year-on-year inflation rate π^a is 100 times the log of the CPI in the current quarter minus the log CPI four quarters earlier.[5] The nominal interest rate is I, the real interest rate is R, the log of nominal exchange rate against the U.S. dollar is S and the log real exchange against the U.S. dollar is Z. Again z is the gap between the real exchange rate (Z) and its steady state value ($\bar{Z}$).

2.2 Stochastic processes and model definitions

2.2.1 Individual countries

The following equations are specified for each individual country i (US, Germany and France). Potential output is affected by level shocks and by quarterly growth

[5] We refer to 100 times log changes as percentage changes.

rate shocks. The corresponding law of motion is

$$\bar{Y}_{i,t} = \bar{Y}_{i,t-1} + g^{\bar{Y}}_{i,t}/4 + \varepsilon^{\bar{Y}}_{i,t}, \qquad \varepsilon^{\bar{Y}}_{i,t} \sim N(0, \sigma^{\bar{Y}}_i), \tag{1}$$

where the shocks $\varepsilon^{\bar{Y}}_{i,t}$ are permanent level shifts in potential GDP. In the long run, potential output grows with its steady-state growth rate $g^{\bar{Y}^{ss}}_i$. In the short run, the growth rate may deviate from the steady state value. This is described by the equation

$$g^{\bar{Y}}_{i,t} = \tau_i g^{\bar{Y}^{ss}}_i + (1-\tau_i) g^{\bar{Y}}_{i,t-1} + \varepsilon^{g^{\bar{Y}}}_{i,t}, \qquad \varepsilon^{g^{\bar{Y}}}_{i,t} \sim N(0, \sigma^{g^{\bar{Y}}}_i), \tag{2}$$

$0 \le \tau_i \le 1$. For the NAIRU we have a similar two-equation system:

$$\bar{U}_{i,t} = \bar{U}_{i,t-1} + g^{\bar{U}}_{i,t} + \varepsilon^{\bar{U}}_{i,t}, \qquad \varepsilon^{\bar{U}}_{i,t} \sim N(0, \sigma^{\bar{U}}_i) \tag{3}$$

$$g^{\bar{U}}_{i,t} = (1-\alpha_{i,3}) g^{\bar{U}}_{i,t-1} + \varepsilon^{g^{\bar{U}}}_{i,t}, \qquad \varepsilon^{g^{\bar{U}}}_{i,t} \sim N(0, \sigma^{g^{\bar{U}}}_i). \tag{4}$$

The real interest rate R is the nominal interest rate $I_{i,t}$ minus the expected inflation rate $\pi_{i,t+1}$ of the subsequent quarter.[6] This is given by

$$R_{i,t} = I_{i,t} - \pi_{i,t+1}. \tag{5}$$

Note that nominal interest rates within the Euro area are the same across the member countries. As a consequence, in the German and French Equation (5) the nominal interest rate is I_{EU}.

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

$$r_{i,t} = R_{i,t} - \bar{R}_{i,t}. \tag{6}$$

The equilibrium value $\bar{R}$ is the real interest rate that corresponds to a zero output gap. It may diverge from its steady state value in response to economic shocks $\varepsilon^{\bar{R}}_{i,t}$,

$$\bar{R}_{i,t} = \rho_i \bar{R}^{ss}_i + (1-\rho_i)\bar{R}_{i,t-1} + \varepsilon^{\bar{R}}_{i,t}, \qquad \varepsilon^{\bar{R}}_{i,t} \sim N(0, \sigma^{\bar{R}}_i), \tag{7}$$

where $0 \le \rho_i \le 1$. The log real exchange rate for country i is computed as 100 times the Euro's nominal exchange rate against the U.S. dollar (S_{EU}) times the consumer prices index in the U.S. (P_{US}), divided by the consumer price index (HICP) in

[6] Variables indexed by $(t+1)$ reflect model consistent (rational) expectations.

country i (P_i)

$$Z_{i,t} = 100 * \log\left(S_{EU,t}P_{US,t}/P_{i,t}\right). \tag{8}$$

Note that there is no corresponding equation for the U.S. An increase in $Z_{i,t}$ is a real depreciation of the Euro.[7]

The change of the log real exchange rate can be expressed as 100 times the change of the nominal exchange rate minus the difference between the quarterly inflation rates in country i and the U.S.:

$$\Delta Z_{i,t} = 100 * \Delta\log\left(S_{EU,t}\right) - (\pi_{i,t} - \pi_{US,t})/4. \tag{9}$$

The real exchange rate gap z is defined as the difference of the log real exchange rate and its long run equilibrium value $\bar{Z}$:

$$z_{i,t} = Z_{i,t} - \bar{Z}_{i,t}. \tag{10}$$

The equilibrium real exchange rate is specified as a random walk,

$$\bar{Z}_{i,t} = \bar{Z}_{i,t-1} + \varepsilon^{\bar{Z}}_{i,t}, \qquad \varepsilon^{\bar{Z}}_{i,t} \sim N(0, \sigma^{\bar{Z}}_{i}). \tag{11}$$

2.2.2 The aggregate Euro area economy

The log level of potential output $\bar{Y}_{EU,t}$ in the Euro area is the sum of the levels of the member countries

$$\bar{Y}_{EU,t} = \ln\left(\sum_{i=1}^{K}\exp(\bar{Y}_{i,t})\right). \tag{12}$$

In the two-country specification ($K = 2$), $\bar{Y}_{EU,t}$ is the sum of potential output of Germany (DE) and France (FR). A similar relationship holds for observed GDP which is defined as

$$Y_{EU,t} = \ln\left(\sum_{i=1}^{K}\exp(Y_{i,t})\right). \tag{13}$$

We can now calculate the output gap as

$$y_{EU,t} = Y_{EU,t} - \bar{Y}_{EU,t}. \tag{14}$$

7 Note, that the real exchange rate between Germany and France can be computed as the difference between Z_{DE} and Z_{FR}.

The Euro area wide price index is a weighted average of member countries' log HICPs and equals

$$P_{EU,t} = \ln\left(\sum_{i=1}^{K} \psi_i \exp(P_{i,t})\right). \tag{15}$$

The weights ψ_i are calculated from the official country specific weights of Germany and France in the Harmonized Index of Consumer Prices (HICP) for the Euro area, such that $\psi_1 + \ldots + \psi_K = 1$. The annualized quarterly EU inflation rate can then easily be calculated as

$$\pi_{EU,t} = (P_{EU,t} - P_{EU,t-1}) * 400.$$

The real interest rate of the Euro area is defined in the same way as for the individual countries, that is, nominal interest rate minus expected inflation rate

$$R_{EU,t} = I_{EU,t} - \pi_{EU,t+1}. \tag{16}$$

The equilibrium real interest rate of the Euro area is a weighted sum of equilibrium real interest rates of the member states defined as

$$\bar{R}_{EU,t} = \sum_{i=1}^{K} \mu_i \bar{R}_{k,t}, \tag{17}$$

where μ_i reflects the country-specific weigth based on GDP in country i.

Equation (18) defines the real exchange rate as

$$Z_{EU,t} = 100 * \log\left(S_{EU,t} P_{US,t} / P_{EU,t}\right). \tag{18}$$

In order to allow for persistence in the exchange rate, expectations $Z^e_{EU,t+1}$ are constructed as a weighted average of rational expectations $Z_{EU,t+1}$ and adaptive expectations $Z_{EU,t-1}$. Following Berg, Karam & Laxton (2006), we allow but do not impose rational expectations for the exchange rate, i.e. when $\phi_{EU} = 1$, expectations are fully rational,

$$Z^e_{EU,t+1} = \phi_{EU} E_t Z_{EU,t+1} + (1 - \phi_{EU}) Z_{EU,t-1}, \tag{19}$$

where E_t denotes the mathematical expectation operator.

2.3 Behavioral equations

Aggregate demand is described by a dynamic IS relation. For each country $i = US, DE, FR$, the IS equation relates the output gap y to its own lead and lag, the lagged value of the real interest rate gap r, the output gaps of the trading partners, the effective real exchange rate gap z and the disturbance term ε^y. The dependence of the output gaps on the main trading partners and on the effective real exchange rate gap z reflects the nature of an open economy where demand conditions of major trading partners and relative goods prices directly affect aggregate demand. The foreign output gap is constructed as a weighted average of foreign output gaps. The weights $\omega_{i,l,5}$ are calculated as the average ratio of exports of country i to country l relative to total exports of country i to all countries in the model. The effective real exchange rate gap also enters the equation with trade weights. The weights for the exchange rate gap, $\omega_{i,l,4}$, are the ratios of exports to plus imports from country l relative to the sum of exports to and imports from all countries in the model. Accordingly, the IS equations are given by

$$\begin{aligned} y_{i,t} = \beta_{i,1} y_{i,t-1} &+ \beta_{i,2} E_t y_{i,t+1} - \beta_{i,3} r_{i,t-1} + \beta_{i,4} \sum_{l=1}^{L} \omega_{i,l,4} z_{i,l,t-1} \\ &+ \beta_{i,5} \sum_{l=1}^{L} \omega_{i,l,5} y_{l,t-1} + \varepsilon_{i,t}^{y}, \qquad \varepsilon_{i,t}^{y} \sim N(0, \sigma_i^y). \end{aligned} \tag{20}$$

Note that the IS curve is specified in a hybrid manner which means that both a lagged and a lead term enter the equation. This allows for some inertia as well as forward looking behavior.[8] The IS equation for the U.S. incorporates an additional financial variable, the bank lending tightening (BLT) variable. As in Carabenciov et al. (2008b), the BLT variable is an unweighted average of the responses to the questions with respect to tightening terms and conditions in the quarterly Senior Loan Officer Opinion Survey on Bank Lending Practices of the Federal Reserve Board.[9]

[8] The forward looking nature of aggregated demand can be rationalized by the optimizing behavior of consumers, see Hall (1978), for example, and the lagged term by habit persistence, see Fuhrer (2000), for example.

[9] For a detailed description of the BLT variable see Carabenciov et al. (2008b), pp.19.

The second behavioral equation is a Phillips curve, which relates inflation to its future and past values and to the output gap.[10] Additionally, the inflation rate is influenced by changes in the effective real exchange rate. The equation also includes a cost-push shock ε^{π}

$$\begin{aligned}\pi_{i,t} &= \lambda_{i,1} E_t \pi^a_{i,t+4} + (1-\lambda_{i,1})\pi^a_{i,t-1} + \lambda_{i,2} y_{i,t-1} \\ &\quad +\lambda_{i,3} \sum_{k=1}^{K} \omega_{i,k,3} \Delta Z_{i,k,t} - \varepsilon^{\pi}_{i,t}, \qquad \varepsilon^{\pi}_{i,t} \sim N(0,\sigma^{\pi}_i).\end{aligned} \tag{21}$$

Unemployment in the model is determined by a dynamic version of Okun's Law

$$u_{i,t} = \alpha_{i,1} u_{i,t-1} + \alpha_{i,2} y_{i,t} + \varepsilon^u_{i,t} \qquad \varepsilon^u_{i,t} \sim N(0,\sigma^u_i). \tag{22}$$

The nominal short-term interest rate is determined by a monetary policy rule, see Orphanides (2003), for example. The central bank reacts to movements of the output gap $y_{i,t}$ and to deviations of the expected inflation rate from its target $\pi^a_{i,t+3} - \pi^{tar}_i$ with $\pi^a_{i,t} = 100 * (P_{i,t} - P_{i,t-4})$. Furthermore, interest-rate smoothing is assumed which is reflected by the lagged interest rate term $I_{i,t-1}$. The Euro area ($i = EU$) and the U.S. ($i = US$) nominal interest rates are given by the interest rate rule

$$\begin{aligned}I_{i,t} &= (1-\gamma_{i,1})\left[\bar{R}_{i,t} + \pi^a_{i,t+3} + \gamma_{i,2}\left(\pi^a_{i,t+3} - \pi^{tar}_i\right) + \gamma_{i,4} y_{i,t}\right] \\ &\quad +\gamma_{i,1} I_{i,t-1} + \varepsilon^I_{i,t} \qquad \varepsilon^I_{i,t} \sim N(0,\sigma^I_i).\end{aligned} \tag{23}$$

Finally, a real interest rate parity is included. The difference between the real exchange rate and its future expected value equals the spread between the Euro area real interest rate and the U.S. real interest rate minus the difference between the equilibrium rates of the Euro area and the U.S. Additionally, a disturbance term ε^{Z-Z^e} is added.

$$\begin{aligned}4 * \left(Z^e_{EU,t+1} - Z_{EU,t}\right) &= (R_{EU,t} - R_{US,t}) \\ &- \left(\bar{R}_{EU,t} - \bar{R}_{US,t}\right) + \varepsilon^{Z-Z^e}_{EU}, \qquad \varepsilon^{Z-Z^e}_{EU,t} \sim N(0,\sigma^{Z-Z^e}_{EU,t}).\end{aligned}$$

The difference between the equilibrium exchange rates can be interpreted as equilibrium risk premium.

[10] see Galí & Gertler (1999) for the derivation of a hybrid Phillips curve specification.

3 Model estimation

We estimate the HEPM using Bayesian methods, as illustrated in DeJong, Ingram & Whiteman (2000), Smets & Wouters (2003), or An & Schorfheide (2007).[11] Thus, we are able to combine sample information with prior knowledge.

3.1 Bayesian estimation

The economic model consists of identities and stochastic difference equations. The corresonding statistical model is formulated as a state space model. The likelihood is computed using the Kalman filter. A statistical model is a class of densities, i.e. $p(X, \theta), \theta \in \Theta$, where X is the data matrix and Θ the parameter space. The likelihood function $L(\theta) = p(X, \theta)$ is a function of the parameters θ.[12] Thus, the maximum likelihood estimator $\hat{\theta}$ is calculated by maximizing the likelihood function $L(\theta)$ with respect to the parameter set Θ.

The most commonly encountered problem when estimating structural macroeconomic models by maximizing the likelihood is a flat objective function, which in turn may lead to serious biases. Bayesian estimation techniques try to deal with this problem by incorporating prior knowledge about central economic relationships from previous macro or micro studies. This prior knowledge is combined with the observed data in order to derive an estimate and its posterior distribution.[13] This relates Bayesian estimation to calibration methods.[14] However, in contrast to calibration one prescribes not only the expected value of a parameter but also its distribution which reflects the uncertainty about the true value. Through specifying the uncertainty surrounding the prior mean the researcher explicitly decides what role the data plays. For instance, specifying a flat prior (prior which is characterized by high uncertainty) increases the impact of the actual data on the estimated

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[11] Ruge-Murcia (2007) gives a a survey of different estimation procedures for DSGE models: maximum likelihood, generalized method of moments, simulated method of moments (see also Canova (1994) and Canova (2007)), and indirect inference (see also Smith (1993) and, for an application, Holtemöller & Schmidt (2008)).

[12] Note that this assumes that the economic model is given as a submodel of the statistical model.

[13] See Del Negro & Schorfheide (2008) for prior elicitation and a method for constructing prior distributions.

[14] See Kydland & Prescott (1996).

coefficient. In particular when the sample size is small Bayesian methods may help to get economically plausible results.

We compute the posterior distribution using the Metropolis-Hastings algorithm.[15] Robustness checks are used to verify the convergence of the algorithm. For this purpose, we use Monte Carlo Markov Chain diagnostics produced by Dynare.[16]

3.2 Data

We use data from the United States, Germany, France and the Euro area. Our sample covers the period from 1999Q1 until 2009Q3. For the United States we use gross domestic product Y_{US}, the federal funds target rate I_{US}, consumer price index P_{US}, and unemployment rate U_{US}. The financial variable BLT_{US} is constructed as an unweighted average of the response to questions with respect to tightening terms and conditions in the federal reserve board's quarterly senior loan officer opinion survey on bank lending practices.[17] For Germany we use GDP (Y_{DE}), the Harmonized Index of Consumer Prices (P_{DE}), ILO unemployment rate (U_{DE}) as well as for France, i.e. Y_{FR}, P_{FR}, and U_{FR}. The Euro area series are the 3-month Euribor (I_{EU}) and the U.S. Dollar/Euro exchange rate (S_{EU}). All data series are seasonally adjusted. For more information on the series see Table 1 and Figure 4 in the Appendix.

4 Results

4.1 Prior and posterior analysis

First we estimate the model for the full sample period. Tables 2, 3, 4, and 5 set out estimation results for the parameters. They show prior means, prior standard deviations, and prior distributions, which reflect our expectations of the coefficient values. Furthermore, the posterior modes and posterior standard deviations are presented.

15 The model is estimated using Dynare 4.1.0. We specified 40000 replications for the Metropolis-Hastings algorithm and 4 parallel chains. The scale for the jumping distribution is 0.35.

16 The corresponding results can be obtained from the authors upon request.

17 The bank lending tightening variable is very similar to the one in Carabenciov et al. (2008b). However, here mortgages are not part of the average.

Parameters. Beginning with the IS equation, we see that all three economies put less weight on the forward-looking component β_2, than on the backward-looking component β_1. This is in line with the empirical literature (see e.g. Fuhrer & Rudebusch 2004) which finds that including some inertia in the output process is necessary to match the data. This implies that habit formation as well as capital adjustment costs are important factors in the Euler equation for output. For Germany, however, the posterior mode for the forward-looking component is still 0.342, such that the sum of the coefficients on the backward and the forward-looking component is highest compared to the other two economies and is close to 1.

The coefficients corresponding to the real interest rate β_3 are similar for all three economies. Also consistent with our expectations is the coefficient corresponding to foreign activity β_5. For Germany, the coefficient is higher than for France, which in turn is higher than the U.S. coefficient. Regarding the impact of the exchange rate gap β_4 the results are different. The coefficient for Germany is smallest, whereas the coefficients for France and the U.S. are close to each other. For Germany, this implies that international shocks are mainly transmitted through the demand situation in foreign countries and less via real exchange rate movements.

The persistence of growth in potential output to shocks (1-τ) is greater than anticipated and essentially close to one. The weight of rational expectations in the formation of real exchange rate expectations, ϕ_{EU}, differs strongly from the anticipated value and suggests a strong degree of forward looking behavior.

Turning to the Phillips curves, we see that German and U.S. inflation are mainly forward looking (this is in line with Galí & Gertler 1999, Scheufele 2010). The estimated λ_1's are between 0.8 and 0.9. For France, the forward- and backward looking components seem equally important. The output gap coefficient λ_2 is smallest in France, implying that price rigidities are highest in this economy. The picture drawn for the exchange rate effects is essentially the other way around. For France, the impact of exchange rate changes on inflation is sizable and more important than for Germany. For the US, this parameter is basically zero.

In the central bank reaction functions, the smoothing coefficient γ_1 is about 0.8 for the ECB and for the Fed and thus consistent with other empirical studies (see e.g. Clarida, Galí & Gertler 2000, Orphanides 2003). The response to deviations of the expected inflation rate from its target γ_2 is a bit higher for the ECB compared to the Fed as might be expected, however the differences are small relative to the existing uncertainty. Finally, the posterior modes corresponding to the output coefficients γ_4

match the anticipated ones, where the U.S. coefficient is clearly larger. In general, the estimated coefficients fit the picture of the ECB as an institution whose primary objective is to maintain price stability. The persistence of the equilibrium real interest rate to shocks $(1-\rho)$ is close to the value of the prior for all economies.

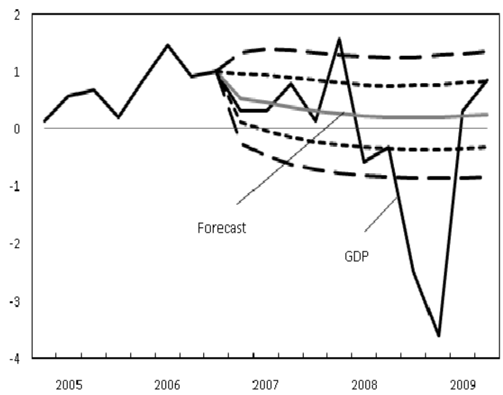
The results concerning the coefficients which correspond to the dynamic version of Okun's law are mixed. All three economies exhibit a huge autoregressive coefficient α_1, where the German one is the biggest and the U.S. coefficient is the smallest. Correspondingly, the Okun coefficient α_2 is highest in the U.S. and lowest in Germany, pointing out the more flexible labor market in the U.S. The persistence of NAIRU growth (1-α_3) is generally greater than assumed by the priors.

Shocks and correlations. The posterior modes regarding the standard deviation of the structural shocks differ more from the priors than the ones corresponding to the parameter estimates. This might be due to the small sample size and the impact of the financial crisis. We have much higher posteriors for the standard deviation of the equilibrium real exchange rate shocks ($\varepsilon_i^{\bar{Z}}$), and all three inflation shocks (ε_i^{π}), where the U.S. inflation shock is about three times the size of its prior. Several lower than anticipated posteriors are also given in Table 5. The value of the posterior mode belonging to the shock in the interest rate parity equation ($\varepsilon_{EU,t}^{Z-Z^e}$) is half the size of its prior, for instance. Beyond that the results for the NAIRU ($\varepsilon_i^{\bar{U}}$) and the U.S. interest rate shocks (ε_{US}^{I}) show also lower posteriors. Following Carabenciov et al. (2008a) we allow for three types of cross correlations of error terms. The cross correlation between potential output and inflation implies that a positive supply shock to the level of potential output puts downward pressure on costs and prices. Furthermore, a correlation between the output gap and long-run GDP growth implies that a positive shock to potential output should increase expected permanent income in the future. Finally, a correlation of the BLT variable and long-run growth implies that easing bank lending conditions will result in higher potential output growth.[18] The resulting posterior modes for all three types of cross correlations, which are displayed in Table 2, are principally in line with the suggested priors.

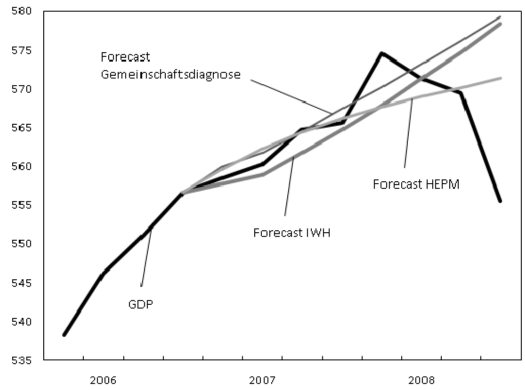
[18] Note, that this correlation is only specified for the U.S. economy, by now.

Figure 1: Forecast Results for Germany (70% and 95% confidence intervals) - Sample 1999Q1-2006Q4, Forecast horizon 2007Q1-2011Q4

(a) GDP Growth and Model Forecast (%, Quarter-on-quarter)



(b) Realized GDP and Forecasts(billion Euros)



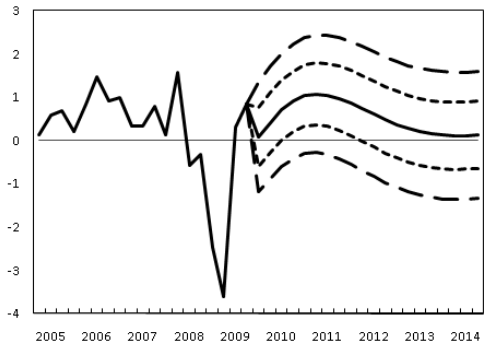
4.2 Forecasting results

We conduct several forecasting experiments. In a first step, we estimate the model for the period 1999Q1 to 2006Q4 to compare the pseudo out of sample model forecasts with the realized GDP and alternative GDP forecasts. The forecast horizon compromises 20 quarters, i.e. five years. Figure 1 (a) reports the forecast of the quarter on quarter GDP growth (solid grey line) with corresponding 70 and 95 percent confidence bounds (dashed lines) and the realized GDP growth (solid black line). The model forecast is in line with the growth pattern in the first two years. However, the dramatical plunge of GDP growth at the end of 2008 was not anticipated. The realized GDP growth rate actually lies beneath the 95 percent confidence bound. Figure 1 (b) shows the corresponding forecasts for the GDP level. In addition to the forecast derived from the HEPM and the realized GDP, forecasts from the 'Gemeinschaftsdiagnose', published by German's leading research institutions, and the Halle Institute for Economic Research (IWH) are reported.[19] We see that both, the IWH and the Gemeinschaftsdiagnose suggested a more pronounced increase in GDP from 2008 to the end of the forecast horizon, whereas the HEPM predicted a declining

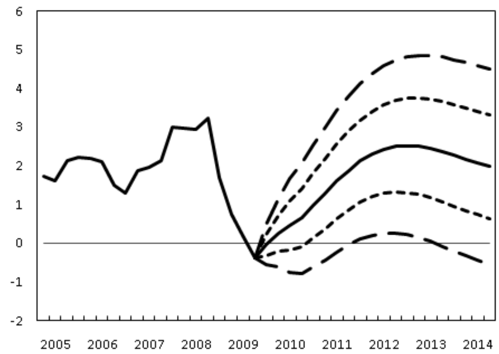
[19] The GDP level forecasts from 'Gemeinschaftsdiagnose' and the Halle Institute for Economic Research (IWH) are based on the forecasts for GDP growth published in Projektgruppe Gemeinschaftsdiagnose (2007) and Arbeitskreis Konjunktur (2007), respectively.

Figure 2: Forecast Results for Germany (70% and 95% confidence intervals) - Sample 1999Q1-2009Q3, Forecast horizon 2009Q4-2014Q3

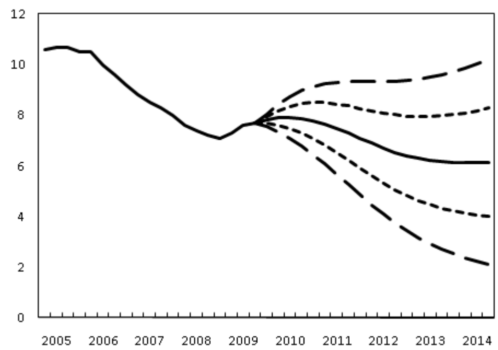
(a) GDP Growth (%, Quarter-on-quarter)



(b) Inflation (%, Year-on-year)



(c) Unemployment Rate (%)



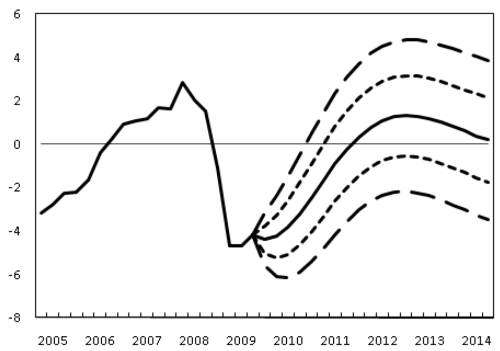
growth rate. In general, the model produces realistic forecasts for the short and medium horizon.

In a next step, we make a forecast analysis based on our full information set, i.e. on the full sample period 1999Q1 to 2009Q3. The results for Germany are reported in Figures 2 and 3.[20] The graphs show the mean forecast (solid line) and the corresponding 70 and 95 percent confidence bounds (dashed lines). Our forecast horizon starts at 2009Q4 and compromises twenty quarters. We forecast three key economic variables: quarterly GDP growth, yearly inflation, and the unemployment rate.

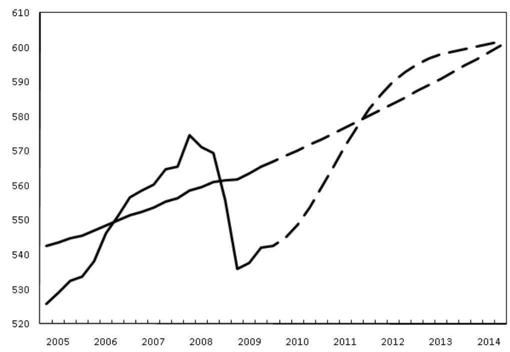
[20] Forecast results for the United States are illustrated in Figures 5 and 6 in the Appendix. Results for France are available upon request.

Figure 3: Output Gap and Potential GDP Forecast Results for Germany (70% and 95% confidence intervals), Sample 1999Q1-2009Q3, Forecast horizon 2009Q4-2014Q3

(a) Output Gap (%)



(b) GDP and Potential GDP (billion Euros)



For Germany the model predicts an increasing GDP growth rate until 2011. Afterwards the growth rate declines. At the end of the forecast horizon the zero bound is almost reached.[21] Inflation is about to rise until the middle of 2012 peaking roughly 2.5 percent. In addition, after a few quarters of increasing growth rates, unemployment will decline until the end of the sample. Furthermore, we estimate the output gap and potential GDP, see Figure 3. The output gap is suggested to be closed until the end of 2011. After peaking around the end of 2012 it is again closed at the end of the forecast horizon.The estimated potential GDP shows a slowdown of growth in the course of the recent crisis.

The results for the U.S. economy show a similar pattern, see Figures 5 and 6 in the Appendix. The growth rate, however, increases at the beginning of the forecast horizon, in contrast to the German GDP growth rate. Afterwards, the growth rate also declines. The inflation rate reaches three percent at the end of 2011 and reduces slightly until the end of the forecast horizon. Correspondingly, the unemployment rate declines. The output gap will be closed by 2011, too. Interestingly, compared to Germany the U.S. output gap is smaller at the end of the forecast horizon.

[21] Note that the long run GDP growth forecast will reach the steady state value (1.6 percent).

5 Summary

This paper presents a first, preliminary version of the new Halle Economic Projection model. At this stage of our ongoing project to develop a macroeconomic projection model to analyze and forecast the interactions between major European economies and the US economy, we analyze three countries, i.e. Germany, France, and the United States. The model is estimated using Bayesian techniques, which are very successful in producing reasonable forecasts and comprehensible dynamics. We provide a rigorous analysis of our prior specifications for the parameters, as informative priors are helpful in limiting the effects of potential misspecifications.
We use this model to forecast the key economic variables GDP growth, inflation and the unemployment rate based on the full sample period and for a subsample period. The pseudo out-of-sample forecasts based on the shortened sample period are compared to forecasts from the 'Gemeinschaftsdiagnose', published by German's leading research institutions, as well as to forecasts by the Halle Institute for Economic Research (IWH). The next stage of our project will be to expand the model to include other European countries and to give a rigorous evaluation of the forecasting properties of our model.

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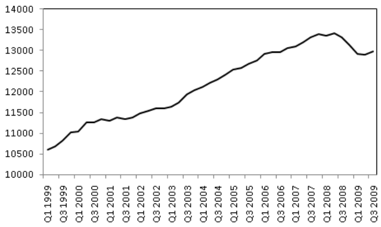
A Data Description and Results

Table 1: Data Definitions

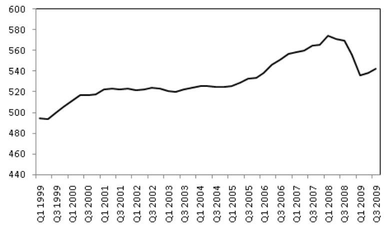
Germany	
GDP	Gross Domestic Product (SA, EURO Billions 2000 Prices), Statistisches Bundesamt
CPI	Consumer Price Index (harmonised): All Items (SA, 2005=100), Eurostat
Unemployment	Unemployment Rate ILO (SA, percentage), Statistisches Bundesamt
France	
GDP	Gross Domestic Product (SA, EURO Billions 2000 Prices), National Institute of Statistics and Economic Studies (INSEE)
CPI	Consumer Price Index (harmonised): All Items (SA, 2005=100), Eurostat
Unemployment	Unemployment Rate ILO (SA, percentage), INSEE
Euro Area	
Interest Rate	3-Month Euro Interbank Offered Rate (EURIBOR), (Average, percentage), ECB
Exchange Rate	U.S. Dollar to 1 EURO, Average, ECB
United States	
GDP	Gross Domestic Product (SAAR, U.S. Dollar Billions 2005 Prices), Bureau of Economic Analysis
CPI	Consumer Price Index (SA, 1982-84=100), Bureau of Labor Statistics
Unemployment	Unemployment Rate (SA, percentage), Bureau of Labor Statistics
Interest Rate	Federal Funds Target Rate (Average, percentage), Federal Open Market Committee
Bank Lending Tightening (BLT)	Average of: Senior Loan Officers Opinion Survey: Banks Tightening C&I Loans to Large and Medium Firms (percentage), Federal Reserve Board (FRB) Senior Loan Officers Opinion Survey: Banks Tightening C&I Loans to Small Firms (percentage), FRB Senior Loan Officers Opinion Survey: Banks Tightening for Commercial Real Estate Loans (percentage), FRB

Figure 4: Data series

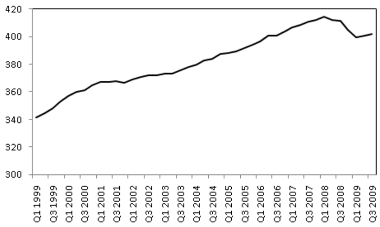
(a) US Gross Domestic Product



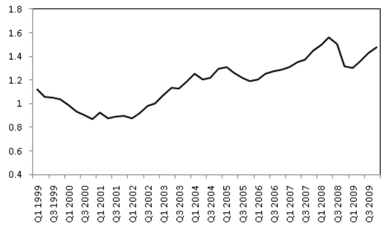
(b) DE Gross Domestic Product



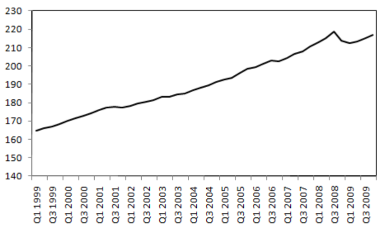
(c) FR Gross Domestic Product



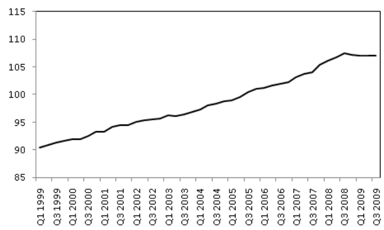
(d) Dollar/Euro exchange rate



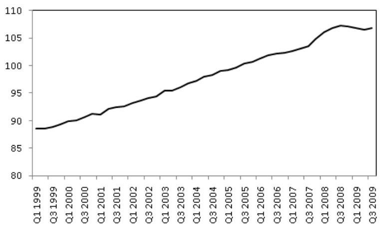
(e) US Consumer Price Index



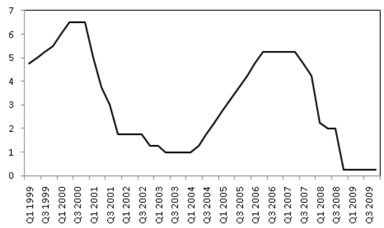
(f) DE Consumer Price Index



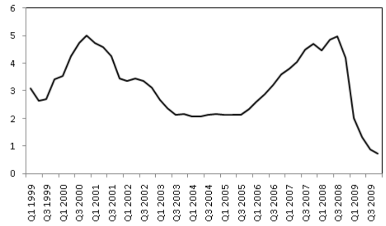
(g) FR Consumer Price Index



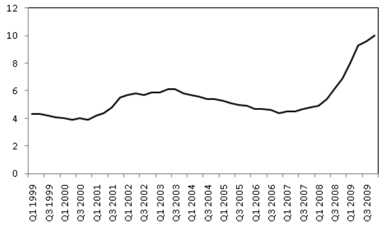
(h) US Interest Rate



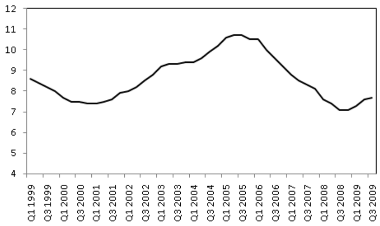
i) EU Interest Rate



(j) US unemployment rate



(k) DE unemployment rate



(l) FR unemployment rate

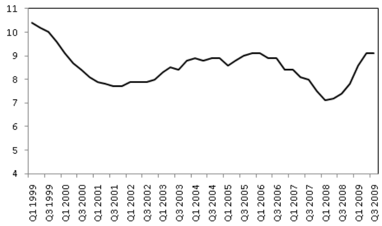


Table 2: Results from Posterior Maximization (correlation of structural shocks)

	posterior mode	posterior s.d.	prior mean	prior s.d.	prior dist.
$\varepsilon^{\bar{Y}}_{US},\varepsilon^{\pi}_{US}$	0.0889	0.0285	0.1	0.03	beta
$\varepsilon^{y}_{US},\varepsilon^{g^{\bar{Y}}}_{US}$	0.2282	0.1079	0.25	0.1	beta
$\varepsilon^{BLT}_{US},\varepsilon^{g}_{US}$	0.0794	0.0481	0.1	0.05	beta
$\varepsilon^{\bar{Y}}_{DE},\varepsilon^{\pi}_{DE}$	0.0934	0.0297	0.1	0.03	beta
$\varepsilon^{y}_{DE},\varepsilon^{g^{\bar{Y}}}_{DE}$	0.2413	0.1111	0.25	0.1	beta
$\varepsilon^{\bar{Y}}_{FR},\varepsilon^{\pi}_{FR}$	0.0893	0.0286	0.1	0.03	beta
$\varepsilon^{y}_{FR},\varepsilon^{g^{\bar{Y}}}_{FR}$	0.216	0.1032	0.25	0.1	beta

Table 3: Results from Posterior Maximization

	posterior mode	posterior s.d.	prior mean	prior s.d.	prior dist.
$\alpha_{1,DE}$	0.8111	0.0757	0.75	0.1	beta
$\alpha_{1,FR}$	0.7546	0.0719	0.75	0.1	beta
$\alpha_{1,US}$	0.7004	0.0575	0.75	0.1	beta
$\alpha_{2,DE}$	0.0783	0.0195	0.11	0.1	gamma
$\alpha_{2,FR}$	0.191	0.0374	0.12	0.1	gamma
$\alpha_{2,US}$	0.2472	0.0365	0.191	0.1	gamma
$\alpha_{3,DE}$	0.1515	0.0713	0.2	0.1	beta
$\alpha_{3,FR}$	0.18	0.0974	0.2	0.1	beta
$\alpha_{3,US}$	0.2377	0.0915	0.3	0.1	beta
$\beta_{1,DE}$	0.6575	0.0441	0.75	0.1	gamma
$\beta_{1,FR}$	0.6434	0.045	0.75	0.1	gamma
$\beta_{1,US}$	0.6858	0.0507	0.75	0.1	gamma
$\beta_{2,DE}$	0.342	0.0526	0.16	0.05	beta
$\beta_{2,FR}$	0.2151	0.0503	0.21	0.05	beta
$\beta_{2,US}$	0.1235	0.0377	0.17	0.05	beta
$\beta_{3,DE}$	0.1399	0.0283	0.2	0.05	gamma
$\beta_{3,FR}$	0.1	0.0244	0.2	0.05	gamma
$\beta_{3,US}$	0.0931	0.026	0.2	0.05	gamma
$\beta_{4,DE}$	0.01	0.0049	0.104	0.04	gamma
$\beta_{4,FR}$	0.0442	0.0129	0.104	0.04	gamma
$\beta_{4,US}$	0.0396	0.0141	0.06	0.02	gamma
$\beta_{5,DE}$	0.0807	0.0112	0.052	0.01	gamma
$\beta_{5,FR}$	0.0517	0.0099	0.052	0.01	gamma
$\beta_{5,US}$	0.0255	0.0088	0.03	0.01	gamma
$\gamma_{1,EU}$	0.8144	0.0249	0.7	0.05	beta
$\gamma_{1,US}$	0.8199	0.0273	0.8	0.05	beta
$\gamma_{2,EU}$	1.2781	0.1764	1.5	0.2	gamma
$\gamma_{2,US}$	1.0604	0.2175	1.5	0.3	gamma
$\gamma_{4,EU}$	0.305	0.0501	0.3	0.05	gamma
$\gamma_{4,US}$	0.4376	0.0485	0.45	0.05	gamma
$g_{DE}^{\bar{Y}^{ss}}$	1.5923	0.0499	1.6	0.05	norm
$g_{FR}^{\bar{Y}^{ss}}$	1.7945	0.0494	1.8	0.05	norm
$g_{US}^{\bar{Y}^{ss}}$	2.4953	0.0501	2.5	0.05	norm
κ_{US}	19.7463	0.4937	20	0.5	gamma

Table 4: Results from Posterior Maximization, continued

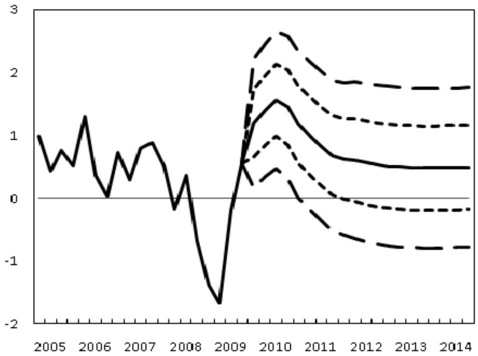
	posterior mode	posterior s.d.	prior mean	prior s.d.	prior dist.
$\lambda_{1,DE}$	0.8808	0.0549	0.75	0.1	beta
$\lambda_{1,FR}$	0.5377	0.0484	0.7	0.1	beta
$\lambda_{1,US}$	0.8377	0.0517	0.63	0.1	beta
$\lambda_{2,DE}$	0.153	0.036	0.15	0.05	gamma
$\lambda_{2,FR}$	0.0537	0.0147	0.233	0.05	gamma
$\lambda_{2,US}$	0.1827	0.0406	0.181	0.05	gamma
$\lambda_{3,DE}$	0.065	0.0348	0.1	0.05	gamma
$\lambda_{3,FR}$	0.1551	0.0847	0.1	0.05	gamma
$\lambda_{3,US}$	0.0273	0.0211	0.08	0.05	gamma
ϕ_{EU}	0.8827	0.0582	0.5	0.2	beta
π_{EU}^{tar}	1.8293	0.1536	1.9	0.2	gamma
π_{US}^{tar}	2.6017	0.3523	2.5	0.5	gamma
ρ_{DE}	0.2686	0.1068	0.3	0.1	beta
ρ_{FR}	0.2784	0.1041	0.3	0.1	beta
ρ_{US}	0.2837	0.0786	0.3	0.1	beta
$\overline{R}_{DE}^{ss}$	1.886	0.282	2	0.3	norm
$\overline{R}_{FR}^{ss}$	1.8415	0.264	2	0.3	norm
$\overline{R}_{US}^{ss}$	1.8802	0.2866	2	0.3	norm
τ_{DE}	0.0267	0.0186	0.05	0.03	beta
τ_{FR}	0.0331	0.0232	0.05	0.03	beta
τ_{US}	0.0286	0.0202	0.05	0.03	beta
θ_{US}	1.5425	0.5799	1	0.5	gamma

Table 5: Results from Posterior Maximization (standard deviation of structural shocks)

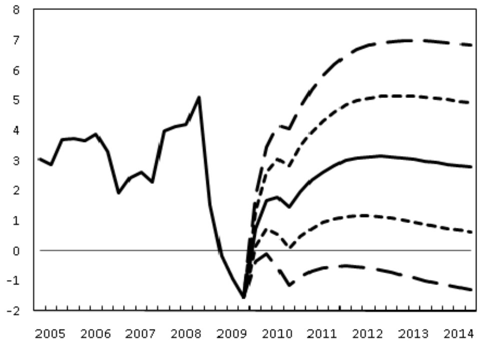
	posterior mode	posterior s.d.	prior mean	prior s.d.	prior dist.
$\varepsilon_{US}^{\overline{BLT}}$	0.0921	0.0376	0.2	Inf	invg
ε_{US}^{BLT}	0.6622	0.259	0.4	Inf	invg
$\varepsilon_{DE}^{g^{\bar{Y}}}$	0.0852	0.0289	0.1	0.05	invg
$\varepsilon_{FR}^{g^{\bar{Y}}}$	0.0761	0.0253	0.1	0.05	invg
$\varepsilon_{US}^{g^{\bar{Y}}}$	0.0851	0.079	0.1	Inf	invg
$\varepsilon_{DE}^{\bar{Y}}$	0.1852	0.0422	0.2	0.05	invg
$\varepsilon_{FR}^{\bar{Y}}$	0.1674	0.0314	0.2	0.05	invg
$\varepsilon_{US}^{\bar{Y}}$	0.1564	0.0799	0.15	0.05	invg
$\varepsilon_{DE}^{\bar{Z}}$	4.7518	0.6554	4	Inf	invg
$\varepsilon_{FR}^{\bar{Z}}$	5.8856	0.9172	4	Inf	invg
ε_{DE}^{π}	1.0153	0.1199	0.7	Inf	invg
ε_{FR}^{π}	0.8538	0.2413	0.7	Inf	invg
ε_{US}^{π}	2.0755	0.226	0.7	Inf	invg
$\varepsilon_{DE}^{\bar{R}}$	0.2829	0.0422	0.3	0.04	invg
$\varepsilon_{FR}^{\bar{R}}$	0.2828	0.0423	0.3	0.04	invg
$\varepsilon_{US}^{\bar{R}}$	1.6602	0.4187	0.7	Inf	invg
$\varepsilon_{EU}^{Z-Z^e}$	0.4628	0.1907	1	Inf	invg
ε_{EU}^{I}	0.3037	0.0359	0.25	Inf	invg
ε_{US}^{I}	0.2845	0.071	0.5	Inf	invg
$\varepsilon_{DE}^{\bar{U}}$	0.0509	0.0226	0.1	Inf	invg
$\varepsilon_{FR}^{\bar{U}}$	0.048	0.0215	0.1	Inf	invg
$\varepsilon_{US}^{\bar{U}}$	0.0498	0.0245	0.1	Inf	invg
$\varepsilon_{DE}^{g^{\bar{U}}}$	0.0836	0.0192	0.1	Inf	invg
$\varepsilon_{FR}^{g^{\bar{U}}}$	0.0415	0.0136	0.1	Inf	invg
$\varepsilon_{US}^{g^{\bar{U}}}$	0.064	0.0251	0.1	Inf	invg
ε_{DE}^{u}	0.0522	0.0207	0.1	Inf	invg
ε_{FR}^{u}	0.1273	0.0205	0.1	Inf	invg
ε_{US}^{u}	0.1061	0.0217	0.1	Inf	invg
ε_{DE}^{y}	0.3969	0.0634	0.3	0.05	invg
ε_{FR}^{y}	0.2679	0.0382	0.3	0.05	invg
ε_{US}^{y}	0.4421	0.0728	0.35	Inf	invg

Figure 5: Forecast Results for the United States (70% and 95% confidence intervals) - Sample 1999Q1-2009Q3, Forecast horizon 2009Q4-2014Q3

(a) GDP Growth (%, Quarter-on-quarter)



(b) Inflation (%, Year-on-year)



(c) Unemployment Rate (%)

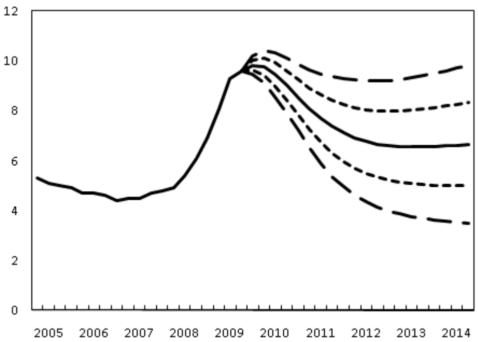
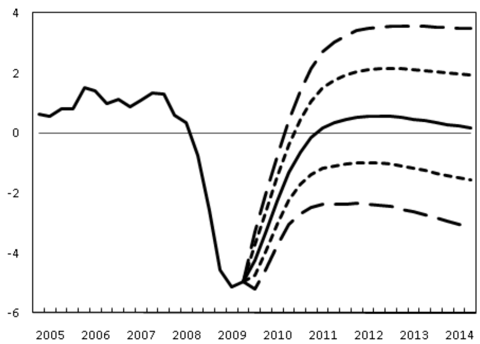


Figure 6: Output Gap and Potential GDP Forecast Results for the United States (70% and 95% confidence intervals) - Sample 1999Q1-2009Q3, Forecast horizon 2009Q4-2014Q3

(a) Output Gap (%)



(b) GDP and Potential GDP (billion U.S. Dollars