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[2]A few days after this paper was presented at the Workshop on Business Fluctuations and International Transmission of Shocks, Kobe University, Kobe, Japan, November 2012, our colleague, co-author and dear friend Jenny Ligthart passed away. This paper could never have been written without her, and the final result would definitely have been better with her input. We thank Adrian Pagan and participants of the Workshop, in particular Tsutomu Miyagawa, for helpful comments.

Abstract

This paper analyses the impact of the Global Financial Crisis on the Euro area utilizing a simple dynamic macroeconomic model with interaction between monetary policy and fiscal policy. The model consists of an IS curve, a Phillips curve, a term structure relation, a debt accumulation equation and a Taylor monetary policy rule supplemented with a Zero Lower Bound, and a fiscal policy rule. The model is calibrated/estimated for EU-16 countries for the period 1980Q1–2009Q4. The impact of the Global Financial Crisis is studied by means of impulse responses following a combined, prolonged aggregate demand and public debt shock. The simulation mimicking the GFC turns out to work fairly well. However, the required size of the shock is quite large.

Keywords: Global Financial Crisis, euro area, monetary policy, fiscal policy, New Neoclassical Synthesis model, Zero Lower Bound

JEL-code: C51, C52, E63

1 Introduction

The Global Financial Crisis (GFC) in 2007–2008 has had an huge impact on the euro area, and until now the recovery is still not under way. Even worse, the European sovereign debt crisis triggered by the GFC resulted in large difficulties for several Euro area countries to refinance their government debt. Starting in late 2009, the Greek government began having problems to meet its debt obligations, and in April 2010 Greece government bonds were downgraded to the status of junk bonds, which led to panic in European and even global financial markets. Despite the fact euro area member states and the IMF provided one hundred and ten billion euro bail-out loans to Greece in May 2010, the debt crisis did not stop and even spread to other euro area countries such as Ireland, Portugal and Spain. Since the Maastricht Treaty was signed by the member countries of the European Union (EU), individual euro area countries design independent macroeconomic (fiscal) policies. This makes dealing with the current economic condition in the Euro area quite complicated.

This paper focuses on the impact of the Global Financial Crisis on the euro area. We utilize a simple dynamic macroeconomic model, which is heavily inspired by Kirsanova, Stehn and Vines (2005; henceforth KSV), who focus on the interaction between monetary and fiscal policy of a single economy against shocks in a dynamic setting. They set up a five-equation model consisting of a dynamic and linearized IS equation with Blanchard-Yaari consumers (Yaari, 1965; Blanchard, 1985), a Phillips curve (Bean, 1998), a linearized debt accumulation equation and two policy rules, a Taylor-like monetary policy rule (Taylor, 1995) and a fiscal policy rule. Both monetary and fiscal policy makers are benevolent; monetary policy makers will make monetary policy do nearly all of the stabilization.

One of the features of the model is the interaction of monetary and fiscal policy. Almost all existing models concerning the interaction between monetary and fiscal policy only include the short-term interest rate and basic macro-founded household consumption structure. However, the long-term interest rate is the relevant interest rate for financing government debt, and microeconomic elements such as real estate values, stock returns and living expectation can also considerably influence household consumption behaviour. Therefore, Jacobs, Kuper and Ligthart (2010; henceforth JKL) add a term structure to the macro model KSV to link the long-term interest rate to the short-term interest rate.

JKL claim that including a term structure equation in the model can improve the estimates of fluctuations of macro variables, which is supported by several studies. For instance, Estrella and Mishkin (1997) state that a yield curve can serve as a efficient method to guide monetary policy making in Euro area, which is supported by Camarero, Ordóñez and Tamarit (2005). Furthermore, Bekaert, Cho and Moreno (2010) show that the inclusion of a term structure can improve the effectiveness of generating large and significant estimates of the Phillips curve and real interest rate response parameters. On the other hand, Rudebusch, Sack and Swanson (2007) argue that the model does not improve by incorporating the term structure, but Berardi (2009) showes that the ability of structural models with a term structure to forecast movements of macroeconomic variables does not deteriorate. Rudebusch and Wu (2008) combine the finance literature of the term structure with a macroeconomic description of the yield curve to allow for a bidirectional feedback between factors that describe the term structure and macroeconomic variables.

To model the impact of the Global Financial Crisis, Lane and Milesi-Ferretti (2010) focus on the changes in values of macro variables before and after the crisis. It turns out that after the crisis, there is a considerable decrease in domestic demand and the growth rate, and an increase in public debt. Moreover, financial topics related to the crisis are also frequently analysed. For example, Shahrokhi (2011) emphasises the cause of the crisis and the future of capitalism, while Bracke and Fidora (2012) focus on the macro-financial environment of the global economy after the crisis. Also, Moshirian (2011) shows that since the global financial framework is not perfectly integrated, cross border regulatory arbitrage still exists even after the Global Financial Crises. In our paper, we model the Global Financial Crisis through a combination of shocks, and study the responses.

We introduce a Zero-Lower-Bound (ZLB) in the monetary policy rule. When confronted with a financial crisis, the most common reaction of developed countries' central banks is to cut nominal short-term interest rates considerably. Belke and Klose (2012) show that both the US Federal Reserve (Fed) and the European Central Bank (ECB) employ this method in reaction to the GFC. However, nominal interest rates cannot become negative, and ZLB frequently serves as a binding constraint on monetary policy with low inflation targets. Reifschneider and Williams (2000) indicate that with a 2% inflation rate, ZLB works as a binding constraint about 10% of the time in the simulations of the Fed Board's FRB/US model. Also, Williams (2010) shows that after the GFC the ZLB has become a binding constraint on monetary policy in most industrial countries with monetary policy rates below 1%. As a result, with already low nominal short-term interest rate, the room left for the ECB to further cut short-term interest rates is limited, and conventional monetary policies are no longer effective (Belke and Klose 2012, Gerlach and Lewis 2010).

The paper is structured as follows. Section 2 introduces the basic analytical framework used in this paper. Section 3 presents the econometric model, data, calibration of the parameters and stability analysis. Section 4 shows single shock simulations in Section 4.1 and the outcomes of the combined shock, the GFC scenario, in Section 4.2. Section 5 concludes.

2 The Model

This section first provides the design of our model, which extends the macro model of KSV with a term structure relationship. The model is a simple dynamic macroeconomic model of a closed economy with Blanchard-Yaari consumers, rule of thumb price setting firms, and a government.

2.1 Households

Household consumption C in period t is defined as:

$$C_t = (1-\tau)(\alpha_1 Y_t + \alpha_2 Y_{t-1}) - \alpha_3(1 + r_{L,t-1}) + \alpha_4 A_t, \qquad \alpha_i > 0, \tag{1}$$

where τ is a proportional income tax rate, Y_t is real GDP in period t, $r_{L,t-1}$ denotes the real long-term interest rate in period $t-1$, and A_t is the real household wealth in period t. Therefore, Equation (1) is a behaviour consumption equation, which indicates that households' consumption depends on current and past disposable income and financial wealth. Even if a utility function is not explicitly postulated in the paper, Equation (1) can easily be derived from optimizing behaviour of finitely lived consumers (e.g., a Yaari-Blanchard specification), who maximize utility subject to a budget constraint. The lagged output term represents 'habit formation' in consumption. A larger long-term real rate of interest induces households to save more. The asset households hold in their wealth portfolio is only government bonds B_t, which means $A_t = B_t$.

2.2 Firms

Backward-looking firms set the price P_t according to:

$$P_t = P^*_{t-1}\,\Pi_{t-1}\left(\frac{Y_{t-1}}{Y^*}\right)^{\chi}, \qquad \chi > 0, \tag{2}$$

where Y^*_t is trend GDP in period t, $\Pi_{t-1} \equiv P_{t-1}/P_{t-2}$ is the inflation rate in period $t-1$, and χ is the relative weight of output in the rule of thumb.

2.3 The Government

The government charges taxes τY_t and issues bonds to support its spendings in period t, which consist of goods consumption G_t and debt-service payments $r_{L,t}B_t$. The government's budget identity is given by:

$$B_t = (1 + r_{L,t-1})B_{t-1} + G_{t-1} - \tau Y_{t-1}, \tag{3}$$

where $r_{L,t-1}$ is the long-term real rate of interest in period $t-1$, which is the return rate of long-term government bonds. In fact, government spending serves as the policy instrument of the government, while the tax rate is kept constant.

The government's fiscal policy rule is

$$G_t = -\phi Y_{t-1} - \mu B_{t-1}, \qquad \phi > 0, \;\; \mu > 0. \tag{4}$$

Fiscal policy reacts with a lag of one period to a demand shock and a debt shock. Increasing ϕ implies that the government assigns a greater weight on stabilizing output than on curtailing debt.

The Taylor (1995) rule links the short-run nominal rate of interest to the inflation gap and the output gap:

$$i_{S,t} = (\theta_\Pi + 1)(\ln \Pi_t - \ln \Pi^*) + \theta_Y(\ln Y_t - \ln Y_t^*), \qquad \theta_\Pi > 0, \;\; \theta_Y > 0, \tag{5}$$

where Π^* is the long-term desired rate of inflation, θ_Π is the weight given by the central bank to deviations from inflation, and θ_Y is the weight assigned to deviations from output. The lag structure of the monetary policy rule implies that monetary authorities react immediately to shocks to output and inflation. Moreover, a Zero Lower Bound has been added following Fukunaga et al. (2011), which set the lowest possible nominal short-term interest rate to zero

$$i_{S,t} = \max\{(\theta_\Pi + 1)(\ln \Pi_t - \ln \Pi^*) + \theta_Y(\ln Y_t - \ln Y_t^*), 0\}. \tag{6}$$

Note that we make the strong assumption here that the introduction of the ZLB does not affect the values of the structural parameters in the Taylor rule and in the other equations of the model.

2.4 Arbitrage Conditions

The term structure of interest rates follows from a modified version of the expectations theory:

$$i_{L,t} = \varphi_0 + \varphi_1 \Xi + \beta i_{S,t} + \varepsilon_{i,t}, \qquad \beta \geq 1, \tag{7}$$

where φ_0 is the intercept and Ξ is a vector of other variables that can affect interest rates, which $\varepsilon_{i,t}$ represents the possible shock in period t. For simplification, we drop the vector of other variables, so the term structure we employed in our analysis is defined as

$$i_{L,t} = \varphi_0 + \beta i_{S,t} + \varepsilon_{i,t}, \qquad \beta \geq 1. \tag{8}$$

Meanwhile, with $\beta \geq 1$ and positive intercept the term structure ensures the nominal long-term interest to be positive.

2.5 Goods Market Equilibrium

Combining Equation (1) with the goods market equilibrium $Y_t = C_t + G_t$ yields:

$$Y_t = \kappa Y_{t-1} - \sigma(1 + r_{S,t-1}) + \psi B_t + \delta G_t, \tag{9}$$

where the coefficients are:

$$\kappa \equiv \frac{(1-\tau)\alpha_2}{1-(1-\tau)\alpha_1} > 0, \qquad \sigma \equiv \frac{\alpha_3}{1-(1-\tau)\alpha_1} > 0, \tag{10}$$

$$\psi \equiv \frac{\alpha_4}{1-(1-\tau)\alpha_1} > 0, \qquad \delta \equiv \frac{1}{1-(1-\tau)\alpha_1} > 0. \tag{11}$$

2.6 The Log-Linearized System

The model is log-linearized around an initial steady state with $B_0 > 0$ and converted into nominal terms. The log-linearized model consists of six equations:

$$y_t = \kappa y_{t-1} - \sigma(i_{L,t-1} + \pi) + \psi b_t + \delta g_t + \varepsilon_{y,t}, \tag{12}$$

$$\pi_t = \pi_{t-1} + \chi y_{t-1} + \varepsilon_{\pi,t}, \tag{13}$$

$$i_{S,t} = \max\{(\theta_\Pi + 1)(\ln \Pi_t - \ln \Pi^*) + \theta_Y(\ln Y_t - \ln Y_t^*), 0\} \tag{14}$$

$$i_{L,t} = \beta i_{S,t}, \tag{15}$$

$$b_t = (1 + r_{L,0})\, b_{t-1} + (i_{L,t-1} + \pi) b_0 + g_{t-1} - \tau y_{t-1} + \varepsilon_{b,t}, \tag{16}$$

$$g_t = -\phi y_{t-1} - \mu b_{t-1}, \tag{17}$$

where the output gap y_t is defined as the difference between the logarithm of real quarterly GDP ($\ln Y_t$) and its HP trend ($\ln Y_t^*$); the quarterly rate of inflation as $\pi_t = P_t/P_{t-1} - 1$; the real short-term (long-term) interest rate $r_{S,t}$ (r_{L_t}) as the nominal short-term (long-term) interest $i_{S,t}$ ($i_{L,t}$) minus inflation π_t, both annualized, i.e. $r_{S,t} \equiv i_{S,t} - 400 \times \pi_t$ and $r_{L,t} \equiv i_{L,t} - 400 \times \pi_t$; b_t and g_t as debt and government expenditures (as a share of GDP); and $\varepsilon_{i,t},\ i = y, \pi, b$ as shocks, or structural innovations.

Equation (12) serves as an IS curve, and it illustrates that the nominal long-term interest rate influences the output gap with one lag, and government indeed sets its expenditure to affect the output gap. In addition, as stated by Yaari (1965) and Blanchard (1985), both government expenditure and public debt affect the IS curve when consumers have finite lives. The increase of government expenditure will not only directly raise aggregate demand, but also increase public debt, which will strengthen the increase of aggregate demand. Therefore, in line with KSV, it has been assumed that government expenditure decision needs to be made one period before its actual implementation, which can also been observed in Equation (17), the government expenditures equation. Equation (13) is a standard acceleration Phillips curve; both fiscal and monetary policy can only indirectly influence the inflation rate through the lagged output gap. Equation (14) and Equation (15) is a Taylor-like monetary policy rule and the term structure equation. Equation (16) is a debt accumulation equation, which is affected by the initial level of real debt, the real debt in the last period, government expenditure and tax revenues.

3 Empirical Methodology

This section describes the econometric model, the data, parameter calibration, and stability analysis of the model that is used in the simulation analysis below.

3.1 The Econometric Model

The model is solved by calculating the implied long-run values for the endogenous variables. Writing the structural model as:

$$\mathbf{\Gamma Y}_t = \mathbf{B}(L)\mathbf{Y}_t + \mathbf{c} + \mathbf{e}_t, \tag{18}$$

where $\mathbf{Y}_t = [y_t,\ \pi_t,\ i_{S,t},\ i_{L,t},\ b_t,\ g_t]'$ denotes the vector of endogenous variables, $\mathbf{\Gamma}$ is the matrix of coefficients of contemporaneous endogenous variables, $\mathbf{B}(L)$ is the matrix of coefficients of lagged endogenous variables, L is the lag operator, $\mathbf{c}$ is the vector of intercepts, and $\mathbf{e}_t$ is the vector of structural innovations. The reduced-form model becomes:

$$\mathbf{Y}_t = \mathbf{B}^*(L)\mathbf{Y}_t + \mathbf{\Gamma}^{-1}\mathbf{c} + \mathbf{u}_t, \tag{19}$$

with $\mathbf{B}^*(L) \equiv \mathbf{\Gamma}^{-1}\mathbf{B}(L)$ and $\mathbf{u}_t \equiv \mathbf{\Gamma}^{-1}\mathbf{e}_t$ is the vector of reduced form innovations with variance-covariance $\mathbf{\Sigma}_u = \mathbf{\Gamma}^{-1}\mathbf{\Sigma}_e\mathbf{\Gamma}^{-1'}$, where $\mathbf{\Sigma}_e$ is the variance-covariance matrix of structural innovations and $\mathbf{\Sigma}_u$ is the variance-covariance matrix of the reduced-form errors.

The moving average representation expresses $\mathbf{Y}_t$ as a function of current and past reduced-form innovations $\mathbf{u}_t$:

$$\mathbf{Y}_t = \mathbf{C}(L)\mathbf{\Gamma}^{-1}\mathbf{c} + \mathbf{C}(L)\mathbf{\Gamma}^{-1}\mathbf{e}_t, \tag{20}$$

with $\mathbf{C}(L) \equiv [\mathbf{I} - \mathbf{B}^*(L)]^{-1}$.

The maximum lag length is set to be unity (i.e., $L = 1$), implying that:

$$\mathbf{\Gamma} \equiv \begin{pmatrix} 1 & 0 & 0 & 0 & -\psi & -\delta \\ 0 & 1 & 0 & 0 & 0 & 0 \\ -\theta_Y & -1-\theta_\Pi & 1 & 0 & 0 & 0 \\ 0 & 0 & -\beta & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}, \qquad \mathbf{B}(1) \equiv \begin{pmatrix} \kappa & \sigma & 0 & -\sigma & 0 & 0 \\ \chi & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -\tau & -b_0 & 0 & b_0 & 1+r_{L,0} & 1 \\ -\phi & 0 & 0 & 0 & -\mu & 0 \end{pmatrix},$$

and the vector of intercepts is

$$\mathbf{c} \equiv [c_y,\ c_\pi,\ c_s,\ c_l,\ c_b,\ c_g]'.$$

3.2 Data

The raw data are provided by the European Central Bank in two databases. The first combines the previous version with updates from the newest version of the Area-Wide

Model (AWM) database (2001). The AWM database gives the data for monetary variables and for some fiscal variables. The second database is from the ECB working paper of Paredes et al. (2009), which provides the fiscal dataset. The fiscal data is retrieved from the AWM database for the period 1970Q1 till 1998Q4, and from the working paper of Paredes et al. (2009) for 1999Q1 till the end. Since the AWM dataset uses the same methodology to build the data for fiscal variables as Paredes et al. (2009), the fiscal variables' data collected from these two databases can be easily combined.

[Table 1 about here.]

For the analysis six quarterly data series are collected, real GDP, the government expenditure/GDP ratio, the public debt/GDP ratio, overall HICP, and the nominal short-term and long-term interest rates. After transformation, they are used for the six endogenous variables in our model: output gap, inflation rate, real short-term and long-term interest rate, public debt and government expenditure. The database covers the period from 1970Q1 till 2009Q4, but for several series the data between 1970 and 1980 is missing. Consequently, in all analysis of this paper the data series start from 1980Q1. Table 1 shows the variables and their corresponding data series.

[Figure 1 about here.]

Figure 1 shows the time series of the six variables in our model. The general tendency in both the short-term and the long-term interest rate is downwards, with several distinct peaks and troughs. Both reach a peak in 2008, and then start to drop. Government expenditures gradually increase in the beginning of the sample and then decrease over time. After a dramatic drop in 1994, it begins fluctuating swiftly, and after reaching its trough in 2008 government expenditures increase towards the end of that year. In contrast, public debt mainly has a upward slope, but it decreases around 1995 and then approximately staying the same with small fluctuations between 2000-2007, followed by a sudden increase from 2008 onwards. Inflation kept on dropping until 1986, and then started fluctuating between 0 to 1.5 percent. The volatility of inflation rate increased since 2000 and reaches its trough at the end of 2008. After that, it rises quickly in 2008-2009. Finally, the output gap fluctuates around zero, and unsurprisingly falls considerably and hits its lowest point at the end of the sample.

3.3 Parameters

In this paper, the macroeconomic model is supplemented with generally accepted parameter values taken from KSV: $\kappa = 0.5$, $\sigma = 1.0$, $\psi = 0.01$, $\delta = 1.1$, $\chi = 0.1$, $\theta_\pi = 1.1$, $\theta_y = 0.6$, and $\tau = 0.3$. Parameter β is estimated from the data, and set at 2.24. The initial values of long-term interest and public debt are set at $r_{L,0} = 0.015$ (quarterly) and $b_0 = 0.6$. Parameters ϕ and μ take the values $\phi = 0$ and $\mu = 0.03$, which indicates that fiscal authorities aim at stabilizing debt. For a sensitivity analysis of the parameters of the fiscal policy rule see JKL.

KSV originally set the sum of α_1 and α_2 in Equation (1) equal to 0.7 (with $\alpha_1 = 0.5$), which is the same with the labour share in GDP, and they also set $\alpha_3 = 0.8$. The tax rate is 30 percent. For Blanchard-Yaari consumers they choose the possibility of death of 1 percent, which corresponds to the average working life of 25 years, so $\alpha_4 = 0.015$. With these parameters, other parameters in the model can be simply calculated.

Estimating our system (12)–(17) with given parameters introduced above, the vector of intercepts becomes $\mathbf{c} \equiv [-0.5407, -0.0002, -0.0031, 0.0021, -0.5066, 0.5139]'$. Moreover, by applying the econometric model and the estimated intercept, the long-run values of the endogenous variables can be calculated as: $\mathbf{Y} \equiv [0.002, 0.0069, 0.0085, 0.0127, 0.5111, 0.4986]'$. In the long run, the output gap will be 0.002, which is almost equal to zero, and the annual inflation is about 2.76 percent. The nominal short-term interest rate is about 3.4 percent, which implies the real short-term interest is 0.64 percent, and the real long-term interest rate is about 1.7 percent higher than the real short-term interest rate. Finally, the equilibrium public debt ratio is around 51 percent, and the government expenditure is about 49 percent of GDP. It can be seen that these results fit reality well, suggesting that parameter values do make sense.

The stability analysis is based on the eigenvalues of $\mathbf{B}^*(L)$. The six eigenvalues are $\lambda_1 = 0$, $\lambda_2 = -0.61$, $\lambda_3 = 0.79$, $\lambda_4 = 0.95$, $\lambda_5 = 0$, and $\lambda_6 = 0.03$. Consequently, the model is stable and has cyclical dynamics with short cycles, because of the small imaginary parts of the complex-values eigenvalues.

4 Impulse Responses

This section analyses the transitional dynamics of the six variables of the model to the Global Financial Crisis. First, a baseline simulation is calculated, which is a simulation without shocks. Then simulations are shown in which individual shocks are applied in one period only to aggregate demand, inflation and public debt. Finally, a simulation is presented that mimics the impact of the Global Financial Crisis through a combination of an aggregate demand shock and a public debt shock. Both the individual shocks and the combined shock show responses relative to the baseline simulation. The impulses consist of one-unit (i.e. one percentage point) shock on the residuals of $\varepsilon_{i,t}$ in system (12)–(17), with either positive or negative signs based on Lane and Milesi-Ferretti (2010). A drawback of our procedure to calculate impulse responses is that we cannot compute confidence intervals. Hence our impulse response figures only show point estimates.

As the Global Financial Crisis occurred only about four years ago, the length of data series is not long enough to provide sufficient information about how the crisis evolved, so we extend the data series to 2040Q4 with zeros for the extended part. Note that this choice does not affect the simulations, which show deviations from the baseline, since the model is linear. It is assumed that the shock occurs in 2008Q4, and since our focus in this section is on the Global Financial Crisis, the graphs display responses from 2008Q4 up to and including 2040Q4.

4.1 Individual Shock Simulations

For the aggregate demand shock we take a negative one-unit shock. Figure 2 shows the difference between this simulation and the baseline simulation, which is referred as "results" later on in this section. On impact, the short run interest rate decreases (monetary policy), and decreases inflation which adds to the decrease of the interest rate. Moreover, the drop in the output gap and the interest rates reduce public debt, and increase government expenditure (fiscal policy). In the period after the shock, decreasing debt and increasing government expenditure affects growth positively, so the output rises and surpasses its equilibrium value. After the shock, government expenditures stabilize public debt. Gradually, the model reaches its new equilibrium.

[Figure 2 about here.]

The results for a positive one-unit inflation shock are shown in Figure 3. The inflation shock immediately results in a monetary policy response, i.e. an increase in the short-term interest rate, which reduces the output gap and increases the public debt through a rise of long-term interest. Fiscal policy reacts with a lag to the shock, which leads to a decline of government expenditure to trade off the public debt. After the shock, output gap and government expenditure increases while public debt decreases because of the drop of nominal interest rates. Over time, the model gradually adjusts to its new equilibrium.

[Figure 3 about here.]

For the public debt shock, a positive one-unit shock is applied, and Figure 4 summarizes the results. The immediate effect is an increase of the output gap since debt is treated as net wealth. Monetary policy jumps in by raising both the nominal long-term and short-term interest rate, while fiscal policy results in a reduction of government expenditure. In the impulse period, the output gap falls after the instantaneous increase because of the jump of nominal interest rates and the decreasing government expenditure. After the shock, with low interest rates, the output gap and government expenditure start rising, while the public debt falls. Both policies are relaxed over time and the model gradually reaches a new equilibrium.

[Figure 4 about here.]

4.2 The Global Financial Crisis

To mimic the Global Financial Crisis we employ a combined shock. An aggregate demand shock and a public debt shock are combined with different weights. In reality, the GFC does not stop shortly after its occurrence, and its direct influence last more than a year. Therefore, different from the single shock simulations that have only one shock in 2008Q4, the shock period is prolonged to the 2008Q4–2009Q4 period.

Figure 1 in Section 3.2 shows that the government expenditures and public debt start increasing from the end of 2008 onwards, whereas the output gap falls substantially during the same period. Our simulations match these stylized facts. After some experimentation, we set the weight of the aggregate demand shock to 1.5 and the weight of the public debt shock to 3. The size of this combined shock is huge, possibly invoking the Lucas critique. We make the strong assumption that the linear character of the model and the 'deep, structural' parameters underlying the economy are not affected by the shock.

[Figure 5 about here.]

Figure 5 shows the responses of all six variables following this combined shock. Three stages can be distinguished. On impact, aggregate demand suffers from a negative shock which gives rise to a decrease of the output gap, and a positive debt shock leads to an increase of the public debt level. The nominal short-term interest rate decreases because of the falling output gap (Taylor rule). The long-term interest rate also becomes lower because of the term-structure relation, Equation (15). Inflation and government expenditure are not influenced on impact, since they only depend on lagged variables. In the impulse period, public debt keeps on increasing due to the prolonged public debt shock. Government expenditure decreases because of the prolonged positive public debt shock and the negative output gap shock, cf. Equation (17). Despite the decrease of government expenditure and prolonged negative demand shocks, the output gap begins climbing up because of higher public debt and lower interest rates. Inflation begins to decrease because of the negative output gap shock in previous periods. This causes the nominal short-term interest rate to fall, which in turn results in a lower long-term interest rate. After the impulse period, public debt gradually comes down to the new equilibrium value, reducing the output gap and the two factors together result in an increase of government expenditures. Inflation moves upward due to the lower output gap. The short-term interest rate increases, and the same holds for the long-term interest rate.

The period for the effects of the GFC shock to die out is about fifteen years, in line with the single shocks simulations. Although it seems that the adjustment period of the Global Financial Crisis estimated here is overstated, the results do make sense, considering the current economic condition in the Euro area, which is still under the strong influence of the crisis. Severe debt crisis have been triggered in the aftermath of the Global Financial Crisis in Euro area countries, and the economic recovery is almost stagnant in the Euro area as well. Main members states of the euro area even have experienced negative growth rates since the crisis.

[Figure 6 about here.]

To check the sensitivity of the outcomes to the inclusion of the ZLB, we compared responses of the combined GFC shock for the model with and without the ZLB. The main trajectories of all endogenous variables are quite similar, see Figure 6. On impact, the responses are the same, but during the impulse period the responses of all six variables are larger if the ZLB is included in the model. In addition, it is worth noting that both the nominal short-term and long-term interest rate are higher with the ZLB, which implies that the ZLB reduces the variation of nominal interest rates and indeed prevents both nominal interest rates from falling below zero.

5 Conclusion

This paper has supplemented the monetary policy rule of the six-equation model of Jacobs, Kuper and Ligthart (2010) with a Zero Lower Bound, re-calibrated/re-estimated the model for the period 1980Q1–2009Q4, and investigated the impact of the Global Financial Crisis by means of impulse responses following a prolonged, combined aggregate demand and public debt shock. Based on the long-run estimates of the six endogenous variables, we conclude that our model provides an appropriate system to display the interaction of monetary and fiscal policy. In addition, the stability test indicates that our model is robust.

The results of the impulse responses of single shocks are as expected. The combined shock simulation mimicking the GFC turns out to work fairly well; the stylized facts on the output gap and pubic debt are more or less matched. However, the required size of the combined shock is quite large, calling into question the linearity assumption of the model, the validity of the policy rules, and the assumption of unchanged structural parameters with and without the Zero Lower Bound, and before and after the GFC. The average adjustment period to the new equilibrium is about fifteen to twenty years for all six variables. This may seem long, but it does make sense given the current condition of economic recovery in the euro area. The GFC will haunt the Euro area for some time!

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Figure 1: Time series of endogenous variables (1980-2009)

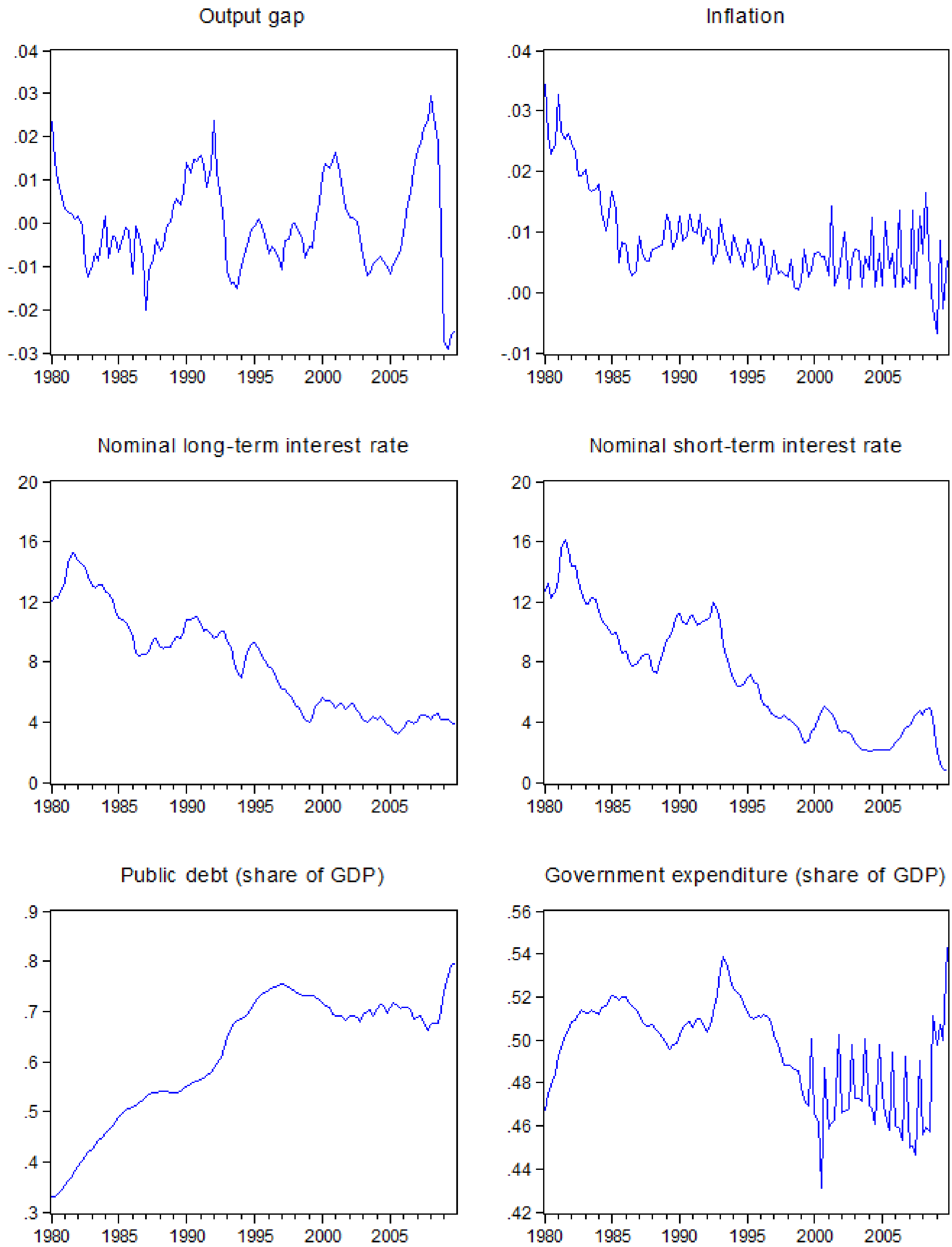

Figure 2: Aggregate Demand Shock Simulation (2008-2040)

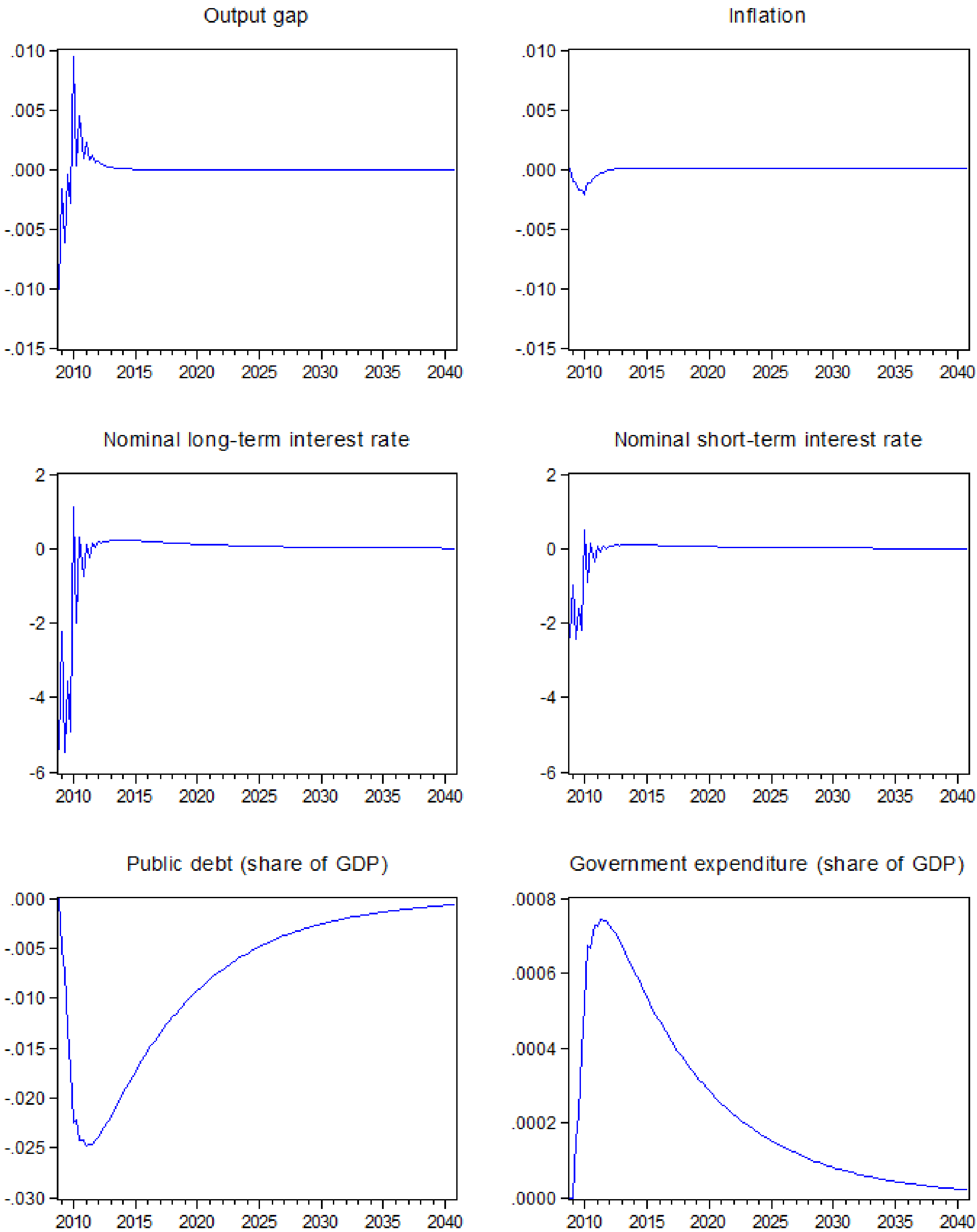

Figure 3: Inflation Shock Simulation (2008-2040)

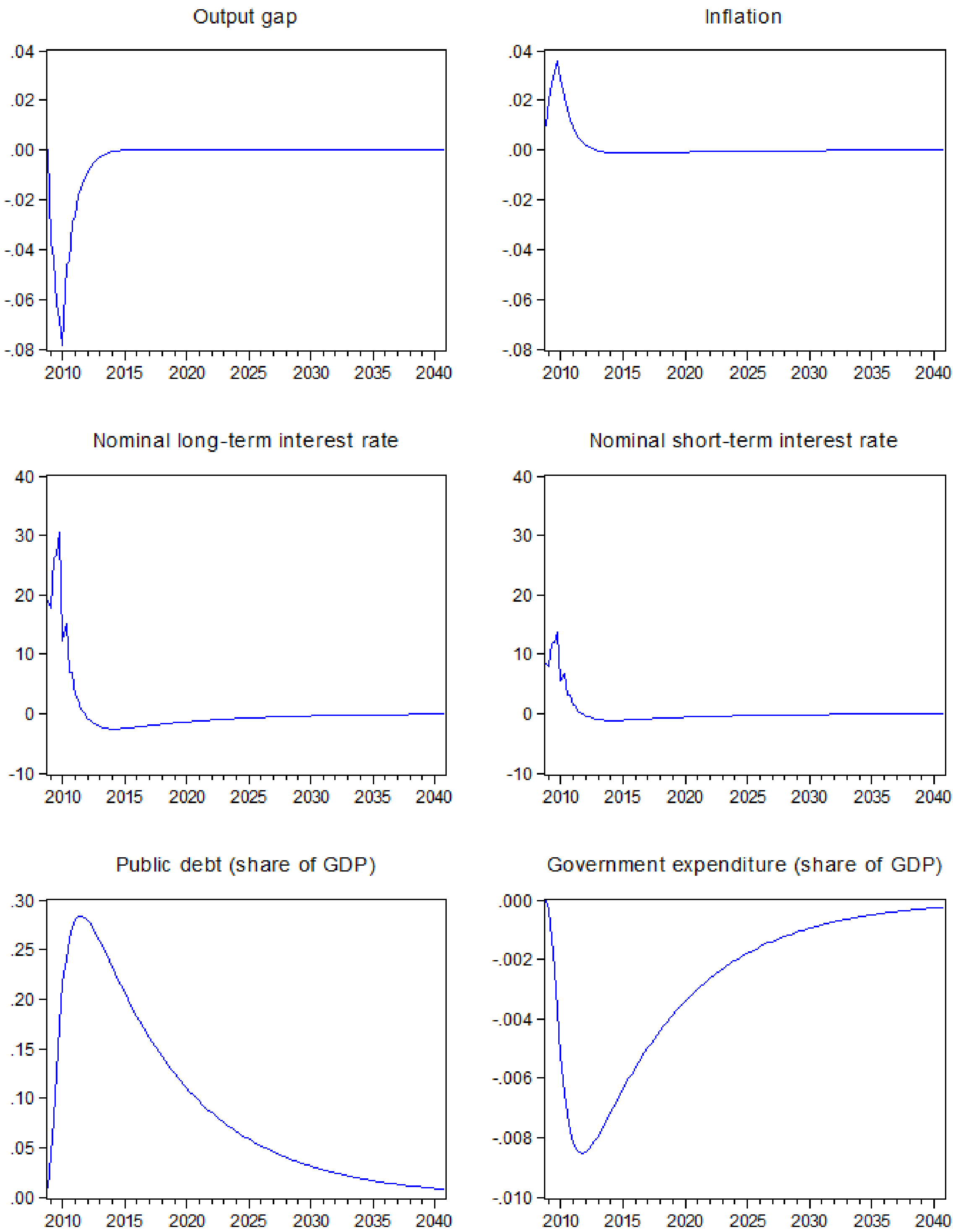

Figure 4: Public Debt Shock Simulation (2008-2040)

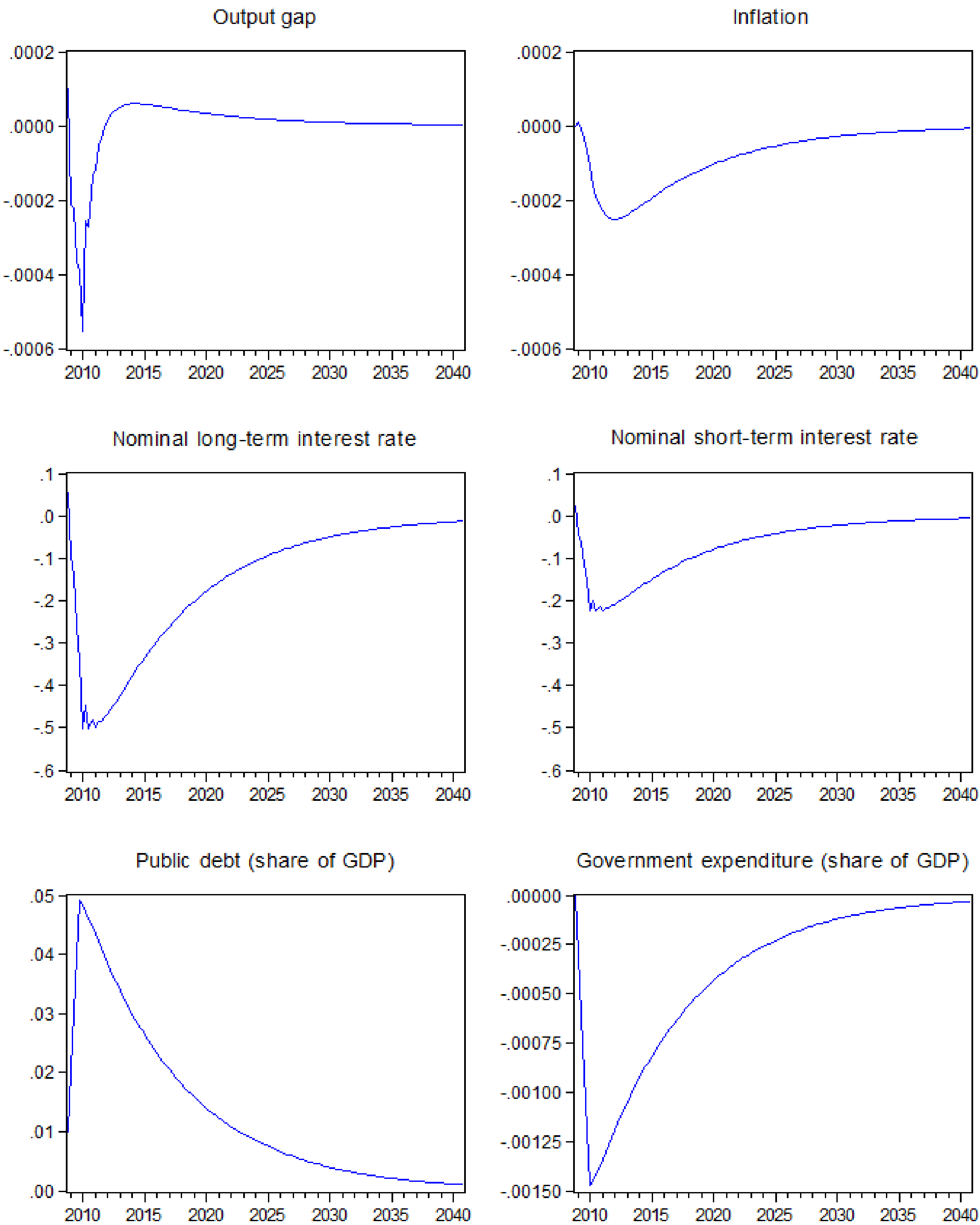

Figure 5: Combined GFC shock

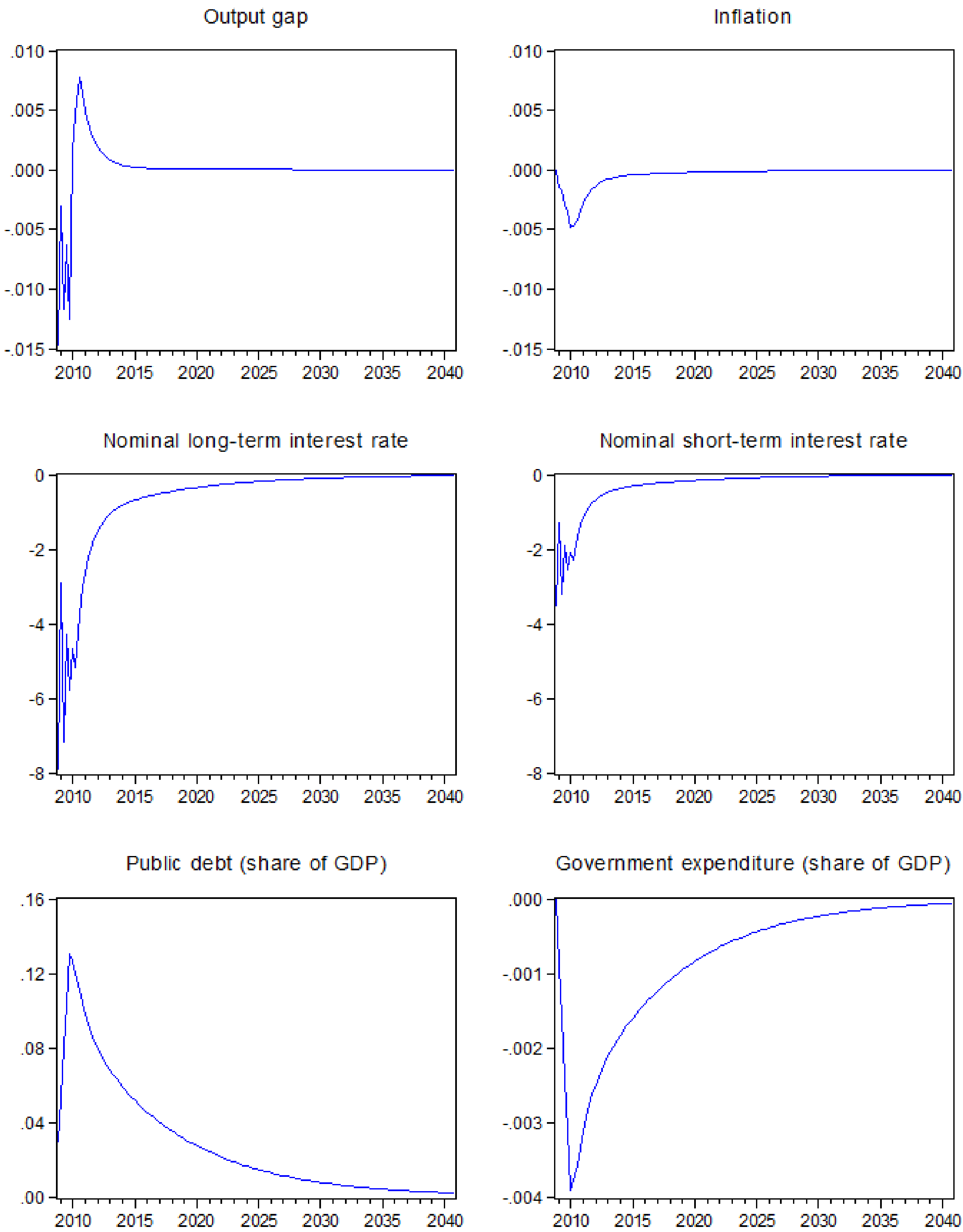

Figure 6: Effect of Zero-Lower Bound on Combined GFC Shock

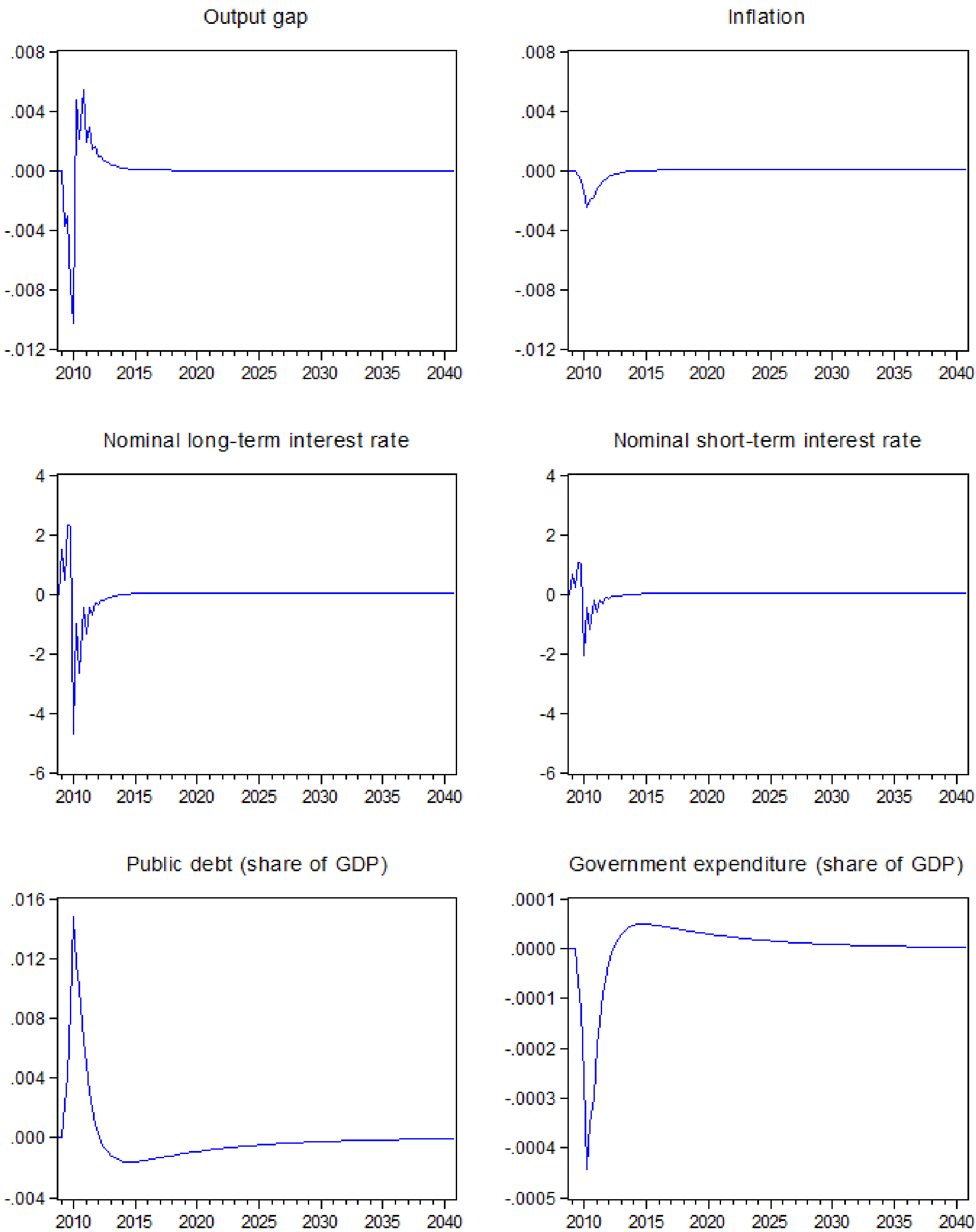

Table 1: List of variables

Symbol	AWM Code	Description	Units
Y_t	YER	Real GDP	Millions of euros
Y_t^*		Trend real GDP	Millions of euros
y_t		Output gap	$\ln Y_t - \ln Y_t^*$
P_t	HICP	Consumer price index	1995=100
π_t		Inflation	$P_t/P_{t-1} - 1$
b_t	GDN_YEN	Public Debt	Share of GDP
g_t	GEN_YEN	Government Expenditure	Share of GDP
$i_{S,t}$	STN	Nominal short-term interest rate	Annual percentage
$r_{S,t}$		Real short-term interest rate	$i_{S,t}/400 - \pi_t$
$i_{L,t}$	LTN	Nominal long-term interest rate	Annual percentage
$r_{L,t}$		Real long-term interest rate	$i_{L,t}/400 - \pi_t$

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