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Monetary and Fiscal Policy Interaction in the Euro Area with different assumptions on the Phillips curve

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October 2004 (Revised)

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Monetary and Fiscal Policy Interaction in the Euro Area with different assumptions on the Phillips curve♣

by

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October 2004 (Revised)

Abstract

In this paper we carry over a static version of a New Keynesian Macromodel a la Clarida Gali Gertler (1999) to a monetary union. We will show in particular that a harmonious functioning of a monetary union critically depends on the correlation of shocks that hit the currency area. Additionally a high degree of integration in product markets is advantageous for the ECB as it prevents that national real interest rates can drive a wedge between macroeconomic outcomes across member states. In particular small countries are vulnerable and therefore in need for fiscal policy as an independent stabilization agent with room to breath.

Keywords: Monetary policy, inflation targeting, fiscal policy, policy coordination.

JEL classification: E50 E60 H70

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1 Introduction

In this paper we apply a static version of a New Keynesian macromodel a la (Clarida, Gali, and Gertler 1999) to a monetary union potentially describing EMU. Additionally the paper serves as a contribution to the optimal currency literature. It is a powerful alternative to the IS/LM-based Mundell Fleming (MF) model. The main advantage of the open economy new keynesian macromodel in its reduced form is its ability to discuss the role of country specific inflation rates while the Mundell-Fleming model is based on the assumption of fixed prices.

With the launch of the third stage of the common monetary policy in January 1999 the participating states of the European Monetary Union delegated monetary policy to an independent central bank that sets monetary conditions in line with the average macroeconomic environment in the union. The unique feature of a currency area is given by the fact that the different macroeconomic agents, the ECB, national governments and labour unions focus on different levels of target variables. The common central bank that is assumed to follow a strategy of flexible inflation targeting focuses on union wide aggregates. It sets the nominal interest rate i for the total currency area in accordance with its inflation target while equally having a concern for economic activity (see Svensson 2003). This means in particular that the interest rate policy of the ECB will be indifferent against mean preserving distributions of macroeconomic outcomes across member states. By contrast, labour unions and in particular national governments basically focus on national aggregates. This constellation nests a free rider problematic that is well documented in literature (see for example Dixit and Lambertini, 2002). In particular, we will show that unsustainable policies that are not consistent with the inflation target of the ECB, e.g. unsustainable fiscal expansions, or overly ambitious wage demands lead to a boom in the home country whereas they inflict negative spill over effects on the rest of the union. This calls for stringent rules. The Maastricht treaty led to the Stability and Growth Pact (SGP) which superimposes some broad guidelines on fiscal policy such as the 3% deficit criterion (see Bofinger, 2003b, for a critical review of the SGP). Our analysis will focus on the sustainability of fiscal policy and provide a rationale for the 3% deficit criterion as well as for its suspension. Among the rich universe of aspects we ask whether fiscal policy should be actively used for stabilizing economic shocks or whether the fiscal stance should be neutral irrespective of the current state of the economy.

Throughout this section we will focus in particular on two aspects. First, we will show that life in a monetary union is easier if the law of one price holds. If product markets are highly integrated the hole currency area shows one common rate of inflation π, and hence, one common real interest rate $(i-\pi)$ which prevents that a further wedge can be driven between macroeconomic outcomes in the vague of demand shocks. Second, we will analyze a scenario in which all countries only produce non-tradables. Such a setting implies the existence of national inflation rates π_i which translate into national real interest rates $(i-\pi_i)$ that amplify shocks. In line with Dornbusch (1997) we show that restrictions on the fiscal instrument might be harmful under such a setting (see also Chari and Kehoe, 1998)[1].

2 Monetary policy with a passive fiscal policy

In this Section we assume that monetary policy is the only macroeconomic player in a monetary union, i.e. national fiscal policies remain completely passive. This means in particular that only the central bank will respond with its instrument – the nominal interest rate – to shocks in order to stabilize economic activity. We assume that monetary policy is guided by the following loss function:

(1) $$L_{ECB} = (\pi - \pi_0)^2 + \lambda y^2 .$$

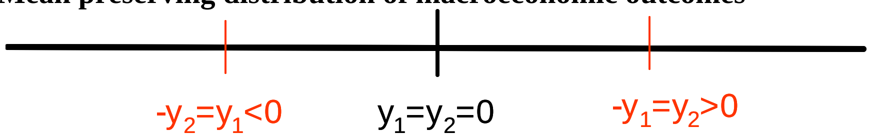
The ECB tries to stabilize squared deviations of the inflation rate and the output gap from their target values respectively. The preference parameter *l* depicts the weight monetary policy attaches to stabilize the output gap versus stabilizing the inflation rate. This loss function is commonly used to map the strategy of flexible inflation forecast targeting (Svensson 1999). Additionally Woodford has shown that it can be derived as a quadratic approximation to a households expected utility problem in the same (dynamic) New Keynesian Macro Model (Woodford 2002).

Hence it is the task of the common central bank to set the interest rate in response to exogenous disturbances and consistent with the structural equations of the model so that the loss function L_{ECB} is minimized. Note that the ECB only targets at euro wide averages, whereas it does not take care on the dispersion of goal variables across countries. In other words the ECB does not consider the spread as a problem as long as it is mean preserving. This means for example that the ECB is indifferent between the following two macroeconomic outcomes as depicted in Figure 1. This convention established in literature

[1] Other related literature that adresses the issues of monetary and fiscal policy interaction in monetary union are: Dixit and Lambertini (2002), Beetsma and Jensen (2002), Benigno and Woodford (2003), Alesina et al. (2001), Mongelli (2002) and Muscatelli et al. (2002).

(linear quadratic loss function in inflation and output) is to our understanding somewhat inconvenient. Nevertheless throughout the exposition we take it as granted that conventional wisdom says that the ECB should only take care of euro wide averages of the inflation rate and the output gap[2].

Figure 1: Mean preserving distribution of macroeconomic outcomes



2.1 The law of one price holds

Let us assume that in the monetary union only tradables are produced and that, in addition to that, the law of one price holds. Technically speaking, this latter assumption means in particular that the currency area is only hit by a common supply shock. Thus, the area-wide Phillips curve has the following structure:

(2) $$\pi = \pi_0 + dy + \varepsilon_2 .$$

Obviously, as monetary conditions which are measured by $r = (i - \pi)$ are identical for all member countries i, we can specify the IS relationship as follows:

(3) $$y_i = a - b(i - \pi) + \varepsilon_{i,1} .$$

Given this description of the economy the ECB solves the following optimization problem[3].

(4) $$\begin{aligned} L_{ECB} &= (\pi - \pi_0)^2 + \lambda y^2 \\ \text{s.t.:}\ y &= a - b(i - \pi) + \varepsilon_1 \\ \pi &= \pi_0 + dy + \varepsilon_2 . \end{aligned}$$

Inserting the Phillips curve into the loss function and solving the optimization problem gives the average output gap:

(5) $$y = -\frac{d}{d^2 + \lambda}\varepsilon_2 .$$

---

[2] Throughout the exposition we abstract from the problematic of a zero lower bound (Coenen Günter 2003).

[3] Note that the aggregate values in general are defined in an union consisting of n countries as: $\sum_{i=1}^{n} x_i = x$.

Inserting (5) into the Phillips curve gives the solution for the area-wide inflation rate which only depends on supply shocks:

(6) $$\pi = \pi_0 + \frac{\lambda}{d^2 + \lambda}\varepsilon_2 .$$

Thus, on average the ECB can protect the union from demand shocks. Nevertheless, we will show that across countries there may be a great dispersion in output, even if the law of one price holds. Inserting the reduced form expressions of the inflation rate and the output gap into the IS relationsshop yields the following reduced form for the interest rate:

(7) $$i = \frac{a}{b} + \pi_0 + \frac{1}{b}\varepsilon_1 + \frac{(d + b\lambda)}{b(d^2 + \lambda)}\varepsilon_2 .$$

Equation (7) nicely depicts that the reaction to demand shocks does not depend on the preferences of the central bank whereas the reaction to supply shocks does. Inserting the inflation rate and the interest rate rule (7) into the national IS curve equation (3) one can easily determine the output gap for country i as follows:

(8) $$y_i = (\varepsilon_{i,1} - \varepsilon_1) - \frac{d}{d^2 + \lambda}\varepsilon_2 .$$

Equation (8) signals the key difference between a closed economy like the US and a monetary union like EMU. Even if the average output gap is equal to zero, this can go hand in hand with a dispersion in national aggregates. Obviously non-synchronized demand shocks, that is $\operatorname{corr}(\varepsilon_{i,1};\varepsilon_1) \neq 1$, can drive a wedge between country specific output gaps. This can in the long run undermine the very existence of the union itself as each country would need notably different monetary conditions which is of course impossible by the very definition of a monetary union itself. To clarify this statement let us make the assumption of uncorrelated shocks, that is $\operatorname{corr}(\varepsilon_{i,1};\varepsilon_1) = 0$, and equally sized countries. What happens if only country i is hit by a shock at time t? To illustrate this case let us assume that the GDP share of country i is

α and $\varepsilon_2 = 0$. Then we can rewrite the aggregate demand shock as the following weighted average[4]:

(9) $$\varepsilon_1 = \alpha\varepsilon_{i,1} + (1-\alpha)\varepsilon_{-i,1},$$

where -i denotes all other countries but country i. Since we assume that country-specific shocks are uncorrelated, that is $\mathrm{corr}(\varepsilon_{i,1}, \varepsilon_{-i,1}) = 0$, the shock "observed" by the ECB is:

(10) $$\varepsilon_1 = \alpha\varepsilon_{i,1}.$$

Inserting equation (10) into (8), we can see that output in country i is given by:

(11) $$y_{i,1} = (1-\alpha)\varepsilon_{i,1},$$

whereas output in the rest of the union is equal to:

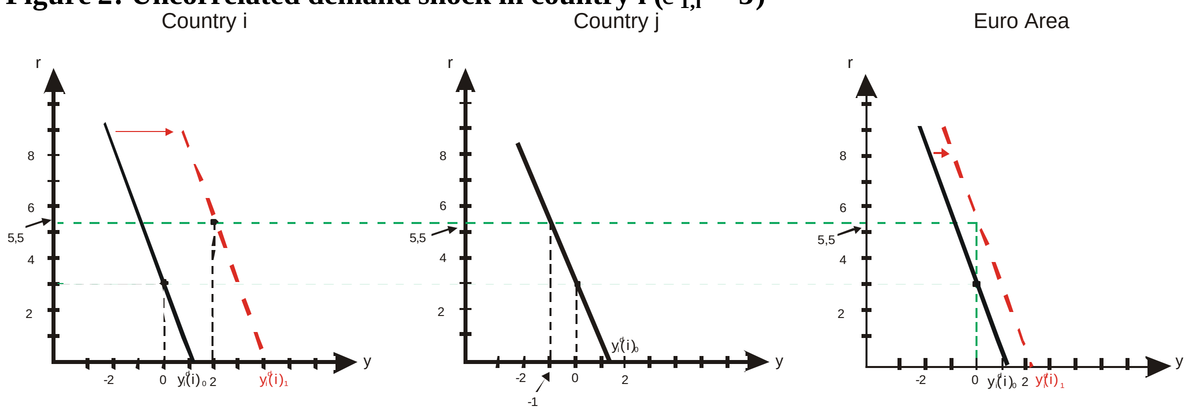
(12) $$y_{-i,1} = -\alpha\varepsilon_{i,1}.$$

Equations (11) and (12) depict the potential conflicts which might prevail in a monetary union. If the law of one price holds, shocks can never be destabilizing, but in the limit, when the GDP share of an individual member country is almost zero, the shock will be fully reflected in the country's output gap. As a consequence of the positive demand shock in country i, output will be above its potential whereas the rest of the union suffers from a somewhat depressed economic activity. Obviously, equation (8) shows that asymmetric shocks are a major problem for small countries participating in a union, as the real interest rate set by the ECB is not coined for a country with a low GDP weight unless $\mathrm{corr}(\varepsilon_i; \varepsilon_{-i}) = 1$. Therefore, as will be shown in Section 3.2, fiscal policy is needed above all in small countries in order to be able to compensate the impact of country specific shocks on the output gap and on the inflation rate.

[4] The assumption that countries are equally sized is not as restrictive as it might seem at first glance. For every arbitrary percentage weight α there exists an (1-α) such that $\frac{1}{n}a + \left(\frac{n-1}{n}\right)a = 1$. Therefore α can take arbitrary values between zero and 1.

We can equally retrieve these results with the help of a graphical analysis (see Figure 2). Country i is hit by a demand shock which shifts the IS curve from IS_0 to IS_1. As we assume that fiscal policy remains completely passive over the cycle, only the ECB reacts to demand shocks to the extend that they influence the average output gap of the euro area. The demand shock in country i translates into a shift of the euro area IS curve from IS_0 to IS_1 by $(1/n)\varepsilon_{1,i}$. As a reaction to this shift, the ECB will tighten monetary conditions from r_0 to r_1 in order to stabilize the demand shock on average. Nevertheless, as Figure 2 shows, this "average" stabilization goes hand in hand with a dispersion of output across member states. Monetary conditions for country i will be too loose, giving a boost to economic activity so that output will be above its potential ($y_i > 0$). By contrast, monetary conditions for the rest of the euro area will be to high resulting in a somewhat depressed economic environment $(y_{-i} < 0)$.

Figure 2: Uncorrelated demand shock in country i ($e_{1,i}$ = 3)



Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration we have used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

2.2 Idiosyncratic Phillips curves

Let us now assume that the country specific output is not tradable. Accordingly, the law of one price can be violated and each member state will be characterized by an idiosyncratic Phillips curve. Nevertheless, as we take idiosyncratic supply shocks to be i.i.d. distributed with mean zero and a constant variance, the conditional as well as the unconditional expectations of the inflation rate of the individual member states are identical. Given this assumption our set of equations can be stated as follows:

(13) $$\pi_i = \pi_0 + dy_i + \varepsilon_{i,2}$$

(14) $$y_i = a - b(i - \pi_i) + \varepsilon_{i,1}.$$

Assuming that the ECB only targets averages, its optimization problem remains unchanged. In other words the aggregate values for the output gap and the inflation gap are identical to the previous scenario on average. Following this line of argumentation we can state in particular that the nominal euro wide interest rate is still given by:

(15) $$i = \frac{a}{b} + \pi_0 + \frac{1}{b}\varepsilon_1 + \frac{\left(d + b\lambda\right)}{b\left(d^2 + \lambda\right)}\varepsilon_2,$$

where ε_1 and ε_2 are weighted averages of the country specific shocks (see equation (9)). The output gap of country i is now given by:

(16) $$y_i = \frac{1}{1-db}\left(\varepsilon_{i,1} - \varepsilon_1\right) + \frac{1}{\left(1-bd\right)}\left[b\varepsilon_{2,i} - \frac{d+b\lambda}{\left(d^2+\lambda\right)}\varepsilon_2\right].$$

Equation (16) shows that an uncorrelated demand shock $\text{corr}\left(\varepsilon_{i,1};\varepsilon_1\right) \neq 1$ can drive a wedge between national cycles. Additionally, the dispersion across national outputs is amplified by a factor of $\left(1/\left(1-bd\right)\right)$ compared to (8), the scenario where the law of one price holds. As we will see below this can be explained by diverging monetary conditions $\left(i - \pi_i\right)$ across member states. Perhaps somewhat surprisingly equation (16) shows that supply shocks originating in country i give a boost to domestic economic activity whereas it is depressed by union wide supply shocks. The argument goes as follows. A supply shock in country i gives a push to its inflation rate π_i that lowers its real interest rate $\left(i - \pi_i\right)$. For instance, excessive wage demands that are transformed via mark up pricing in higher inflation rates in country i. This calls the ECB upon to act only insofar as the European inflation rate raises. Therefore, the expansionary impact of declining real interest rates in country i is not totally undone by subsequent raising nominal interest rates so that as net effect output will increase. Thus, the ECB can not punish individual member states by rising average real rates which clearly shows that stringent rules for labour unions as well as for national governments are a prerequisite for a well functioning monetary union, to prevent free rider behaviour and negative spill over effects for other member states. The inflation rate of country i is given by equation 17:

(17) $$\pi_i = \pi_0 + \frac{d}{1-bd}\left(\varepsilon_{1,i} - \varepsilon_1\right) + \frac{1}{1-db}\left[\varepsilon_{2,i} - \frac{d\left(d+b\lambda\right)}{d^2+\lambda}\varepsilon_2\right].$$

The individual inflation rates in a monetary union can – in sharp contrast to a closed economy – depend on demand shocks. Although the ECB will meet its inflation target on average this can go hand in hand with a significant dispersion in inflation rates across countries in the case of a demand shock. If we are dealing with a symmetric supply shock $\varepsilon_{2,i} = \varepsilon_2$ the inflation rate will again be depicted by the equations (5) and (6).

To further illustrate the results we calculate the monetary conditions in real terms for uncorrelated demand shocks. The real interest rate is given by $r = i - \pi_i$. Making use of the reduced form of the inflation rate and the nominal interest rate in country i we can compute real monetary conditions for country i as follows:

(18) $$r_i = \left(i - \pi_i\right) = \frac{a}{b} + \frac{\alpha - bd}{b\left(1-db\right)}\varepsilon_{i,1}.$$

Monetary conditions for the rest of the union are given by

(19) $$r_{-i} = \frac{a}{b} + \frac{1}{b\left(1-bd\right)}\varepsilon_{i,1},$$

which translates into the following inflation rates:

(20) $$\pi_i = \pi_0 + \frac{d}{1-db}\left(1-\alpha\right)\varepsilon_{1,i},$$

(21) $$\pi_{-i} = \pi_0 + \frac{d}{1-db}\left(-\alpha\varepsilon_{1,i}\right).$$

With equations (20) and (21) at hand we can easily compute the corresponding output gaps:

(22) $$y_i = \frac{1}{1-bd}\left(1-\alpha\right)\varepsilon_{i,1},$$

(23) $$y_{-i} = \frac{-\alpha}{1-bd}\varepsilon_{i,1}.$$

This set of equations depicts that if country i is hit by an uncorrelated demand shock and the ECB only cares about averages, than national outcomes may greatly diverge. Additionally, compared to a scenario where the law of one price holds the degree of dispersion in output is amplified by a factor of $\left(1/1-bd\right)$ as a consequence of diverging monetary conditions across countries. Hence, the previous two sections underline that from the perspective of monetary policy a higher degree of integration in product markets is favourable as the central bank can influence more directly the real interest rate in each country.

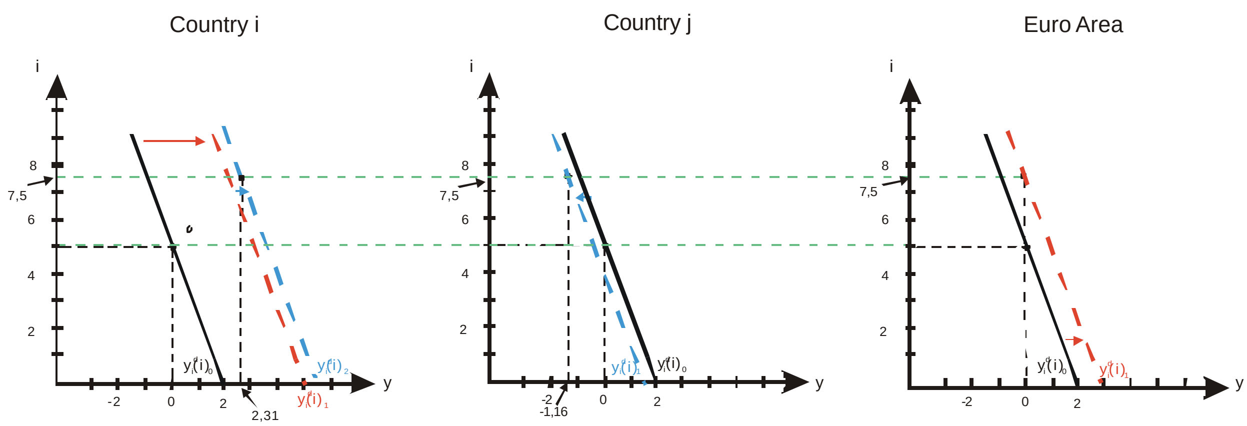
In a scenario without fiscal policy it essentially depends on the size of the individual member state whether idiosyncratic shocks will be stabilizing or destabilizing. According to the Taylor principle, uncorrelated demand shocks will be destabilizing if real interest rates $\left(i-\pi_i\right)$ will not be raised. This will only be the case if (see equation (18))

$$\alpha - bd < 0 \Leftrightarrow \alpha < bd. \tag{24}$$

Given our baseline calibration ($b = 0.4$ and $d = 0.34$), equation (24) indicates that idiosyncratic shocks will be destabilizing if the GDP share of the individual country under consideration is smaller than approximately 14%. An intuition for this result is easy to find. As the ECB is the only macroeconomic agent that stabilizes shocks, it only reacts to euro wide averages. The smaller the individual country in size, the smaller the impact of an idiosyncratic shock on the currency area and hence the smaller the reaction of the ECB to this idiosyncratic shock. This underlines that by far most countries in EMU need fiscal policy as an independent institution in order to deal with asymmetric shocks. Some further intuition to these results can be given by taking a look at Figure 3 and Figure 4.

Figure 3 depicts a scenario where country i is hit by a demand shock of size $\varepsilon_{1,i} = 3$. This translates into a shift of the IS curve from IS_0 to IS_1. In response to the boom in economic activity the ECB raises nominal interest rates from i_0 to i_1 inducing a change in economic activity that exactly compensates the impact of the initial demand shock on the euro wide economic activity. Hence, we arrive at the result that demand shocks can be totally stabilized for the currency are on average. Nevertheless this goes hand in hand with a dispersion on the national level. The increase in nominal rates leads to a decreased economic activity in the rest of the union. As the inflation rate is a shift parameter in the (y;i)- space the IS curve is shifted inwards in the rest of the union. In country i the boom in economic activity leads to an additional outward shift of the IS curve. As we already indicated the size of shifts critically depends on the GDP share of country i.

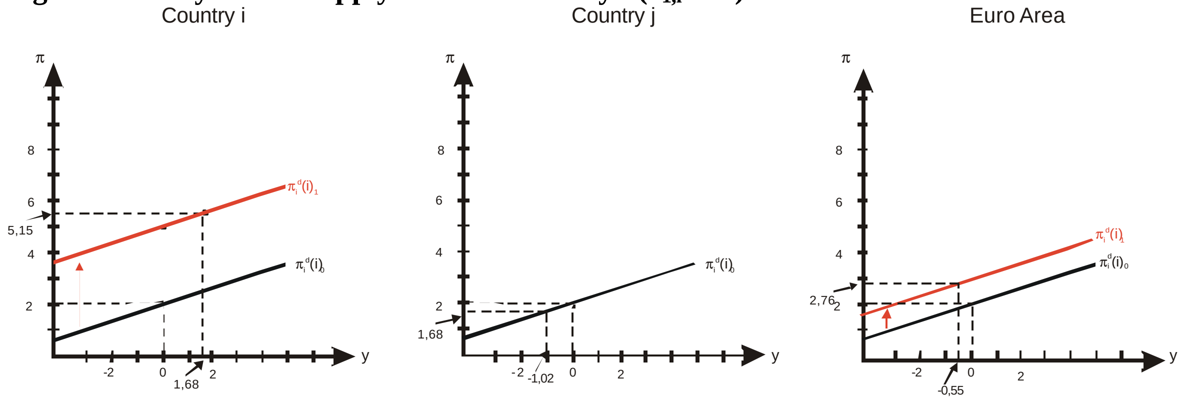
Figure 3: Idiosyncratic demand shock in country i ($e_{1,i} = 3$)



Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration we have used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

Figure 4 depicts a currency area when country i is hit by a supply shock of size $\varepsilon_{2,i} = 3$. This translates into a shift of the aggregate inflation rate by a factor of $\varepsilon_2 = (1/n)\varepsilon_{2,i}$. Depending on preferences the ECB chooses its preferred stabilization mix on the aggregate level by setting nominal rates according to its preferences. This increase in euro wide nominal rates partially stabilizes the inflation rate in country i. The rest of the union suffers from a deflationary environment. Figure 4 impressively underlines that national real interest rates – if existent – can drive a massive wedge between national outcomes and call for stringent rules that prevent unsustainable policies in individual member states which inflict negative spill over effects for the rest of the union. Additionally, the Figures display that we need fiscal policy as an additional macroeconomic agent in order to stabilize idiosyncratic shocks. The impact of the negative spill-over effect depends again on the GDP share of country i.

Figure 4: Idiosyncratic supply shock in country i ($\varepsilon_{1,i}$ = 3)



Note Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration we have used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

3 Monetary and fiscal policy interaction

In the previous Section we modelled a monetary union when monetary policy is the only macroeconomic agent that actively stabilizes shocks. We basically saw for the two possible specifications of a Phillips curve that life in a monetary union is easier if shocks are correlated and product markets are integrated. In this Section we introduce a fiscal authority in each member state that is guided by a loss function and which has g, the fiscal stance parameter, as its only instrument. The stance of fiscal policy is defined as expenditures minus revenues. Hence if $g > 0$, the fiscal stance is expansionary, and if $g < 0$, the fiscal stance is contractionary.

3.1 The loss function of fiscal authorities

We assume that national fiscal authorities are guided by the following loss function:[5]

(25) $$L_{G,i} = y_i^2 + \varphi g_i^2 .$$

Each government is interested in stabilizing output around its potential. The second term in the loss function captures the notion that governments behavior might be motivated for instance by the treaty of Maastricht that penalizes excessive (downward) movements in the fiscal stance parameter g. Additionally, if g would be permanently larger than zero the

[5] Note that we implicitely assume that both macroeconomic agents have an identical output target. For diverging targets see Dixit and Lambertini (2001).

solution would exhibit some unpleasant debt arithmetic's as the fiscal balance exhibits a structural deficit.[6] φ scales the costs of using the fiscal policy instrument.

As a specific characteristic of a monetary union, the common central bank targets at union wide aggregates whereas the individual governments focus on national aggregates. This set-up nests possible conflicts as the ECB can only on average meet its targets which is likely to go hand in hand, depending on the correlation of country specific shocks, with a greatest dispersion in the individual target variables under consideration in each member state. The question we will answer now is to what extend fiscal policy can prevent national outcomes from diverging across the currency area.[7] Hence, we will look to what extend national fiscal policies can mitigate asymmetric shocks.

3.2 The law of one price holds

Let us assume that the law of one price holds. Then the Phillips curve for all countries is given by:

$$\pi = \pi_0 + dy + \varepsilon_2 . \tag{26}$$

Hence the commodity bundles produced in each country are perfect substitutes with a common inflation rate π. The currency union has only one common real interest rate $r = i - \pi$. Additionally, the union is hit only by a common supply shock. The second building bloc of the model is the IS-equation:

$$y_i = a - b(i - \pi) + \kappa g_i + \varepsilon_{i,1} . \tag{27}$$

Aggregate demand now also depends on the fiscal stance parameter. We assume that $g = g^{opt}$. Hence g is set in order to minimize the loss function of fiscal policy. Given the structure of the economy the ECB solves the following optimization problem:

$$\begin{aligned} & L_{CB} = (\pi - \pi_0)^2 + \lambda y^2 \\ \text{s.t.:}\quad & y = a - b(i - \pi) + \kappa g + \varepsilon_1 \\ & \pi = \pi_0 + dy + \varepsilon_2 \end{aligned} \tag{28}$$

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[6] For a paper that focuses more strongly on the political interaction between the national governments and a common central bank see Hallett et al. (1999).

[7] For a focus on automatic stabilizers see Gali and Perotti (2003).

where $g = \sum_{i=1}^{n} g_i$. As the optimization problem is unaltered, the ECB determines the overall inflation rate and the output gap as follows:

(29) $$\pi = \pi_0 + \frac{\lambda}{d^2 + \lambda}\varepsilon_2 ,$$

(30) $$y = -\frac{d}{d^2 + \lambda}\varepsilon_2 .$$

Equations (29) and (30) underline that the ECB is the dominating actor of the game as it can push its preferred bliss point through. In other words, it can always completely offset the effects of fiscal policy on average. The reaction function of the central bank is given by:

(31) $$i = \frac{a}{b} + \pi_0 + \frac{1}{b}\varepsilon_1 + \frac{b\lambda + d}{b\left(d^2 + \lambda\right)}\varepsilon_2 + \frac{\kappa}{b}g .$$

This reaction function specifies the optimal nominal interest rate if governments of the individual member states play $\left(\sum_{i=1}^{n} g_i = g\right)$ on average. It depicts the optimal response of the central bank to the average current stance of fiscal policy across the currency area. Equation (31) is characterized by the following features: In the absence of macroeconomic shocks $\varepsilon_1 = \varepsilon_2 = 0$ the ECB will set interest rates equal to their long run equilibrium value $i = (a/b) + \pi_0$ which corresponds to a union wide output gap of zero and an inflation rate that is equal to the inflation target. The global response to demand shocks in a union compared to a scenario of a closed economy is on average unaltered and given by $\Delta i = (1/b)\varepsilon_1$. Again, the response to supply shocks depends on preferences.

Fiscal authorities in each member state solve the following optimization problem:[8,]

(32) $$\begin{aligned} &L_{G,i} = y_i^2 + \varphi g_i^2 \\ &\text{s.t.:} \quad y_i = a - b\left(i - \pi\right) + \kappa g_i + \varepsilon_{i,1} . \end{aligned}$$

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[8] Note that we do not intend to model alliances between individual member st ates (see van Aarle et al., 2002). For an analysis that includes the real exchange rate in the strategic analysis between the central bank and the government see Leitemo (2003).

Solving this optimization problem we arrive at the following relationship depicting the way according to which fiscal policy is conducted:

$$g_i = \frac{-a\kappa}{\kappa^2+\varphi} + \frac{b\kappa}{\kappa^2+\varphi}(i-\pi) - \frac{\kappa}{\kappa^2+\varphi}\varepsilon_{i,1}. \tag{33}$$

It shows that the goverment reacts to the current stance of monetary policy and to country specific demand shocks. Concerning the reaction to the current stance of monetary policy equation (33) exhibits the following features: The partial derivative of g with respect to $r(=i-\pi)$ is $(\partial g/\partial r) = (\kappa b/(\kappa^2+\varphi)) > 0$. Hence, if monetary policy gets more restrictive the government will switch to a more expansionary stance. The higher the weight on stabilizing its instrument (φ), the lower will be the strategic interaction between the two macroeconomic agents. Concerning the reaction to demand shocks equation (33) shows that following e.g. a negative demand shock ε_1, fiscal policy will become more expansionary. Note that in contrast to monetary policy the government does not face a lower bound. Hence, g can become negative. The strategic interaction between fiscal and monetary authorities results from the fact that the ECB responds to union-wide averages:

$$\varepsilon_1 = \alpha\varepsilon_{i,1} + (1-\alpha)\varepsilon_{-i,1}. \tag{34}$$

If only country i is hit by a demand shock, this triggers a feedback mechanism as all member countries have to share the adjustment burden of higher interest rates. The extend of the strategic feedback depends on the GDP share α of country i. Nevertheless, to simplify the exposition, we will assume equal GDP shares in the following.

Given the reaction function of n fiscal authorities and the ECB we can easily compute the reduced form solution as we have $n+1$ unknowns $(g_1;...;g_n;i)$ and $n+1$ reaction functions. Inserting (29) and (33), averaging and plugging the resulting expression into (31) we get the following reduced form equation for the interest rate:

$$i = \pi_0 + \frac{a}{b} + \frac{1}{b}\varepsilon_1 + \frac{b\lambda\varphi + d(\kappa^2+\varphi)}{b(d^2+\lambda)\varphi}\varepsilon_2. \tag{35}$$

In the absence of macroeconomic shocks ($\varepsilon_1 = \varepsilon_2 = 0$) the ECB will set interest rates equal to their long run equilibrium value $i = (a/b) + \pi_0$ which corresponds to a union wide output gap of zero and an inflation rate that is equal to the inflation target. The global response to monetary shocks in a union compared to a scenario of a closed economy is on average unaltered and given by $\Delta i = (1/b)\varepsilon_1$.

The reduced form for the fiscal stance parameter can be computed by inserting the inflation rate and the interest rate into the reaction function of the central bank:

$$g_i = \frac{\kappa}{\kappa^2+\varphi}\left(\varepsilon_1 - \varepsilon_{1,i}\right) + \frac{\kappa d}{\varphi\left(d^2+\lambda\right)}\varepsilon_2 . \tag{36}$$

Equation (36) displays the difference between a closed and open economy set-up. First, we see that fiscal authorities have a stabilization task in response to demand shocks as long as these exhibit a degree a asymmetry. Second, as individual shocks are assumed to be i.i.d., there is some positive probability $\left(\frac{\kappa^2+\varphi}{\kappa}\int_{-\infty}^{-0,03} f\left(\varepsilon_i\right)d\varepsilon_i\right)$ that the 3% deficit criterion cannot be met. In other words, if the size of the shocks is large, (36) clearly demonstrates that even under an optimal and sustainable fiscal stance (defined as $g = 0$ in the absence of shocks) the Maastricht deficit criterion is likely to be violated with some positive probability. Nevertheless, as long as the violation stems from the size of exogenous shocks and not from a fiscal policy that is conducted in an unsustainable fashion ($g > 0$) the violation of the Maastricht criterion is a necessary precondition to restore the overall optimal outcome. Exactly for that reason the 3% deficit criterion can be suspended if a country is hit by large shocks, so that $\left|g_i\left(e_1;e_2\right)\right| \geq 3$.

Inserting (35) and (36) into the IS-curve equation we arrive at the following expression for the country specific output gap:

$$y_i = -\frac{d}{d^2+\lambda}\varepsilon_2 + \frac{\varphi}{\kappa^2+\varphi}\left(\varepsilon_{i,1} - \varepsilon_1\right). \tag{37}$$

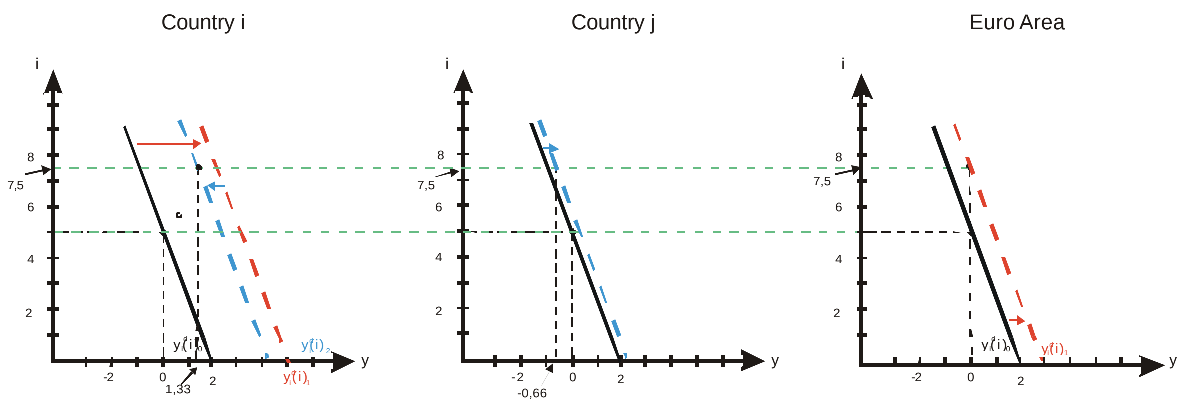
Note that given a standard parameterization $(\kappa = \varphi = 0.5)$, uncorrelated demand shocks are likely to have a smaller impact on the overall economic activity compared to a scenario were fiscal policy remains passive. So indeed we can state that a Keynesian stabilization policy is able to dampen economic cycles compared to a policy that sets $g = 0$.[9] Nevertheless the stabilization of shocks will not be perfect. The argument goes as follows. Assume that only one country is hit by a negative demand shock. Obviously, given the Nash equilibrium, monetary conditions measured in real terms $(i - \pi)$ will be to restrictive for that country to restore an output in line with potential $(y_i < 0)$. By contrast, monetary conditions for the rest of the union will be too loose giving a boost to economic activity ($y_{-i} > 0$). At first glance this result might seem at odds with intuition. One might ask why fiscal authorities do not use their instrument more rigorously in response to demand shocks in the equilibrium. The key to this answer lies in the strategic interaction between the agents. A more expansionary fiscal policy triggers higher interest rates for the currency area so that the marginal costs of an expansionary fiscal policy outweigh the marginal benefits.

The degree of conflicting potential can be summarized by the correlation between the idiosyncratic demand shocks versus the eurowide average $corr(\varepsilon_i; \varepsilon_{-i})$. Equation (37) depicts that in a union where demand shocks are perfectly correlated $corr(\varepsilon_i; \varepsilon_{-i}) = 1$ the output gaps of individual member states y_i are identical at each point in time. Obviously a maximum dispersion in output will be given if $corr(\varepsilon_i; \varepsilon_{-i}) = -1$. Then, the individual output gaps y_i would exhibit a maximum dispersion which could potentially undermine the existence of the union in the long run as at each point in time country i finds it beneficial – evaluated in terms of $L_{G,i}$ – to leave the union as it requires significantly different monetary conditions. Therefore, our simple static analysis clearly makes the prediction that if the law of one price holds, life within a monetary union is easier if demand shocks are highly correlated and if fiscal policy is actively engaged in the stabilization of shocks. Additionally, the exposition provided a rationale for the suspension of the 3% deficit criterion in the vague of large shocks as a necessary condition for fiscal policy to be conducted optimally.

It is important to note that if we set $\varphi = 0$ shocks can be completely stabilized. In other words, if fiscal policy does not put any weight on smoothing its instrument it is possible to completely offset uncorrelated demand shocks. Nevertheless the smoothing objective is a common theme in literature.

[9] For a critical view that stresses that fiscal shocks itself might be a source of dispersion in output see for instance Canova and Pappa (2003).

Figure 5: Idiosyncratic demand shock in country i ($e_{1,i} = 3$)



Note Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration we have used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

We can present the same results with the help of a graphical analysis. Let us assume that country i is hit by an uncorrelated demand shock. The shock shifts the IS curve from IS_0 to IS_1. As a result, the aggregate European IS shifts from IS_0 to IS_1. As the ECB can stabilize shocks on average, it will raise nominal interest rates from i_0 to i_1 which brings output back to its potential and the inflation rate to the inflation target. The new nominal rate depresses economic activity in the rest of the union so that fiscal policy becomes expansionary which leads to an outward shift of the IS curve. In country i the increase in nominal rates is to small so that fiscal policy will become contractionary leading to an inward shift of the IS_0 curve.

3.3 Idiosyncratic Phillips curves

In this Section we analyze the strategic interaction between fiscal and monetary authorities in a monetary union if the law of one price does not hold. We will again focus on uncorrelated idiosyncratic demand and supply shocks. As already shown in Section 2.2 the existence of country specific real interest rates drives a further wedge between macroeconomic outcomes compared to a scenario where the law of one price holds. Nevertheless, we will show that fiscal policy has stabilizing effects on the performance of member countries. Like in Section 2.2the Phillips curve can be specified as:

(38) $$\pi_i = \pi_0 + dy_i + \varepsilon_{i,2}.$$

This means in particular that each country only produces non-tradable commodities. Note that this assumption does not mean that the country specific inflation rates can diverge arbitrarily over time, as we take non-autocorrelated shocks to be the workhorse through out our exposition. The inflation rate in country i is driven by the country specific output gap (y_i) and the idiosyncratic supply shock $\varepsilon_{i,2}$, e.g. non-sustainable wage policies. With equation (38) we effectively reintroduce country specific real interest rates. The government in the individual member state i has to solve the following optimization problem:

$$L_{G,i} = y_i^2 + \varphi g_i^2 \tag{39}$$
$$\text{s.t.:} \quad y_i = a - b(i - \pi_i) + \kappa g_i + \varepsilon_{i,1}.$$

The reaction function of fiscal policy can than be stated as follows:

$$g_1 = -\frac{\kappa a}{\kappa^2 + \varphi} + \frac{\kappa b}{\kappa^2 + \varphi}(i - \pi_i) - \frac{\kappa}{\kappa^2 + \varphi}\varepsilon_1 . \tag{40}$$

In order to solve the game we impose symmetry, we assume that not only the coefficients in the country specific Phillips curves and the IS curves are identical, but also that the countries are of equal size. Consequently, averaging over the fiscal stance parameter results in:

$$\overline{g} = \frac{1}{n}\left[g_1 + g_2 + \ldots + g_n\right] = g = -\frac{\kappa\left(a + b(i - \pi) + \varepsilon_1\right)}{\kappa^2 + \varphi}. \tag{41}$$

With equation (41) at hand we get the following reduced form expression for the interst rate:

$$i = \frac{a}{b} + \pi_0 + \frac{1}{b}\varepsilon_1 + \frac{b\lambda\varphi + d\left(\kappa^2 + \varphi\right)}{b\left(d^2 + \lambda\right)\varphi}\varepsilon_2 . \tag{42}$$

Most notably equation (42) is identical to the reduced form we already saw in Section 3.2. This cannot come as a surprise as the averages of the variables under consideration (output gap, fiscal stance parameter) from the perspective of the ECB are identical under both scenarios. Hence, from the viewpoint of monetary policy it does not matter whether the supply side of the economy is characterized by only one or many Phillips curves as long as the ECB only cares about shocks and is indifferent between mean preserving spreads. The fiscal stance parameter is given by:

$$g_i = q_1\left(\varepsilon_1 - \varepsilon_{1,i}\right) + q_2\varepsilon_{i,2} + q_3\varepsilon_2 , \tag{43}$$

where

$$q_1 = \frac{\kappa}{\kappa^2 + (1-bd)\varphi} < 0,$$

$$q_2 = -\frac{\kappa b}{\kappa^2 + (1-bd)\varphi} < 0,$$

$$q_3 = \frac{\kappa\left(b\lambda\varphi + d\left(\kappa^2 + \varphi\right)\right)}{\left(d^2 + \lambda\right)\varphi\left(\kappa^2 + (1-db)\varphi\right)} > 0 .$$

Fiscal policy exhibits a higher level of activity compared to a scenario where the law of one price holds as q_1 is larger than the corresponding coefficient in equation (36). This shows that fiscal policy needs to become more counter cyclical as country specific real rates $(i - \pi_i)$ amplify shocks that hit the individual economies. A negative demand shock originating in the own country leads to a fiscal expansion, whereas a negative output shock in the other member states leads to a contraction in the own fiscal stance parameter. This nicely depicts that the ECB will relax monetary conditions which would give a boost to output in country j if fiscal policy would not contract. This result clearly shows the macroeconomic assignment which is nested in the Nash equilibrium. Demand shocks are mainly stabilized by the ECB and not – as one might expect – by the individual member states. As expected a foreign inflation shock leads to a more expansionary fiscal stance since the government is only concerned about output and not about inflation. Therefore, as a response to tighter monetary conditions for the whole area, the fiscal stance becomes more expansionary. These results are qualitatively identical to those we already saw in Section 3.2.

The output gap equation is given by:[10]

(44) $$y_i = q_5\left(\varepsilon_{i,1} - \varepsilon_1\right) + q_6\varepsilon_2 + q_7\varepsilon_{i,2}$$

where

$$q_5 = \frac{\varphi}{\left(\kappa^2 + (1-bd)\varphi\right)} > 0,$$

[10] Note if we set $\varepsilon_{i,1} = \varepsilon_1$ and $\varepsilon_{i,2} = \varepsilon_2$, hence if the currency area is hit by symmetric shocks then equation (44) simplifies to (30).

$$q_6 = -\frac{b\lambda\varphi + d\left(\kappa^2 + \varphi\right)}{\left(d^2 + \lambda\right)\left(\kappa^2 + \left(1 - bd\right)\varphi\right)} < 0 \, ,$$

$$q_7 = \frac{b\varphi}{\left(\kappa^2 + \left(1 - bd\right)\varphi\right)} > 0 \, .$$

Note, in particular, that given our standard calibration $\left(\kappa = \varphi = 0.5, d = 0.34, b = 0.4\right)$, the stabilization of idiosyncratic demand shocks is only partial compared to a scenario where the law of one price holds. This underlines again that diverging real interest rates $(i - \pi_i)$ amplify shocks. Accordingly, by the very definition of a (stable) Nash equilibrium fiscal policy has no incentive to deviate from the final outcome of the game as otherwise monetary policy would have an incentive to raise real interest rates. Again, we come to the result that a country specific supply shock, e.g. wage demands that are not consistent with the inflation target of the ECB $(\Delta w > \pi_0)$ lead to an increase in domestic inflation and to a drop in national real interest rates. Thus, the ECB cannot punish individual member states which calls for a wage policy that is consistent with the inflation target of the ECB. For a foreign and an aggregate supply shock we come to the same results as in Section 2.2. But again, the analysis shows that fiscal policy as an independent agent is able to stabilize the impact of supply shocks. So indeed, as in the case of demand shocks, equation (41) clearly demonstrates the advantageous of a Keynesian stabilization policy that significantly reduces the impact of supply and demand shocks on the macroeconomic goal variables. To complete the reduced form description of the economy we present the inflation rate which is given by the following expression:[11]

(45) $$\pi_i = \pi_0 + q_8\left(\varepsilon_{i,1} - \varepsilon_1\right) + q_9\varepsilon_2 + q_{10}\varepsilon_{i,2}$$

where

$$q_8 = \frac{d\varphi}{\left(\kappa^2 + \left(1 - bd\right)\varphi\right)} > 0 \, ,$$

[11] Note if we set $\varepsilon_{i,1} = \varepsilon_1$ and $\varepsilon_{i,2} = \varepsilon_2$, hence if the currency area is hit by symmetric shocks then equation (45) simplifies to (29).

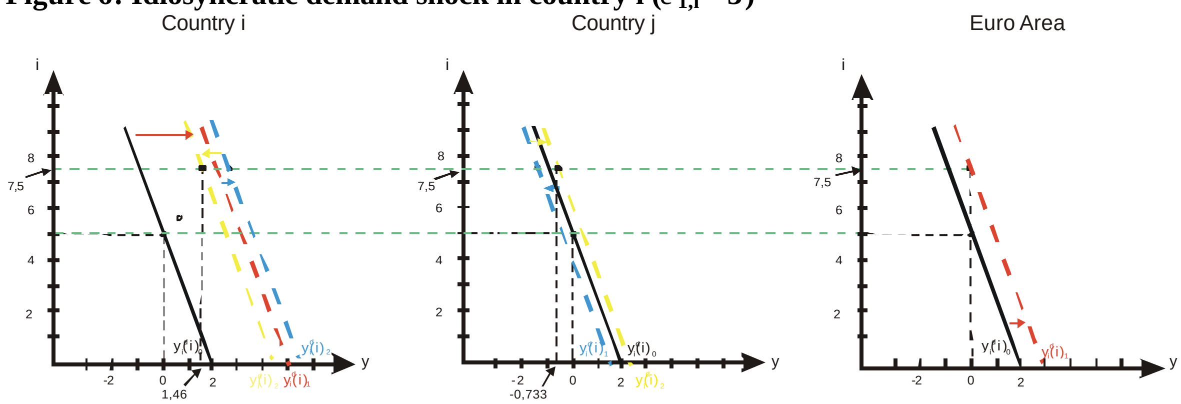
$$q_9 = -\frac{d\left(b\lambda\varphi + d\left(\kappa^2 + \varphi\right)\right)}{\left(d^2 + \lambda\right)\left(\kappa^2 + (1 - bd)\varphi\right)} < 0\,,$$

$$q_{10} = \frac{\left(\kappa^2 + \varphi\right)}{\left(\kappa^2 + (1 - bd)\varphi\right)} > 0\,.$$

The reduced form inflation rate is characterized by the following features. In the absence of macroeconomic shocks that hit the euro area the individual inflation rate will be equal to the inflation target. Demand shocks will only have an impact on the idiosyncratic inflation rate to the extend that they are uncorrelated. Compared to a scenario where only monetary policy takes care of shocks, the introduction of a Keynesian stabilization policy $g = g^{opt}$ reduces the impact of demand shocks on the inflation rate and the output gap. The same dramatic decrease (given our standard calibration) can be recorded following idiosyncratic supply shocks.

Let us illustrate the results of this Section. Country i is hit by a positive demand shock of size $\varepsilon_{i,1} = 3$ which gives a massive boost to economic activity in that country given unchanged monetary conditions (π serves as a shift parameter). The IS curve in country i shifts from IS_0 to IS_1. Nevertheless the idiosyncratic shock in country i translates into an average euro-wide shock of size $\left(1/n\right)\varepsilon_1$. This calls the ECB upon to act. As we already saw in the case of demand shocks, the ECB can always maintain its bliss point. Accordingly, it will tighten monetary conditions and raise real interest rates from i_0 to i_1 which induces a change in economic activity for the whole currency area that exactly compensates the initial demand shock. As output on average will be back to potential for the currency area, the inflation rate will equally return to the inflation target. Nevertheless, the policy stance in country i will be too loose. By contrast, for the rest of the union monetary conditions will be too tight resulting in a somewhat depressed economic activity. Accordingly, the inflation rate in the country that was hit by the initial demand shock will be above the inflation target of the ECB whereas inflation in the rest of the union will be below the ECB's inflation target. But remember for the union as a whole inflation will be back to target. This result nicely depicts that the common central bank is indifferent when it comes to mean preserving macroeconomic outcomes. Given this global picture we still need to look at the behaviour of the individual member states in equilibrium. Obviously the government in country i initiates a fiscal contraction as output is above its potential shifting the IS-curve inward. In the rest of the union the governments relax the fiscal stance in order to stabilize economic activity shifting the IS curve outward. The degree of strategic interaction critically depends on the size of country i. Compared to a scenario where monetary policy is the only stabilizing actor fiscal authorities succeed in partially stabilizing the output as depicted in Figure 6. Given this sequence of shifts we arrive at a final policy outcome in response to the idiosyncratic demand shock that is described by the following features. In country i output will be above potential and the inflation rate will be higher than the inflation target. In the rest of the union the economic environment is characterized by the opposite picture. Output will be below potential and inflation will be below its target level. As in the case of a closed economy, the shock will be stabilized on average.

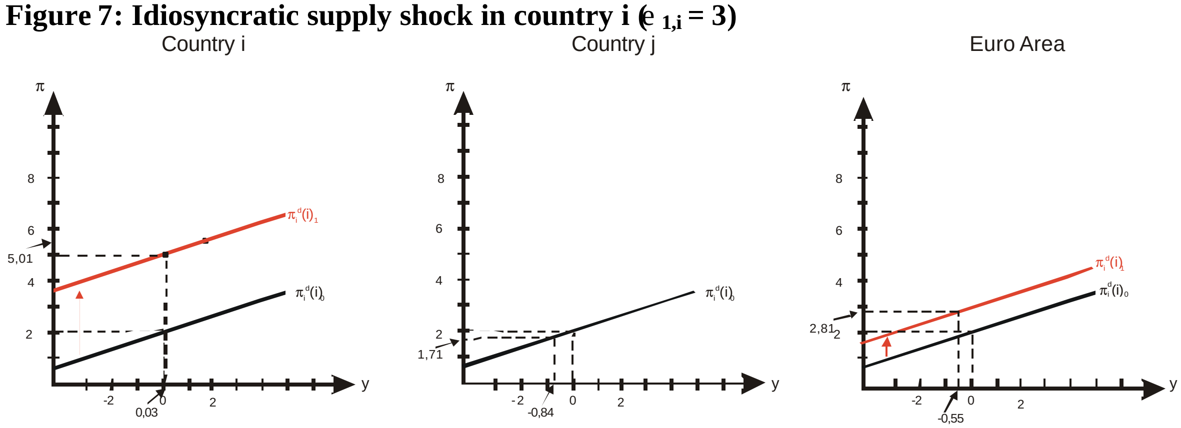
Figure 6: Idiosyncratic demand shock in country i ($e_{1,i} = 3$)



Note Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration we have used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

Figure 7 and Figure 8 depict what happens if country i is hit by an idiosyncratic supply shock. Assume that country i is hit by a supply shock of size $\varepsilon_{i,2} = 3$. As in the case of a closed economy the ECB determines the overall outcome of the game depending on preferences λ by setting the nominal interest rate accordingly. Equations (29) and (30) depict the union wide outcomes that will prevail given an aggregate supply shock of size $(1/n)\varepsilon_{i,2} = \varepsilon_{i,2}$. For λ equal to 0.5 we can see that the inflation rate will increase to 2.81% and the output gap will drop to a level of –0.55%. Now the interesting question is how this global outcome translates into national macroeconomic performances. Obviously the rest of the union will suffer from a recession as it will face higher real interest rates which translate into a negative output gap. Therefore, we will move along the Phillips curve to a point that is characterized by a lower output and a lower inflation rate. In the rest of the union the fiscal stance is expansionary to (partially) unwind the effects of the contractionary monetary stance. For country i itself the massive increase in inflation by 3% leads to almost unchanged real rates so that fiscal policy is somewhat contractionary to prevent real interest rats from decreasing. Figure 7 nicely maps the 'dynamics' captured in a static version of a New Keynesian macro model. Supply shocks are only contractionary on average to the extend that monetary policy reacts to them. As the massive inflationary shock only translates by (1/n) on the aggregate the reaction of the ECB for that individual country will be far too weak to contract economic activity. Within a monetary union, labour unions can potentially hide behind the (1/n)-effect as the ECB cannot 'punish' a particular country for a wage policy that is not in line wit h its inflation target.

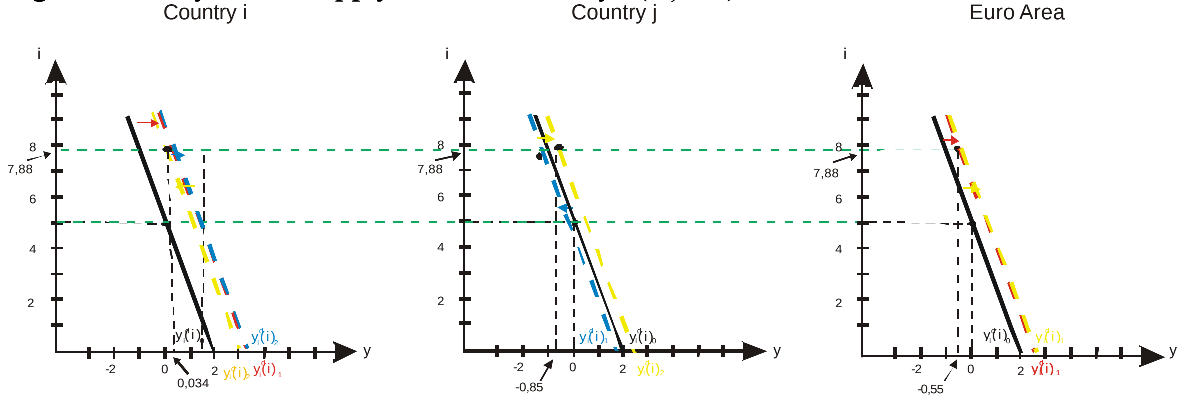
Figure 7: Idiosyncratic supply shock in country i ($e_{1,i}$ = 3)



Note Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration wehave used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

Of course we can equally evaluate supply shocks by mapping the strategic interaction between the agents in the y-i space. Given that the policy of the ECB is conducted optimally we have to take into account that the inflation rate as well as the fiscal stance parameter serves as a shift factor in the y-i space. Given the initial supply shock in country i the IS curve will shift due to the increase in economic activity by $b\Delta\pi$. This shift in economic activity is translated into a shift of the IS curve by a factor of $(1/n)\,b\Delta\pi$. Now the ECB steps in and chooses its preferred stabilization mix taking the reaction of fiscal authorities appropriately into account. Given the ECB's preferences it will raise nominal interest rates and induce a stabilizing recession in order to minimize its loss function. This move by the ECB triggers an expansionary fiscal stance in the rest of the monetary union and a somewhat contractionary stance in country i. The overall policy outcome is depicted in Figure 8.

Figure 8: Idiosyncratic supply shock in country i ($\varepsilon_{1,i} = 3$)



Note: The figure maps the situation in which the monetary union consists of three countries of equal size. For the sake of illustration we have used concrete numerical values. As baseline calibration we have set b=0.4 and d=0.34.

Finally to demonstrate the advantages of a Keynesian stabilization policy we can compute real monetary conditions for individual member states in the event of asymmetric demand shocks. Making use of the reduced form, the real interest rate for country i that was hit by the shock can be written as:

$$(46) \qquad (i - \pi_i) = \frac{a}{b} + \frac{\kappa^2 + (\alpha - bd)\varphi}{b(\kappa^2 + (1 - db)\varphi)} \varepsilon_{i,1} .$$

With the help of equation (46) we can see that shocks will not be destabilizing unless

$$(47) \qquad \alpha \leq \frac{\kappa^2 - \varphi bd}{\varphi} .$$

Given our standard parameterization this will not be the case unless $\alpha < 0.8\%$. (47) shows that only Luxembourg and Ireland are in the neighbourhood of such a threshold value. Accordingly, the analysis clearly demonstrates the advantageous of a Keynesian stabilization policy that dramatically reduces the risk that shocks will be amplified.

4 Conclusion

In this paper we applied a static version of a New Keynesian Macro Model a la (Clarida, Gali, and Gertler 1999) to a currency union. We focussed in particular on the impact of asymmetric shocks and the integration of product markets and its implication for the well functioning of a currency union. Our results are very easy to state: Life within a monetary union is much easier if shocks are highly correlated and product markets are integrated. Under such a scenario shocks that hit the area are unlikely to be amplified across individual member states as the ECB can within an inflation targeting regime easily deal with global shocks. Additionally we find that in particular small countries are in a vulnerable position as the ECB almost neglects their idiosyncratic situations unless shocks are correlated. This is of course a strong argument for a Keynesian stabilization policy that actively fights shocks to stabilize economic activity. We showed that by this very argument one can provide a strong rationale for the suspension of the 3% deficit criterion in the vague of asymmetric demand and supply shocks that hit individual countries as a necessary precondition to restore optimal outcomes. Our analysis showed that in order to avoid negative spill over effects stringent rules are necessary in order to prevent national governments as well as national labour unions to conduct a beggar-my-neighbour policy. Therefore the grandfathers of the Stability and Growth Pact (SGP) were right to implement rules that endorse a sustainable fiscal stance in each member state.

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Appendix I: Phillips curve with tradable and non-tradable sector

Let us now discuss a third scenario which nests the two previously derived solutions as corner cases. We assume that each country has a tradable and a non-tradable sector. Therefore the consumer price inflation is given by a weighted average of the two product bundles:

(48) $$\pi_i^{CPI} = \alpha \pi^T + (1-\alpha)\pi_i^{NT} .$$

In each sector – tradables and nontradables – the inflation rate is determined by the difference between increases in nominal wages minus productivity:

(49) $$\pi_i = w_i - prod_i + \varepsilon_i .$$

It is generally assumed that the productivity growth q_i in those sectors that face international competition is larger than in those sectors that only produce for domestic markets, hence $q_i > v_i$. To simplify the exposition we assume that in each sector wages are negotiated separately. Very much in line with a static version of Fuhrer and Moore (1995) we assume that the nominal wage is determined as:

(50) $$w_i^T - q_i = \pi_0 + dy$$

(51) $$w_i^{NT} - v_i = \pi_0 + dy_i .$$

Hence the union in each sector negotiates wages above productivity that are consistent with the inflation target of the ECB. Additionally, workers' wages depend on the state of the cycle. It seems plausible to assume that wage changes depend on overall activity as the sector specific characteristics are already taken into account by q_i and v_i. Wage changes that face international competition are assumed to depend on the overall cycle in the union, whereas wage demands for non-tradables are orientated on domestic markets.

(52) $$\pi^T = \pi_0 + dy + \varepsilon_2^T ,$$

(53) $$\pi_i^{NT} = \pi_0 + dy_i + \varepsilon_{i,2}^{NT} .$$

Inserting leads to the following expression for consumer price inflation (CPI):

(54)
$$\pi_i^{CPI} = \pi_0 + \alpha dy + (1-\alpha)\, dy_i + \varepsilon_{i,2}$$
$$\text{where } \varepsilon_{i,2} = \alpha \varepsilon_2^T + (1-\alpha)\,\varepsilon_{i,2}^{NT}.$$

Note that this specification nests the two corner solutions discussed in Sections 2 and 3. If the law of one price holds ($\alpha = 1$), the Phillips curve is given by:

(55)
$$\pi_i^{CPI} = \pi_0 + dy + \varepsilon_2^T.$$

If each country only produces a non-tradable commodity bundle ($\alpha = 0$), the Phillips curve can be written as:

(56)
$$\pi_i^{CPI} = \pi_0 + dy_i + \varepsilon_{i,2}^{NT}.$$

We now turn to the specification of the demand side. The static version of the usual IS equation can be specified as in the previous sections:

(57)
$$y_i = a - b\left(i - \pi_i^{CPI}\right) + \kappa g_i + \varepsilon_1.$$

In each member state the political party in power faces the following optimization problem:

(58)
$$L_{G,i} = y_i^2 + \varphi g_i^2$$
$$\text{s.t.: } y_i = a - b\left(i - \pi_i^{CPI}\right) + \kappa g_i + \varepsilon_{i,1}.$$

Solving gives the following reaction function:

(59)
$$g_i = -\frac{\kappa}{\kappa^2 + \varphi}\left(-a + b(i - \pi_i^{CPI}) - \varepsilon_{1,i}\right).$$

The union wide output gap is given by:

(60)
$$y = -\frac{d\left(\alpha\varepsilon^T - (\alpha - 1)\varepsilon^{NT}\right)}{d^2 + \lambda},$$

and the union wide inflation rate can be calculated as:

(61)
$$\pi = \pi_0 - \frac{d^2\alpha\varepsilon^T + (\alpha - 1)\lambda\varepsilon^{NT}}{d^2 + \lambda} + \alpha\varepsilon^T.$$

The reaction function of the interest rate is given by:

(62) $$i=\pi_0+\frac{a}{b}+\frac{\kappa}{b}g+\frac{\left(d-bd^2\right)\alpha+b\alpha\left(d^2+\lambda\right)}{b\left(d^2+\lambda\right)}\varepsilon_T+\frac{(1-\alpha)(d+b\lambda)}{b\left(d^2+\lambda\right)}\varepsilon_{NT}+\frac{1}{b}\varepsilon_1,$$

which underlines that the interest rate setting behaviour is equal under the two scenarios previously considered. This result cannot come as a surprise as the ECB only reacts to euro-wide averages, which are identical under the two scenarios as the shocks are i.i.d. This underlines that the behavior of the ECB remains unaltered.

(63) $$\begin{aligned} i &= \pi_0+\frac{a}{b}+\frac{d\left(\kappa^2+\varphi-bd\varphi\right)\alpha+b\alpha\left(d^2+\lambda\right)\varphi}{b\left(d^2+\lambda\right)\varphi}\varepsilon_T+ \\ &+\frac{(1-\alpha)d\kappa^2+(1-\alpha)d\varphi+(1-\alpha)b\lambda\varphi}{b\left(d^2+\lambda\right)\varphi}\varepsilon_{NT}+\frac{1}{b}\varepsilon_1. \end{aligned}$$

Applying the usual solving strategy we get the following reduced form equations for consumer price inflation

(64)

$$\pi_i^{CPi}=\pi_0+\frac{1}{\left(d^2+\lambda\right)\left(\kappa^2+\left(1+bd(\alpha-1)\right)\varphi\right)}\left[\begin{array}{l}\left(-bd^3(\alpha-1)\varphi+\lambda\left(\kappa^2+\varphi\right)\right)\alpha\varepsilon_T \\ +(\alpha-1)\left(\begin{array}{l}-d\left(d^2+\lambda\right)\varphi\varepsilon_1+d\left(d^2+\lambda\right)\varphi\varepsilon_1 \\ d^2\kappa^2\varepsilon_{NT}+d^2\varphi\varepsilon_{NT}+bd\lambda\varphi\varepsilon_{NT}-bd\alpha\lambda\varphi\varepsilon_{NT} \\ -d^2\kappa^2\varepsilon_{NTi}-\kappa^2\lambda\varepsilon_{NTi}-\kappa^2\lambda\varepsilon_{NTi}-d^2\varphi\varepsilon_{NTi} \\ -\lambda\varphi\varepsilon_{NTi}+bd\alpha\left(d^2+\lambda\right)\varphi\varepsilon_T\end{array}\right)\end{array}\right]$$

and the output gap

(65) $$y_i=\frac{1}{\left(d^2+\lambda\right)\left(\kappa^2+\left(1+bd(\alpha-1)\right)\varphi\right)}\left[\begin{array}{l}\left(bd^2(\alpha-2)\varphi-b\lambda\varphi+d\left(\kappa^2+\varphi\right)\right)\alpha\varepsilon_T \\ \left(d^2+\lambda\right)\varphi\left(\varepsilon_{i,1}-\varepsilon_1\right)+\left(d\kappa^2-d\alpha\kappa^2\right)\varepsilon_{NT} \\ +d\varphi\varepsilon_{NT}-d\alpha\varphi\varepsilon_{NT}+bd^2\alpha\varphi\varepsilon_{NT}-bd^2\alpha^2\varphi\varepsilon_{NT} \\ +b\lambda\varphi\varepsilon_{NT}-b\alpha\lambda\varphi\varepsilon_{NT}-bd^2\varphi\varepsilon_{NTi}+bd^2\alpha\varphi\varepsilon_{NTi} \\ -b\lambda\varphi\varepsilon_{NTi}-b\lambda\varphi\varepsilon_{NTi}+b\alpha\left(d^2+\lambda\right)\varphi\varepsilon_T\end{array}\right]$$

The fiscal stance parameter which nests the two corner solutions:

(66) $$g_i = \frac{1}{\left(d^2+\lambda\right)\varphi\left(\kappa^2+\left(1+bd(\alpha-1)\right)\varphi\right)}\begin{bmatrix} \kappa\left(\left(bd^2\left(\alpha-2\right)\varphi-b\lambda\varphi+d\left(\kappa^2+\varphi\right)\right)\alpha\varepsilon_T\right) \\ -\left(d^2+\lambda\right)\varphi\varepsilon_1+\left(d^2+\lambda\right)\varphi\varepsilon_3+d\kappa^2\varepsilon_{NT}-d\alpha\kappa^2\varepsilon_{NT} \\ +d\varphi\varepsilon_{NT}-d\alpha\varphi\varepsilon_{NT}+bd^2\alpha\varphi\varepsilon_{NT}-bd^2\alpha^2\varphi\varepsilon_{NT} \\ +b\lambda\varphi\varepsilon_{NT}-b\alpha\lambda\varphi\varepsilon_{NT}+b\alpha\left(d^2+\lambda\right)\varphi\varepsilon_T \end{bmatrix}$$

Appendix II: Tables for Figures

Table 1: GDP weights

Country	EU11
Belgium	3.3
Germany	29.9
Greece	2,6
Spain	10.9
France	20.5
Ireland	1.3
Italy	19.2
Luxembourg	0.3
Netherlands	5.4
Austria	3.2
Portugal	2.1
Finland	1.6

Data were taken from (ECB 2003).

Table 2: Monetary Policy: Many Prices: Demand Shock ($e_{1,i} = 3$) Figure 50

	Country one	Country two	Country three	Initial levels
Interest rate	7.5	7.5	7.5	5
Output gap	2	-1	-1	0
Fiscal stance	/	/	/	0
Inflation rate	2	2	2	2
Real interest rate	5.5	5.5	5.5	3

Table 3: Monetary Policy: Many Prices: Demand Shock ($e_{1,i} = 3$) Figure 51

	Country one	Country two	Country three	Initial levels
Interest rate	7.5	7.5	7.5	5
Output gap	2.31	-1.16	-1.16	0
Fiscal stance	0	0	0	0
Inflation rate	2.79	1.61	1.61	2
Real interest rate	4.71	5.89	5.89	3

Table 4: Monetary Policy: Many Prices: Supply Shock ($e_{1,i}$ = 3) Figure52

	Country one	Country two	Country three	Initial levels/averages
Interest rate	7.19	7.19	7.19	5
Output gap	0.37	-1.02	-1.02	0
Fiscal stance	0	0	0	0
Inflation rate	5.15	1.68	1.66	2
Real interest rate	2.07	5.53	5.53	3

Table 5: Fiscal Policy: Many Prices: Demand Shock ($e_{1,i}$ = 3) Figure 53

	Country one	Country two	Country three	Initial levels
Interest rate	7.5	7.5	7.5	5
Output gap	1.33	-0.66	-0.66	0
Fiscal stance	-1.33	0.66	0.66	0
Inflation rate	2	2	2	2
Real interest rate	5.5	5.5	5.5	3

Table 6: Fiscal Policy: Many Prices: Demand Shock ($e_{1,i}$ = 3) Figure54

	Country one	Country two	Country three	Initial levels
Interest rate	7.5	7.5	7.5	5
Output gap	1.46	-0.73	-0.73	0
Fiscal stance	-1.46	0.73	0.73	0
Inflation rate	2.50	1.75	1.75	2
Real interest rate	5.00	5.75	5.75	3

Table 7: Fiscal Policy: Many Prices: Supply Shock ($e_{1,i}$ = 3) Figure 55/ Figure55

	Country one	Country two	Country three	Initial levels
Interest rate	7.88	7.88	7.88	5
Output gap	0.03	-0.85	0.85	0
Fiscal stance	-0.46	0.42	0.42	0
Inflation rate	5.01	1.71	1.71	2
Real interest rate	2.87	6.17	6.17	3

Appendix III: Tables for comparison

Table 8: Comparison of impact coefficients in the event of idiosyncratic demand shocks $e_{1,i}$

		Only Monetary Policy		Montary and Fiscal Policy	
		Law of one Price	Many Phillips Curves	Law of One Price	Many Phillips Curves
y_i	General	1	$\frac{1}{(1-bd)}$	$\frac{\varphi}{\kappa^2+\varphi}$	$\frac{\varphi}{\kappa^2+(1-bd)\varphi}$
	Calibrated	1	1.16	0.67	0.73
g_i	General	/	/	$\frac{\kappa}{\kappa^2+\varphi}$	$\frac{\varphi}{\kappa^2+(1-bd)\varphi}$
	Calibrated	/	/	0.67	0.73
π_i	General	/	$\frac{d}{(1-bd)}$	/	$\frac{\varphi}{\kappa^2+(1-bd)\varphi}$
	Calibrated		0.40		0.25

Table 9: Comparison of impact coefficients in the event of idiosyncratic supply shocks $e_{2,i}$

		Only Monetary Policy		Monetary and Fiscal Policy	
		Law of one Price	Many Phillips Curves	Law of One Price	Many Phillips Curves
y_i	General	/	$\frac{b}{(1-bd)}$	/	$\frac{b}{(1-bd)}$
	Calibrated	/	0.4629	/	0.29
g_i	General	/	/	/	$\frac{b}{(1-bd)}$
	Calibrated	/	/	/	-0.29
π_i	General	/	$\frac{b}{(1-bd)}$	/	$\frac{b}{(1-bd)}$
	Calibrated		1.16		0.,25

Table 10: Comparison of impact coefficients in the event of global supply shocks e_2

		Only Monetary Policy		Monetary and Fiscal Policy	
		Law of one Price	Many Phillips Curves	Law of One Price	Many Phillips Curves
y_i	General	$-\frac{d}{d^2+\lambda}$	$-\frac{d}{d^2+\lambda}$	$-\frac{d}{d^2+\lambda}$	$-\frac{d}{d^2+\lambda}$
	Calibrated	-0.55	-1.02	-0.55	-0.55
g_i	General	/	/	$-\frac{d}{d^2+\lambda}$	$-\frac{d}{d^2+\lambda}$
	Calibrated	/	/	0.55	0.55
π_i	General	$\frac{\lambda}{d^2+\lambda}$	$\frac{\lambda}{d^2+\lambda}$	$\frac{\lambda}{d^2+\lambda}$	$\frac{\lambda}{d^2+\lambda}$
	Calibrated	-0.81	-0.81	-0.81	-0.81

Appendix IV: Alternative assumptions about real interest rates and fiscal policy

Quite naturally each theoretical model critically depends on the assumptions one makes about the functioning of the economy. In order to check the robustness of our results which we have derived throughout the main part of the text we want to alter our set of assumptions along two dimensions. First, we illustrate the effects of introducing the Fisher equation in the IS-curve instead of the (ex-post) real interest rate. Second, we analyze the consequences if each government in country i internalizes its impact on the euro-wide inflation rate. To shorten the appendix we only calculate the most complicated case for each alternative assumption, that is monetary and fiscal policy interaction when the law of one price does not hold.

Introducing the Fisher equation

Following other strands of the literature (see for example Uhlig, 1999) we introduce the Fisher equation into the IS-curve which defines the nominal interest rate as the sum of the real interest rate and the expected inflation rate:

$$\mathrm{i} = \mathrm{r} + \pi^{\mathrm{e}} .$$

The IS equation can then be written as:

$$y = a - b\left(i - p^{e}\right) + kg_{i} + e_{i,1} .$$

In order to simplify the exposition we assume – without loss of generality – that the inflation target of the central bank is equal to zero $\left(\pi_0 = 0\right)$. Accordingly, we can state the Phillips curve as follows:

$$\pi = \mathrm{d}y + \varepsilon_2 .$$

Let us assume that the private sector builds rational expectations according to the following loss function:

$$\mathrm{L} = \left(\pi\left(\pi^{\mathrm{e}}\right) - \pi^{\mathrm{e}}\right)^{2} .$$

Hence, the private sector is happy if it anticipates the inflation rate correctly at the outset of the game (i.e. before any shocks occur), which boils down to the following equation:

$$\pi^e = \pi_0 = 0 .$$

Given this somewhat altered structure of the economy the ECB mimises its loss function

$$L_{ECB} = \pi^2 + \lambda y^2$$

subject to the aggregate Phillips curve which translates into the following average area wide output gap:

$$y = -\frac{d}{d^2 + \lambda}\varepsilon_2 .$$

Inserting the output gap into the Phillips curve yields the following expression for the inflation rate:

$$\pi = \frac{\lambda}{d^2 + \lambda}\varepsilon_2 .$$

Making use of this assumption as well as on the timing of the game we arrive at the following nominal interest rate rule:

$$i = \frac{a}{b} + \frac{1}{b}\varepsilon_1 + \frac{d}{b\left(d^2 + \lambda\right)}\varepsilon_2 + \frac{\kappa}{b}g .$$

Note that this equation is exactly equal to the one we derived in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. This cannot come as a surprise as a nominal instrument rule that targets zero inflation should be identical to a monetary policy that targets the real interest rate. Let us now turn to the optimization problem of the fiscal authorities. The government faces the following optimisation problem:

$$L_{G,i} = y_i^2 + \varphi g_i^2$$

s.t.:

$$y_i = a - b\left(i - \pi_i^e\right) + \kappa g_i + \varepsilon_{i,1} .$$

Given the assumptions we have made on the private sector and its way according to which expectations are formed it holds that in each member state $\pi_i^e = 0$. Making use of this result the reaction function of fiscal policy can be stated as follows:

$$g_i = -\frac{a\kappa}{\kappa^2 + \varphi} + \frac{b\kappa}{\kappa^2 + \varphi} i - \frac{\kappa}{\kappa^2 + \varphi} \varepsilon_{i,1} .$$

Taking expectations of the average fiscal stance parameter $\underset{\sim}{g}$ and inserting it into the reaction function of monetary policy we arrive at the following reduced form expression for the interest rate:

$$i = \frac{a}{b} + \frac{1}{b}\varepsilon_1 + \frac{d\left(\kappa^2 + \varphi\right)}{b\left(d^2 + \lambda\right)\varphi}\varepsilon_2 ,$$

which can be used to solve for the fiscal stance parameter,

$$g_i = \frac{\kappa}{\kappa^2 + \varphi}\left(\varepsilon_1 - \varepsilon_{1,i}\right) + \frac{\kappa d}{\varphi\left(d^2 + \lambda\right)}\varepsilon_2$$

the output gap in the individual member country i,

$$y_i = \frac{\varphi}{\left(\kappa^2 + \varphi\right)}\left(\varepsilon_{i,1} - \varepsilon_1\right) - \frac{d}{\left(d^2 + \lambda\right)}\varepsilon_2$$

and the corresponding inflation rate in member country i:

$$\pi_i = \frac{d\varphi}{\kappa^2 + \varphi}\left(\varepsilon_{i,1} - \varepsilon_1\right) + \frac{1}{d^2 + \lambda}\left[\left(d^2 + \lambda\right)\varepsilon_{2,i} - d^2\varepsilon_2\right].$$

In order to shortly evaluate the plausibility of the results one can see that if shocks are symmetrical, i.e. $\rho\left(\varepsilon_{i,1};\varepsilon_1\right) = 1$ and $\rho\left(\varepsilon_{i,2};\varepsilon_2\right) = 1$, than the equations simplify to:

$$y_i = -\frac{d}{\left(d^2 + \lambda\right)}\varepsilon_2$$

$$\pi_i = \frac{\lambda}{d^2 + \lambda}\varepsilon_2 .$$

As this setup may be a natural alternative to the structure of the economy as assumed throughout the main Part of the text let us give some comments on the results:

- Demand shocks only have an impact on the average macroeconomic outcomes if they are not synchronized.
- In the absence of shocks the output gap will be equal to zero and the inflation rate will be equal to the inflation target.
- The model setup is internally consistent because the country specific equations boil down to the euro area equations in the case of synchronized supply and demand shocks.

Nevertheless one result dramatically changed. As we assume that instead of the actual real interest rate the expected real interest rate matters, real interest rates are de facto equal across countries. Hence we do have no longer the phenomenon that country specific real interest rates can drive a wedge between country specific macroeconomic outcomes. In the main part of the text we saw that a dispersion across national outcomes could be amplified by diverging monetary conditions. By assuming that the real interest rate is derived from the Fisher equation this scenario is ruled as π_i^e is always zero.

Alternative assumptions on the optimisation problem of fiscal authorities

In this part of the Appendix we want to illustrate that the results derived in the main text are qualatively the same, irrespectively whether we assume that the government in country i internalizes the Phillips curve. Internalizing the Phillips curve means that the government takes the effects its own actions on the euro wide inflation rate into account. As in the previous sections we assume that the ECB solves the following optimization problem:

$$L_{CB} = \pi^2 + \lambda y^2$$

s.t.

$$\pi = \pi_0 + dy + \varepsilon_2 .$$

Using this setup we arrive at the following reduced-form equation for the inflation rate:

$$\pi = \pi_0 + \frac{\lambda}{d^2 + \lambda}\varepsilon_2 ,$$

which translates into the following output gap equation:

$$y = -\frac{d}{d^2+\lambda}\varepsilon_2 ,$$

and into the following reaction function for monetary policy:

$$i = \frac{a}{b} + \pi_0 + \frac{1}{b}\varepsilon_1 + \frac{b\lambda + d}{b\left(d^2+\lambda\right)}\varepsilon_2 + \frac{\kappa}{b} g .$$

Let us now turn to fiscal policy. As a novelty compared to the analysis in Chapter 3 we assume that the government in country i internalizes the effects of its individual actions on the euro-area wide inflation rates:

$$L_{G,i} = y_i^2 + \varphi g_i^2$$

s.t.:

$$y_i = a - b(i - \pi_i) + \kappa g_i + \varepsilon_{i,1}$$

$$\pi_i = \pi_0 + d y_i + \varepsilon_{i,2} .$$

Consolidating the constraint it can equally be written as follows:

$$y_i = \frac{a}{1-bd} + \frac{b\pi_0}{1-bd} - \frac{b}{1-bd} i + \frac{\kappa}{1-bd} g_i + \frac{1}{1-bd}\varepsilon_{1,i} + \frac{b}{1-bd}\varepsilon_{2,i} .$$

Given this somewhat altered optimization problem we arrive at the following reduced forms for the interest rate:

$$i = \frac{a}{b} + \pi_0 + \frac{1}{b}\varepsilon_1 + \frac{-d\kappa^2 + (bd-1)(d+b\lambda)\varphi}{b\left(d^2+\lambda\right)(bd-1)\varphi}\varepsilon_2 ,$$

the fiscal stance parameter:

$$g_i = \frac{\kappa}{\kappa^2 + (bd-1)^2\varphi}(\varepsilon_1 - \varepsilon_i) - \frac{\kappa b}{\kappa^2 (bd-1)^2 \varphi}\varepsilon_{i,2} + \frac{\kappa\left(-d\kappa^2 + (bd-1)(d+b\lambda)\varphi\right)}{(bd-1)\left(d^2+\lambda\right)\varphi\left(\kappa^2 + (bd-1)^2\varphi\right)}\varepsilon_2 ,$$

the reduced form output gap parameter:

$$y_i = -\frac{(bd-1)\varphi}{\kappa^2 + (bd-1)^2 \varphi}(\varepsilon_{i,1} - \varepsilon_1) + \frac{-d\kappa^2 + (bd-1)(d+b\lambda)\varphi}{(d^2+\lambda)(\kappa^2 + (bd-1)^2 \varphi)}\varepsilon_2 + \frac{(1-bd)b}{\kappa^2 + (bd-1)^2}\varepsilon_{i,2},$$

and the inflation rate:

$$\begin{aligned}\pi_i &= \pi_0 + \frac{d(1-bd)\varphi}{\kappa^2 + (bd-1)^2 \varphi}(\varepsilon_1 - \varepsilon_{1,i}) + \\ &+ \left(\frac{db(1-bd)\varphi}{(\kappa^2 + (bd-1)^2 \varphi)} + 1\right)\varepsilon_{i,2} + \frac{d(-d\kappa^2 + (bd-1)(d+b\lambda)\varphi)}{(d^2+\lambda)(\kappa^2 + (bd-1)^2 \varphi)}\varepsilon_2.\end{aligned}$$

In order to shortly evaluate the plausibility of the results one can see that if shocks are symmetrical, i.e. $\rho(\varepsilon_{i,1};\varepsilon_1) = 1$ and $\rho(\varepsilon_{i,2};\varepsilon_2) = 1$, the equations simplify to:

$$y_i = -\frac{d}{(d^2+\lambda)}\varepsilon_2,$$

$$\pi_i = \frac{\lambda}{d^2+\lambda}\varepsilon_2.$$

The following results can be summarised:

- Demand shocks only have an impact on the overall results if demand shocks are not perfectly synchronized.
- In the absence of macroeconomic shocks the inflation rate is equal to the inflation target and the output gap is equal to zero.
- The results are qualatively similar to those derived in the main part of the text.

In order to compare the results somewhat deeper we compute the value for the reduced form coefficients given our standard calibrations and compare them with those derived in the main text. Without going into detail the tables impressively demonstrate that the internalisation of the aggregate inflation rate does not alter the quantative results significantly.

Table 11: The parameters of the fiscal stance equation

	$g_i = q_1(\varepsilon_1 - \varepsilon_i) + q_2\varepsilon_{i,2} + q_3\varepsilon_2$	
	Main part	Appendix
q_1	0.733	0.802
q_2	-0.293	-02143
q_3	0.846	1.4

Calibration: $b = 0.4; d = 0.34; \lambda = 0.5; \varphi = \kappa = 0.5$

Table 12: The parameters of theoutput gap equation

	$y_i = q_1(\varepsilon_1 - \varepsilon_i) + q_2\varepsilon_2 + q_3\varepsilon_{i,2}$	
	Main part	Appendix
q_1	0.733	0.69314
q_2	-0.846	-0.319
q_3	0.293	0.867

Calibration: $b = 0.4; d = 0.34; \lambda = 0.5; \varphi = \kappa = 0.5$

Table 13: The parameters of the inflation equation

	$\pi_i = \pi_0 + q_1(\varepsilon_1 - \varepsilon_i) + q_2\varepsilon_{i,2} + q_3\varepsilon_2$	
	Main part	Appendix
q_1	0.250	0.2357
q_2	-0.287	-0.282;
q_3	1.10	1.094

Calibration: $b = 0.4; d = 0.34; \lambda = 0.5; \varphi = \kappa = 0.5$

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