Fiscal and Monetary Policies in a Monetary Union

A Reduced Form Approach*

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preliminary, comments welcome

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Abstract

In this paper we explicitly model strategic interaction between two independent national fiscal authorities and a single central bank. We base the analysis on a dynamic general equilibrium model of a monetary union with monopolistic competition and staggered price setting. Closed analytical solutions for the policy instruments are computed for several strategic games. These results depend highly non-linear on parameters of the model. Thus, impulse response graphs to asymmetric shocks are depicted.

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1 Introduction and Literature Review

During the last years there has been an extensive research agenda concerning monetary policy in a closed economy within the framework of a micro-founded dynamic general equilibrium model, as can be found, for example, in the well-known books by Woodford (2003) or Galí (2008). This area of research is mostly concerned with the optimality of monetary policy and hence abstracts from fiscal policy.

But with the formation of the European Monetary Union (EMU) in 1999 macroeconomic conditions have changed for all EU member countries. By handing over monetary policy to an independent and unique central bank for all members national governments cannot use monetary policy as a stabilization tool any longer. On matters of fiscal policy each member country is assumed to maintain the autonomy of its own fiscal policy, but the Stability and Growth pact (SGP) with its thresholds for debt-GDP ratio of 60% and deficit-GDP ratio of 3% disciplines national governments to ensure monetary stability. Thus, having to obey the fiscal constraints of the SGP the stabilization role of fiscal policy is hampered. As a consequence one question concerning the optimal monetary-fiscal policy regime in the current policy framework of the EMU is whether there is still a role for fiscal policies to serve as potential stabilization tools of cyclical fluctuations.

However, fiscal policy is conducted to serve national interests rather than union interest. But in a highly integrated region like a monetary union the stabilization of asymmetric shocks might lead to spill-overs on other members. This raises the question whether a coordination of fiscal policies is more likely to be welfare enhancing. Moreover, it might be possible for fiscal authorities to strengthen their policy tools if the governments coordinate.

Our paper tries to give answers to these questions. To be more precise, this paper studies different strategic games between the fiscal authorities and the common central bank. We focus on a two-country model of a monetary union (Home and Foreign) with monopolistic competition and staggered price adjustment. Each country is hit by cost-push shocks. National governments set government spending financed by lump-sum taxes. Foremost we abstract from debt dynamics. We explore the outcome of different kind of games played by the fiscal and monetary authorities. We assume that governments and the central bank maximize appropriate welfare functions in order to set their instruments optimally, but we abstract from rules for fiscal and monetary policy. Moreover, all policy makers cannot commit to future policies on assumption. Therefore, we focus on discretionary policy making. In contrast to the current research we allow for non-coordination focusing on a Nash equilibrium. We compare this result with different other possible strategic interactions between independent national fiscal policies and a centralized monetary policy.

Both monetary policy and fiscal policy within New Keynesian models for one single country are considered by, for example, Schmitt-Grohé and Uribe (2006) or Benigno and Woodford (2003). Both works focus on a centralized perspective, i.e. one authority solves the problem how to implement both fiscal and monetary policy in an optimal way which is meant to be welfare enhancing. In the field of open economy macroeconomic literature focusing on currency areas modeled with the help of general dynamic equilibrium models with micro-foundation, Benigno (2004) investigates in a two-country model how monetary policy should be conducted in a monetary union which is hit by asymmetric shocks across regions. Beetsma and Jensen (2005) extend the above two-country model including fiscal policy in form of government spending as an active stabilization tool. They analyze the performance of several monetary and fiscal policy rules in a currency union where all three authorities, i.e. a common central bank and two national governments coordinate their policies in order to maximize union-wide welfare.
Ferrero (2005) includes governmental debt in the model of a two-country monetary union. He determines optimal fiscal and monetary rules when policy is conducted in a coordinated fashion.

All of the above mentioned works have in common that they focus entirely on *coordinated* monetary

and fiscal policy in dynamic general equilibrium models with micro-foundation. Analyses of non-coordinated policies are not performed.

The main contribution of this paper is to characterize the solution to the problem in analytical form. In order to find analytical closed solutions we abstract from a proper micro-foundation, but base our key equations which are given in reduced form on a DSGE model of a monetary union.[1] Thus, we have built a simple framework to describe the interaction of monetary and fiscal policy which allows us to derive explicit analytical solutions.

The key findings of this paper are the following: To begin with, concerning modeling we have to notice that though we have chosen the most simplest form of equations the results are no longer straightforward and depend non-linearly on parameters of the model. Thus, to interpret the outcome we go back to calibrating the model and plot impulse responses to the underlying shocks.

The rest of the paper is organized as follows. Section 2 introduces the key equations of the economic model. The next section 3 introduces the policy problem of the economy. In section 4 we analyze the case of joint coordination whereas in section 5 we derive the results for a Nash game and in section 6 for a Nash game where fiscal policy coordinates . The last section 7 concludes and gives an overview over the further research project.

2 A Simple Model of a Monetary Union

In this section we lay out a model of a monetary union which consists of two countries in reduced form, i.e. the structural and welfare equations are formulated *ad hoc*. The advantage of this *reduced form approach* is given by the simple structure of all equations and analytical results. Moreover we have spared the tedious algebra of microfoundation. But all equations can be based on a stochastic dynamic general equilibrium model of a monetary union, and are taken in a simplified form from Beetsma and Jensen (2004) or Beetsma and Jensen (2005).[2]

The world economy consists of two countries, H(ome) and F(oreign). Total population is normalized to 1. We assume that the home country has got a weight of $n \in [0, 1]$, i.e. the foreign country weighs $(1 - n)$. Both countries form a monetary union with monetary policy delegated to a single authority, the union's central bank. The two independent governments are in charge of the fiscal policy of their countries. Government spending is country-specific and financed by collecting lump-sum taxes. Financial markets are complete at the national and international level. Goods markets are characterized by monopolistic competition and nominal price rigidities. Labor markets are perfectly competitive within a country, but labor is immobile internationally. Countries are hit by different cost-push shocks which might lead to spill-over effects. As both countries share the same currency the nominal exchange rate a an automatic stabilizer is gone.

The economic conditions of the domestic country are summarized by

$$\pi_t^H = \beta E_t \pi_{t+1}^H + k^H y_t^H + u_t^H \tag{1}$$

$$y_t^H = c_y[(1-n)q_t + c_t^W] + (1 - c_y)g_t^H. \tag{2}$$

The first equation (1) is the aggregate supply of the economy and has got features of what is labeled in recent literature on monetary policy a "New Keynesian Philips Curve" (NKPC). The

[1] There are many advantages and disadvantages of micro-foundation, but these are not the topic of this papers.
[2] Approaching the problem in this way we follow the suggestion made by Blanchard (2008).

inflation rate in the home country π_t^H depends on the discounted value of the expected inflation rate of the next period containing thus the forward looking behavior of a NKPC because firms cannot adjust their prices every period. β is the discount rate. Moreover the domestic inflation rate positively depends on the domestic output y_t^H and a county specific cost-push shock u_t^H.

The second equation (2) is the aggregate demand relation of the economy. Domestic output is either consumed by the domestic government g_t^H or is determined by world consumption c_t^W. As domestic goods are traded relative prices between both countries determine the choice of home output. Higher terms of trade q_t switch demand towards goods produced in the Home country.

By substituting (2) into the Phillips-Curve relation (1) we depict the influence of international trade on the inflation rate. An increase of world output has got a positive effect on inflation. A rise in the terms of trade q_t resulting in higher domestic output, more work effort and rising prices.

Analogous equations hold for the Foreign economy:

$$\pi_t^F = \beta E_t \pi_{t+1}^F + k^F y_t^F + u_t^F \tag{3}$$

$$y_t^F = c_y[-nq_t + c_t^W] + (1 - c_y)g_t^F. \tag{4}$$

Inflation dynamics in the Foreign country are given by (3). The analogue counterpart of the impact of a change in the terms of trade can be found in the aggregate demand relationship (4) for the Foreign country which output depends negatively on the terms of trade. Substituting (4) into (3) reveals that the terms of trade have the opposite effect on the inflation rate as an increase in the terms of trade as mentioned above results in a shift of demand towards Home produced goods which implies less work effort in the Foreign country and, hence, decreasing prices. The degree of price stickiness is measured by k^H and k^F.

The model equation reveal two differences between both countries. First of all different price rigidities lead to structural differences. Secondly, the exogenous shocks are assumed to be country-specific.

Having in mind a micro-foundation of all equations we add a standard intertemporal "consumption Euler equation" as in the above mentioned papers which determines the real interest rate r_t of the monetary union:

$$E_t c_{t+1}^W = c_t^W + \rho^{-1}\left[r_t + E_{t+1}(\pi_t^W)\right] \tag{5}$$

Moreover the terms of trade is defined through the inflation differential:

$$q_t = q_{t-1} + \pi_t^F - \pi_t^H. \tag{6}$$

To conclude, the system of equations (1) to (6) determines solutions for the endogenous variables $c_t^W, y_t^H, y_t^F, \pi_t^H, \pi_t^F$ and q_t given paths for r_t, g_t^H and g_t^F and an initial value of q_{t-1}.

Before we proceed we would like to introduce the following notation for a generic variable x which will be useful in the further analysis. With $x^W \equiv nx^H + (1-n)x^F$ we denote the *world level* of a variable, i.e. a weighted average of the Home and the Foreign variable, whereas $x^R \equiv x^F - x^H$ denotes the *relative level*. Using this notation we can express a variable for the Home respectively for the Foreign country as:

$$x^H = x^W - (1-n)x^R \tag{7}$$

$$x^F = x^W + nx^R. \tag{8}$$

3 The Policy Problem

We consider two independent governments and an independent monetary authority, a central bank in the monetary union. As we mainly want to focus on non-coordination of fiscal and monetary policy we do not consider a union-wide welfare criterion. As policy authorities do not set their instruments by following a rule, but choose their instruments optimally by maximizing an appropriate welfare criterion, we assign a loss function to each of the three players.

These will be postulated *ad hoc* in this paper in contrast to the current approach in research of deriving a welfare criterion based on a second order Taylor approximation of a weighted average of utilities of all consumers in the union.[3]

The *common central bank* is supposed to stabilize the economy of the monetary union according to the following welfare criterion W

$$W = -E_0 \left\{ \sum_{t=0}^{\infty} \beta^t L_t^{MP} \right\}$$

which is the discounted value of expected period losses L_t^{MP} with

$$L_t^{MP} = \frac{1}{2} \left\{ \left(\pi_t^W - \overline{\pi}_{MP}^W \right)^2 + \mu_c \left(c_t^W - \overline{c}_{MP}^W \right)^2 \right\} \tag{9}$$

where μ_c is a positive constant.[4]

According to (9) the monetary authority wants to stabilize deviations in the world inflation rate π_t^W from its target $\overline{\pi}_{MP}^W$. This seems plausible in the sense that the common central bank just takes union wide variables into consideration not focusing on national levels.
Moreover fluctuations in the world consumption should be stabilized.
We assume that monetary policy is conducted by setting the union-wide nominal interest rate.

The *fiscal authority* of both countries finance a stream of public spending g_t^j , $j = H, F$ for goods produced in its own country (complete home bias) by collecting lump-sum taxes so that government budget balances each period.

Both governments want to stabilize the economy of their country according to the following welfare criterion W

$$W = -E_0 \left\{ \sum_{t=0}^{\infty} \beta^t L_t^{G,i} \right\} \qquad i = H, F$$

which is the discounted value of expected period losses $L_t^{G,i}$ with

$$L_t^{G,i} = \frac{1}{2} \left\{ \left(\pi_t^i - \overline{\pi}_{FP}^i \right)^2 + \nu_y^i \left(y_t^i - \overline{y}_{FP}^i \right)^2 \right\} \qquad i = H, F \tag{10}$$

where $\overline{\pi}_{FP}^i$, respectively $\overline{y}_{FP}^i$, $i = H, F$ denote the target levels of governments set for national inflation rate respectively the output, and ν_y^i, $i = H, F$ are positive constants.[5]
In contrast to the central bank national governments just focus on national variables. They want

[3] The aim of this paper is to be able to compare analytical results. See also footnote 1

[4] Note that in this reduced form approach model the constant is given exogenously and chosen by the central bank. In case of a micro-founded loss function the weight depends on parameters of the underlying model and cannot be chosen strategically by the policy maker.

[5] The same remarks as in the previous footnote apply to these weights.

to minimize losses which depend on the national inflation rate and the national output.
Given the welfare objectives as above fiscal policy is characterized by different weights in the loss functions and different targets of national output and inflation.

The aim of this paper is to characterize the outcome of different policy scenarios. In contrast to most existing literature we allow for non-coordination among fiscal authorities and between fiscal and monetary policy.

As all three policy makers do not coordinate in setting their instruments the timing of policy actions is relevant for the analysis. We analyze Nash equilibria, leadership equilibria and coordinated equilibria.

Arguments for and against each kind of game can be derived. A Nash equilibrium in a monetary union seems plausible as actual policy reveals that policy authorities hardly coordinate. Rather they set their instruments independently of each other.
If one is convinced of the argument that time-lags in fiscal policy between recognition of a shock and hence a necessity to implement a new policy action and the implementation itself, are longer than in monetary policy, a Stackelberg game with the central bank as a leader (in setting its instruments) and the two governments reacting to the monetary decision is the appropriate framework to analyze stabilization policy.
Finally, the argument that monetary policy reacts on the decisions made by fiscal policy to stabilize inflation is in favor of a leadership concept with the governments as first mover.

Moreover, we analyze the case of fiscal coordination independently of the central bank, i.e. both home and foreign government cooperate in setting their instruments aiming at minimizing a weighted average of the loss function (10).

All policy plans are compared to the optimal policy plan which a single social planner implements. The benevolent social planner chooses all fiscal and monetary instruments in order to maximize union-wide welfare.

This paper describes the results of *discretionary* policy, i.e. we assume that no policy authority can commit to future policy choices. Optimal policy under discretion describes best reality, as no major central bank makes any kind of binding commitment (Clarida, Galí, and Gertler (1999)). Regarding governments even within the limits imposed by the SGP fiscal policy is conducted in a discretionary manner.

4 Benchmark: Joint coordination

Before we start analyzing all different kind of strategic interaction we have to focus on the benchmark of full coordination of all three policy makers, i.e. we assume that both governments and the central bank set their instruments to minimize welfare losses of a representative agent of the monetary union. To be more precise we consider this case as if there is one single authority maximizing welfare of a representative household living in the monetary union assuming that it is a single country where the household faces an (aggregated) inflation rate π_t^W and an (aggregated) output gap y_t^W. But the single authority takes into account that the two regions may be hit by inflation differential, i.e. the authority takes the terms of trade q_t into account. Thus the loss function the centralized policy maker just takes these three macroeconomic variables into account. Instruments are the nominal interest[6], aggregated government spending $g_t^W = ng_t^H + (1-n)g_t^F$

[6] As the interest rate is pinned down by the Euler consumption equation (5), we take for computational reasons c_t^W as the monetary instrument.

and differential government spending $g_t^R = g_t^F - g_t^H$.[7]

To summarize, the single authority wants to stabilize the economy of the whole monetary union according to the following welfare criterion W

$$W = -E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{1}{2} \left\{ \left(\pi_t^W - \overline{\pi}_{CO}^W\right)^2 + \lambda_y^{CO} \left(y_t^W - \overline{y}_{CO}^W\right)^2 + \lambda_q^{CO} n(1-n) q_t^2 \right\} \right\} \tag{11}$$

where $\overline{\pi}_{CO}^W$, respectively $\overline{y}_{CO}^W$, denote the target levels of governments set for the aggregated inflation rate respectively the output, and λ_y^{CO} and λ_q^{CO} are positive constants.

The loss function features a quadratic term of terms of trade. In this set up we follow for example Ferrero (2005) or Benigno (2004). Like them we argue that fluctuations in the terms of trade lead to fluctuations in production across countries as relative prices allocate resources within the union. If one country constitutes the whole union, i.e. it gets big in size ($n \to 1$ or $n \to 0$) the loss function resembles the one of a closed economy. The central bank focuses on variation of the inflation rate of the bigger country. Relative prices are no longer of importance and the terms of trade vanish.

The optimization is subject to the following constraints[8]

$$\begin{aligned}
\pi_t^W &= \beta E_t \pi_{t+1}^W + k y_t^W + u_t^W \\
y_t^W &= c_y c_t^W + (1 - c_y) g_t^W \\
q_t &= \pi_t^F - \pi_t^H = \frac{\beta}{1 + k c_y} E_t \pi_{t+1}^R + \frac{k(1-c_y)}{1+kc_y} g_t^R + \frac{1}{1+kc_y} u_t^R
\end{aligned}$$

First order conditions of the above problem with respect to c_t^W, g_t^W and g_t^R result in

$$\begin{aligned}
0 &= k\pi_t^W + \lambda_y^{CO} y_t^W \\
0 &= k\pi_t^W + \lambda_y^{CO} y_t^W \\
0 &= \lambda_q^{CO} n(1-n) \frac{k(1-c_y)}{1+kc_y} q_t
\end{aligned}$$

The first two optimality conditions give the usual trade-off between inflation rate and output-gap stabilization

$$\pi_t^W = c_{MP} \lambda_y^{CO} u_t^W \qquad \text{and} \qquad y_t^W = -k c_{MP} u_t^W \tag{12}$$

where c_{MP} is a constant spelled out in the additional appendix depending on underlying parameters of the model.

Thus, it is optimal for the single authority to set the nominal interest rate and aggregate government spending such that

$$-k c_{MP} u_t^W = c_y c_t^W + (1 - c_y) g_t^W$$

[7] Deriving solutions for theses policy instrument we have solutions for the home and foreign variables as well using (7) and (8).

[8] under the additional assumptions that $q_{t-1} = 0$ and $k^H = k^F = k$

Assuming that $g_t^W = 0$ monetary policy stabilizes aggregated shocks.

Using the last optimality condition we derive that the terms of trade vanish $q_t = 0$ which results in equal inflation rates across both countries. Exploring the equations further we get the result that relative government spending stabilizes relative shocks:

$$g_t^R = -\frac{1}{k(1-cy)} u_t^R$$

5 Simultaneous decisions of all policy-makers

In this section we derive the targeting rules for both governments and the central bank assuming that all three policy makers do not coordinate and set their instrument independently of the others.

The timing of the events is as follows: Considering discretionary policy expectations of the private sector on inflation have been made beforehand, i.e. expectations $E_t \pi_{t+1}^j$, $j = H, F$ are given for all policy makers. The monetary union is hit by the shocks u_t^H and u_t^F at the same time. The policy makers observe these shocks, then they set their instruments.

We first consider the problem of the government. Then we will derive the central bank's optimal reaction function.

5.1 Government

Under non-coordination and discretion the Home government solves the following problem

$$\min_{g_t^H} \quad L_t^{G,H} \quad \text{given} \quad c_t^W, g_t^F \quad \text{and s.t.} \quad (1) \quad \text{and} \quad (2)$$

As the choice of government spending does not have any dynamic implications the problem is a static one-period problem.[9] Setting up the Lagrangian, deriving the first order conditions (FOC) and manipulating these yields the following reaction function for the home government:

$$0 = \nu_y^H \left(y_t^H - \overline{y}_{FP}^H \right) + k^H \left(\pi_t^H - \overline{\pi}_{FP}^H \right) \tag{13}$$

The problem for the foreign government is absolutely symmetric resulting in

$$0 = \nu_y^F \left(y_t^F - \overline{y}_{FP}^F \right) + k^F \left(\pi_t^F - \overline{\pi}_{FP}^F \right) \tag{14}$$

There is a negative trade off between output gap and inflation stabilization.

5.2 Monetary Policy

The central bank's instrument is the nominal interest rate. As the consumption Euler equation (5) pins down the nominal interest rate in dependence of world consumption spending c_t^W we can use c_t^W as monetary policy instrument.
To simplify the problem from now on we impose the additional assumption that nominal rigidities

[9] The problem gets more complex if considering, for example, a Phillips curve which includes inflation inertia as in Steinsson (2003). Then **?** provides a method to solve the discretionary case.

are equal across countries, i.e. $k^H = k^F \equiv k$.[10]
Therefor, the central bank's problem can be described as follows:

$$\min_{c_t^W} \quad L_t^{MP} \quad \text{given} \quad g_t^H, g_t^F \quad \text{and s.t.}$$

$$\begin{aligned} \pi_t^W &= \beta E_t \pi_{t+1}^W + k y_t^W + u_t^W \\ y_t^W &= c_y c_t^W + (1 - c_y) g_t^W \end{aligned}$$

The solution to this problem is given by

$$\mu_c \left(c_t^W - \overline{c}_{MP}^W \right) + k c_y \left(\pi_t^W - \overline{\pi}_{MP}^W \right) = 0 \tag{15}$$

5.3 Equilibrium

To summarize, in case of a Nash game of complete uncoordinated policy the equilibrium is given by equations (1), (2), (3), (4), (6), (13), (14) and (15).

Assuming that the country-specific cost push shocks u_t^j, $j = H, F$, are AR(1)-shocks with coefficients ρ^j, $j = H, F$, i.e. $u_t^j = \rho^j u_{t-1}^j + \varepsilon_t^j$ an explicit analytical solution to the above system can be derived. The algebra is deferred to a technical appendix which is available upon request.
All constants in the next formulas are spelled out in the appendix.

In equilibrium inflation rates in the Home and Foreign country are given by

$$\pi_t^H = q_H \nu_y^H u_t^H + \nu_y^H C_{FP}^H \tag{16}$$

$$\pi_t^F = q_F \nu_y^F u_t^F + \nu_y^F C_{FP}^F \tag{17}$$

Output is given by

$$y_t^H = -k q_H u_t^H - k C_{FP}^H + const_{FP}^H \tag{18}$$

$$y_t^F = -k q_F u_t^F - k C_{FP}^F + const_{FP}^F \tag{19}$$

Using these results the aggregate inflation rate and terms of trade can be computed.

As for the instrument of the monetary policy we note that from (15) we have

$$c_t^W = const_{MP} - \frac{k c_y}{\mu_c} \left(n \pi_t^H + (1 - n) \pi_t^F \right) \tag{20}$$

With (16) and (17) we derive an analytical solution for the optimal central bank's response.

For the governmental instruments we solve the demand equations (2) respectively (4) for govern-

[10] Otherwise we have to use dynamic programming in order to derive the optimal response of the central bank.

ment spending, use the definition of the terms of trade (6) and the previous results to obtain

$$\begin{aligned} g_t^H &= \frac{1}{1-c_y}\left[-kq_H + \left(c_y(1-n) + n\frac{kc_y^2}{\mu_c}\right) q_H \nu^H\right] u_t^H \\ &\quad + \frac{1}{1-c_y}\left[-c_y(1-n) + (1-n)\frac{kc_y^2}{\mu_c}\right] q_F \nu^F \, u_t^F \\ &\quad + constant(c_y, n, q_{t-1}, k\mu_c, \nu^H, \nu^F) \end{aligned} \tag{21}$$

Government spending abroad is given analogously. To summarize, in case of a Nash game we have found a closed analytical expression. Governmental spending and the instrument of the central bank are a linear combination of the country-specific cost-push shocks. The parameters depend highly non-linearly on the parameters of the underlying model equation. Thus, we calibrate the model in order to be able to plot impulse response functions to a one standard deviation of a shock.

5.4 Calibration

In order to derive numerical expressions and to plot impulse responses we assign the following values to the parameters: The discount factor β is set to 0.99. Following the relevant literature on monetary policy we set the parameter k equal to 0.024 (see for example Rotemberg and Woodford). As we want to model a monetary union consisting of a big country and a smaller one, we set the size of the Home country to 0.8. This set-up pictures the situation of the new accession countries. The home country then stand for the now existing EMU whereas the foreign country is to be understood as the new members. Consumption accounts for three quarters of output in both countries, whereas one quarter of output is made out of government consumption, i.e. $c_y = 0.75$. The central bank's primary goal is inflation stabilization with a target of overall inflation of 2%. The monetary policy sets the weight on consumption stabilization to 0.5. In contrast, governments want to stabilize output and put more weight on output stabilization. Whereas the Home country assigns a weight of 1 to the output term the foreign country is more concerned about output as they want to generate growth. The target inflation rate of the home country is set to 3% whereas the foreign country is more concerned about output and is less concerned about inflation than the other policy makers. The foreign country sets its target to be equal to 5%. Shocks are assumed to be highly persistent with a ρ of 0.9.

5.5 Graphical Results

Impulse responses are plotted for the case of asymmetric shocks, i.e. $u_t^H = -u_t^F$ in figure 1

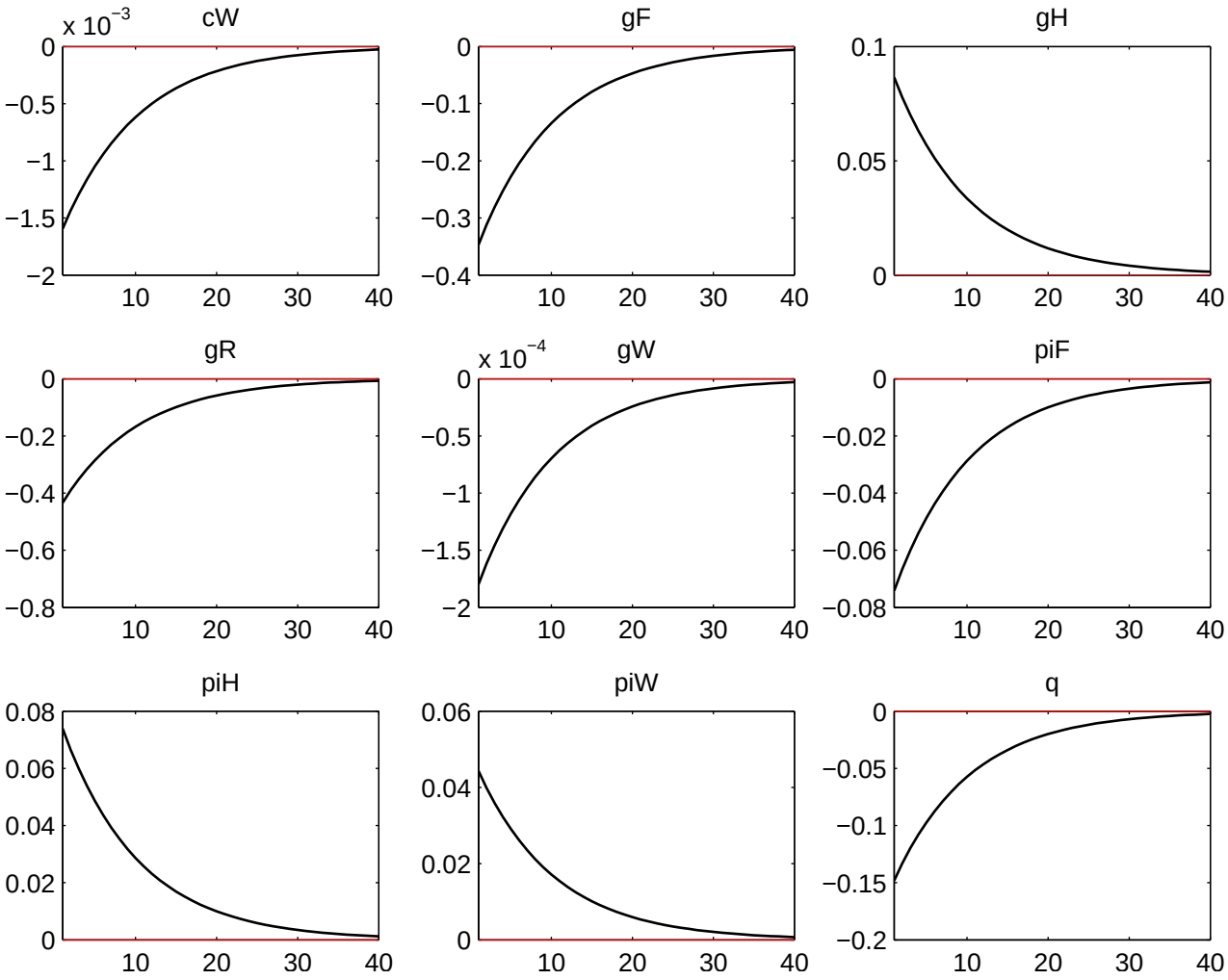

Figure 1: Impulse Responses to asymmetric shocks, Nash

6 Simultaneous decisions of all policy-makers - Coordination of Fiscal Policy

In this section we analyze the case when all policy makers set their instruments simultaneously, and both governments coordinate their policy. The timing of the events is as in the previous case. We first consider the problem of the government. Then we will derive the central bank's optimal reaction function.

6.1 Government

Both governments coordinate by minimizing the weighted average of the loss-functions (10).

$$\min_{g_t^H, g_t^F} \quad nL_t^{G,H} + (1-n)L_t^{G,F} \quad \text{given} \quad c_t^W \quad \text{and s.t.} \quad (1),(3),(2) \quad \text{and} \quad (4) \tag{22}$$

The optimality conditions are given by

$$0 = (1+nkc_y)\left[\nu_y^H\left(y_t^H - \overline{y}_{FP}^H\right) + k\left(\pi_t^H - \overline{\pi}_{FP}^H\right)\right] + (1-n)kc_y\left[\nu_y^F\left(y_t^F - \overline{y}_{FP}^F\right) + k\left(\pi_t^F - \overline{\pi}_{FP}^F\right)\right] \tag{23}$$

$$0 = nkc_y\left[\nu_y^H\left(y_t^H - \overline{y}_{FP}^H\right) + k\left(\pi_t^H - \overline{\pi}_{FP}^H\right)\right] + (1+(1-n)kc_y)\left[\nu_y^F\left(y_t^F - \overline{y}_{FP}^F\right) + k\left(\pi_t^F - \overline{\pi}_{FP}^F\right)\right] \tag{24}$$

These optimal conditions lead to the same equations as in the case of fully uncoordinated policy, and thus to the same analytical results. But considering numerical evaluation of the game we use a different calibration than in the Nash game as explained in the next section.

6.2 Calibration

The parameters values of the coordinated case change in the following manner. As both government coordinate, they change their target values. Home government is aware of the fact that fiscal policy abroad has got a "slack" inflation target and thus sets its own target lower than before, namely to a rate of 2.5%. In contrast the foreign country knowing that the home country is more strict about inflation set their target higher than before to be equal to 7%. Moreover the foreign country assigns more weight to output stabilization (on the cost of inflation stabilization).

6.3 Graphical Results

Impulse responses are displayed for the case of asymmetric shocks, i.e. $u_t^H = -u_t^F$ in figure 2.

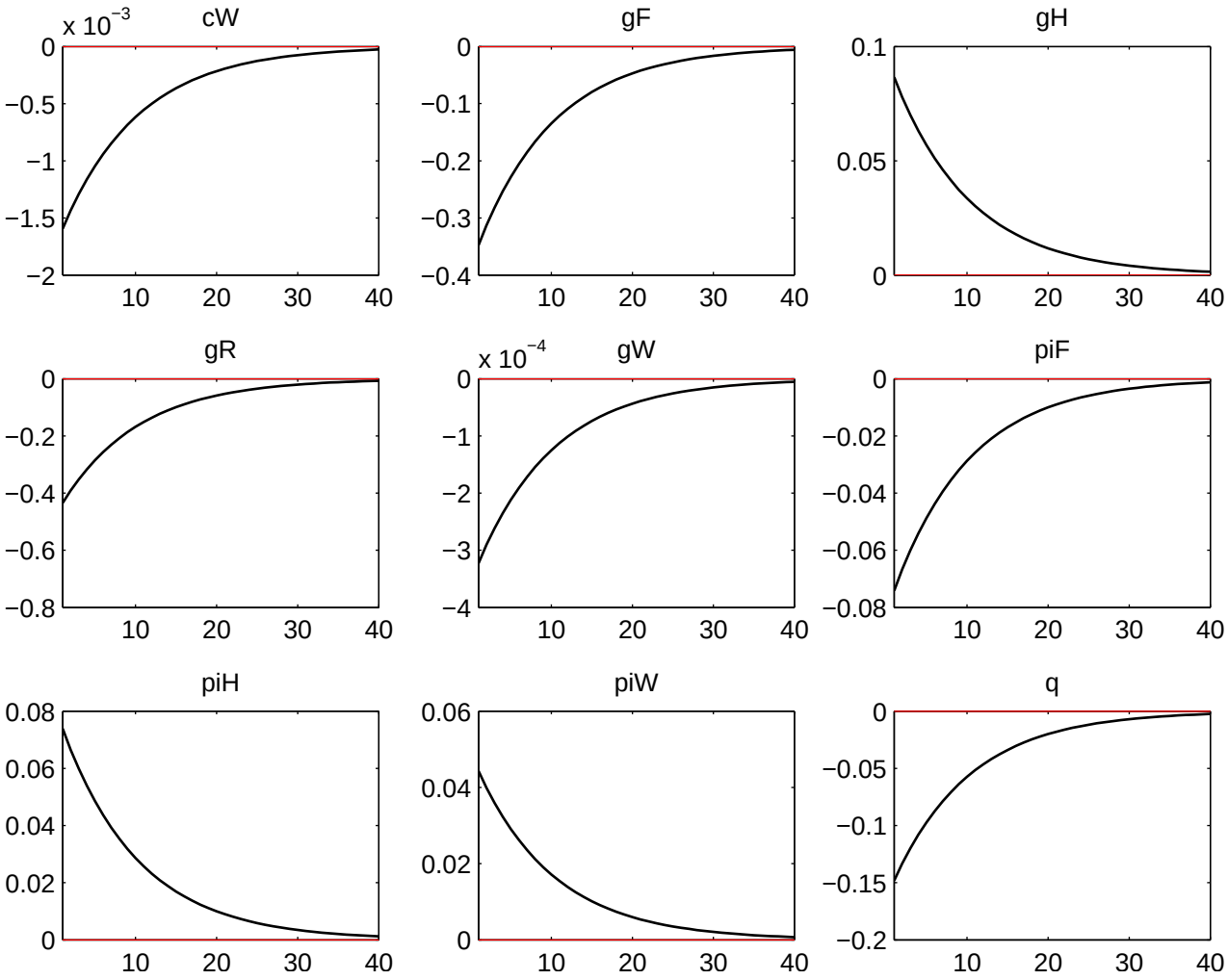

Figure 2: Impulse Responses to asymmetric shocks, Nash, coordinated fiscal policy

7 Conclusion and Further Research Project

We have set up an ad hoc model of a monetary union of two countries where three policy makers, i.e. two governments and one single central banks decides over policy variables to stabilize the economy. Authorities do not coordinate but set their instruments in an uncoordinated manner. We focus on several strategic games and have the ambition to compute closed analytical solutions for the policy instruments.

In this paper we have derived the exact formulae of the policy instruments of government spending g_t^H respectively g_t^F and world consumption c_t^W in case of a benchmark scenario of full coordination, a Nash game of uncoordinated policy and the case of coordination of governments.

We have found closed, analytical solutions as we wanted, but they are not nice to interpret as they depend on various constants of the underlying model in a non-linear way. Thus we have calibrated the model and plotted impulse response functions.

Of course, this paper and project is far from being complete; much work remains to be done. But the calculations done in this paper can be regarded as a good starting point.

Obviously, if we compute the policy outcome of several games we have to compare these outcomes in order to answer the questions if cooperation is desirable or not. In a way we must rank the results using an appropriate welfare measure. Moreover, we have to perform a sensitivity analysis to describe how the results change with the parameters of the model.

Many questions still remain open. We have mentioned that the equations are formulated ad hoc in this paper to keep the model *tractable and simple*, but we still have a micro-foundation in mind. At the end we would like to find a microfoundation for all the equations and hope that they do not differ that much from my postulated equations. But we know that they will become much more complicated. Maybe then, we will not be able to find closed solutions any longer.

Concerning modeling: This set-up abstracts from debt dynamics at the beginning. But at the end we would like to include government debt into the framework as we would like to analyze the problem taking into consideration the Stability and Growth Pact of the European Monetary Union. Which form of governmental budget constraint is to chose if the model must be tractable and simple. Ferrero (2005) and Benigno and Woodford (2003), among others, provide an answer how to include debt dynamics in this kind of model but the budget constraint is far from being tractable or simple.
Secondly, we are thinking about including time lags, specially in fiscal policy.
Thirdly, maybe it is easier not to solve optimization problems as described above for all authorities but to include either some kind of Taylor rule for the central bank or a debt or deficit rule for the governments and find optimal rules. But as far as we know this has already been done in literature.

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