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UNCONVENTIONAL POLICIES IN A MONETARY UNION: A POLICY GAME APPROACH

Abstract:

How does the availability of fiscal and unconventional monetary measures modify the composition of the optimal policy mix, in a monetary union, when ZLB is binding? In order to answer to this question, we have built a simply three-period generalized New Keynesian model, in which we have assumed that non-money assets are not perfect substitutes. Following Friedman (2013), private agents' choice is responsive to a sort of long run interest rate.
We have proved that in a monetary union, greater is the number of member countries adopting autonomous fiscal policy, greater will be public spending and more moderate will be the use of unconventional policies measures by central bank. Anyway, deviations in output and inflation decrease with the enlargement of the monetary union.

Keywords:

Unconventional Monetary policies, ZLB, Fiscal policy, Quantitative Easing, Forward Guidance, Policy game

JEL Classification: C70, E52, E60

1 Introduction

Since the process of creation of the European monetary Union has taken-off, it has emerged a large debate about the mandate and the role of central bank as well as the limits to the discretion of governments. The financial crisis has evidenced the weakness of the EU policy-making process and the lack of coordination between fiscal policymakers. Globally, a new policy-making approach has been implemented, where fiscal and unconventional monetary policies have had a more significant role than before. However, what it emerges from a review of the recent literature is that our understanding of the new policy-making design is in an initial phase. There are large margins of analysis that have not been investigated yet.

Already in 1999, Clarida, Galì and Gertler stated that their results, evidencing the full effectiveness of conventional monetary policy in preserving the economic stability, were conditional to the assumption that the zero lower bound (ZLB) constraint on the nominal interest rate was not binding. They pointed out that it is crucial to understand how central bank has to behave in ZLB situations, when the economy does not back at its steady state level, despite nominal policy rate has been reduced to zero; furthermore, in such a case, they consider it should be necessary to verify if the additional fiscal policy interventions could be useful to preserve the stability of economy (Clarida et al., 1999).

In Gertler et al., (2013) the effectiveness of Large-Scale Asset Purchase depends on the level of the risk of asset purchased. The model is drawn on Gertler et al., (2010), but it provides a more general formalization of different types of private asset purchase programs. Caballero et al., (2017) demonstrate that in a ZLB situation, after the occurrence of an endogenous risk premium, central bank must either purchase private risky assets or increase the inflation target; on the other side, any forward guidance operation is ineffective. Others focus on the effectiveness of the forward guidance policy (Eggertsson et al., 2003; Campbell et al., 2012; Woodford, 2012).

From the empirical point of view, Gürkaynak et al., (2004) through an high frequency event-study analysis, show that both monetary policy actions and FOMC statements about the future path of policy, have effects on asset prices; public announcements have a greater impact on longer-term Treasury yields. At the same time, different analysis are devoted to identify the effectiveness of various quantitative easing programs (Krishnamurthy et al., 2011; Swanson 2011; Chen et al., 2012).

As described, the reference literature has become very large in the last decade. Nevertheless, few contributions study the interactions among different unconventional instruments and none of them focus on the interaction among different policymakers responsible for them, i.e., monetary and fiscal authorities. Differently, we are indeed interested to the identification of the optimal fiscal and monetary strategy, when policymakers can manage specific conventional and unconventional instruments in a binding ZLB situation.

We are interested, instead, to identify the optimal policy mix in that specific circumstance, when public expenditure measures are under control of different monetary Union Member Countries and the common central bank can use conventional and unconventional monetary policies. We aim to evaluate the contribution of the fiscal policies coordination in this different framework.

For the sake of tractability, our analysis is based on a simplified New Keynesian framework, where the major simplification concerns the dynamics of the model.Our model is drawn on Friedman B., (2013), who considers contemporaneous effects derived by the use of conventional and unconventional monetary instruments, above mentioned. Quantitative easing and forward guidance policies can impact on the long-run interest rate, while short term policy rate is fixed directly by the central bank, through standard conventional policy. The model gives a more exhaustive description of the economic system: otherwise, when the zero lower bound is binding, central bank will be unable to further stimulate the economy. We are interested to identify how optimal policy mix depends on the number of size of monetary union.

We develop our analysis on a three-period interval, namely, short, medium and long run. We are interested to identify the optimal policy from the policymakers' point of view. In order to do that, we consider specific formalization used in different policy game contributions. Barro et al., (1983) argue that central bank aims to minimize a specific quadratic loss function. It summarizes the costs related of any inflation' and unemployment rate' deviation from target, related to each period considered. Dixit et al.,(2013a) formalize specific quadratic loss function for both fiscal and monetary policymakers: per each one authority it is considered the cost of deviation of inflation and output from prefixed objective; for fiscal policymaker, it is included also the cost associated to the use of fiscal policy. We do not consider any quadratic loss representing welfare loss (Rotemberg et al., 2003; Benigno et al., 2005).

Many economic studies have dealt with the functioning of a monetary union, by adopting a game theoretical approach. But we are particularly interested to contributions focusing on effects of fiscal coordination.According to some, fiscal coordination can have counterproductive effects: the results depend on magnitude and sign of the fiscal spillovers (Andersen et al., 1995; Jensen, 1996). Several authors evidence that fiscal coordination worsens the time-inconsistency problem (Agell et al., 1996; Beetsma et al., 1995). Amongst others, Beetsma et al., (1995) sustain that in the monetary union, the ability of each government to manipulate the policies of central bank is reduced. But if Member States coordinate fiscal policy, they can lead central bank to create excessive inflation. In particular, they stylize a fiscal leadership game, to reproduce a n-Countries monetary union, where Members States have identical economies and the same utility function of the society, except for the aversion versus inflation. Through unanticipated tax interventions, each government aims to push central bank to raise inflation, in order to benefit from the increase of seignorage and the reduction of real debt service. Fiscal policymakers do not care of inflation. Thus, fiscal coordination is particularly disadvantageous, because it favors the increase of the inflation.

Instead, we consider fiscal policymakers who are inflation adverse, even if they are less conservative than central bank. As in Beetsma, we prove that the enlargement of the monetary Union weakens the strategic power of each government. However, the fiscal coordination helps governments to internalize the spillover of respective fiscal policies. That increases utility of all policymakers and it reduces output' and inflation' deviation.

Our result is more similar to Dixit et al. (2003b) ones, according to which, the monetary union' Members Countries prefer to use fiscal instrument, even in non-coordinated way, rather than to induce central bank to create surprise inflation. The best outcome is always achieved when policymakers agree about targets, even if they have different preferences. Fiscal policies, even if uncoordinated, and the common monetary intervention can balance each other' effects: thus, the common target is achieved, without any monetary commitment or a specific first-mover rule.

In our analysis, policymakers must react to shock, in a general binding ZLB situation. In this sense, our study can give a new contribution to the debate about the effects of coordination in different shocks situations.

This paper is organized as follows. In the first section, we set up the benchmark model, so that it can represent the monetary union. In the second one, we apply it at different scenarios, under fiscal leadership assumption, in considering the same type of shock. In particular, we consider a n-countries monetary union, in order to verify how the degree of coordination between fiscal policymakers modifies the optimal mix strategy.

2 Our benchmark: GNKM

Our benchmark is a simple generalized New Keynesian model (GNKM). The generalization consists of abandoning the assumption that all non-money assets are perfect substitutes.

Here, we have a sort of private-sector interest rate, i_t, and a policy rate (or short term rate), ρ_t. The latter is under the control of the monetary authority, while the former one affects the households' and firms' spending decisions and, thus, the economy, through an IS-kind relationship. As long as the policy rate and the so-called private-sector interest rate are not perfect substitutes, output is only partially responsive to the policy rate, i.e., the current central bank's decisions.

Following Friedman (2013), a log-reduced-form relation between the long and short run interest rates can be written as follows:

$$i_t = (1-\delta)\rho_t + \delta E_t \rho_{t+1} + \theta r u_t + \varepsilon_t^i \quad (1)$$

where E_t is the time t expectation about time t+1; δ∈[0,1] is the private security maturity; ru_t is the deviation of risky ratio of financial markets from its natural level, which affects the long run interest rate by θ. Finally, $\varepsilon_t^i$is a disturbance term, which represents a financial shock, i.e., a temporary spread between the long and short run interest rates.

Equation (1) identifies three potential policy instruments under the control of the central bank:

1. $\rho_t$is the policy rate fixed directly by the central bank at time t;
2. $E_t\rho_{t+1}$ is the policy rate that the central bank will implement in the medium run. We assume that central bank can influence private expectations, through forward guidance;
3. ru_t is the risky ratio rate resulted from an intervention of quantitative easing in financial markets. We assume that any risk premium can be determined exclusively by the central bank, through her asset transactions in financial markets. If monetary authority does not implement any quantitative easing operations, the risky ratio rate is at its equilibrium level ($ru_t = 0$).

It is worth noting that if $\delta = 0$ and $\theta = 0$ (or $ru_t = 0$), the central bank has only one instrument to manage, the short term policy rate, which however is one-by-one mapped to the long run interest rate (a part from a possible disturbance), as it occurs in the textbook New Keynesian model.

Our formalization of the policy rate and forward guidance is quite standard. By contrast, the way we model the quantitative easing is specific. Other authors differently formalize quantitative easing operations. For instance, Gertler et al. (2013) model quantitative easing, by assuming that the central bank substitutes the private banks in the financial intermediation, by providing direct credit to the firms. Thus, the quantitative easing is the direct credit of central bank to the private sector, without any banking intermediation. In their model, central bank can provide credit to the non-financial firms in different ways. In order to design a tractable simple model, we do not formalize the credit market and financial intermediation, so in our model the quantitative easing is indirectly captured by the risky ratio deviations.

We model a simple n-country monetary union. Independent local authorities manage domestic fiscal policies, whereas a common central bank (ECB) autonomously implements the monetary policy.

Financial markets and monetary policy have the same structure, features and instruments of the model described in the previous chapters, even if optimal policy rules can differ in the monetary Union context.

Despite financial markets and monetary policy are uniform in overall area, the economy of the Union is still nationally fragmented; per each j Country, domestic demand and supply side can be generalized as follows:

$$x_{j,t} = E_t x_{j,t+1} - \frac{1}{\sigma}\left(i_t - E_t \pi_{j,t+1} - R\right) + g_{j,t} + \\ + \lambda \sum_{i=1}^{n} g_{i,t} + \varepsilon^{x}_{j,t}, \text{ for any } i \neq j \tag{2}$$

$$\pi_{j,t} = \beta E_t \pi_{j,t+1} + \kappa x_{j,t} + \varepsilon^{\pi}_{j,t} \tag{3}$$

where $\boldsymbol{x_{j,t}}$ and $\boldsymbol{\pi_{j,t}}$ are, respectively, the domestic output and inflation deviations from their steady state levels at time t in Country j; $\boldsymbol{E_t x_{j,t+1}}$ and $\boldsymbol{E_t \pi_{j,t+1}}$ are the output and inflation deviations, expected at time t for t+1 in Country j;$\boldsymbol{g_{j,t}}$ is the public expenditure implemented at time t by the government of Country j; $\boldsymbol{g_{i,t}}$ is the public expenditure implemented at time t by the government of foreign Country i which affects demand in Country j by λ; R is the value of real interest rate, when it is at its steady state.

Our model simplifies the complex fiscal policy structure. Government can use only one policy tool, represented by the public spending level at time t. We do not consider neither any detail regarding the type of fiscal instruments (lump-sum tax, subsidy, tax rate as in Beestma et al.,1998) nor a specific government budget constraint (as in Beestma et al.,1998, Gertler et al., 2000 and Schmitt-Grohè et al., 1994). As in Dixit et al. (2003), we assume that when $\boldsymbol{g_{j,t}} > \mathbf{0}$, the fiscal policy is expansionary, whereas when $\boldsymbol{g_{j,t}} < \mathbf{0}$, the fiscal policy is contractionary. Public finance is at its natural equilibrium for $\boldsymbol{g_{j,t}} = \mathbf{0}$, according to domestic budget constraint. As usual, σ represents the intertemporal substitution in consumption, β is the discount rate and κ is the coefficient representing the effect of the output gap on the inflation deviation due to nominal frictions. Finally, $\boldsymbol{\varepsilon^{x}_{j,t}}$ and $\boldsymbol{\varepsilon^{\pi}_{j,t}}$are shocks occurring, respectively, in the demand and supply side.

The model (2)-(3) is quite standard. The IS curve is derived from the representative consumer's Euler equation and it is based on the ideas of consumption smoothing; as in the standard new-Keynesian literature, it is inversely proportional to the market interest rate. However, now this is not under the control of the central bank, who can affect it onlyindirectly by (1). Equation (3) is a standard Phillips curve, derived under the assumption of some form of price stickiness.

In the long run, when current and expected policy rates and risky ratio are at their steady states, there is not any spread between the private interest rate and the policy rate. From equation (1), both are equal to the natural interest rate (R). Since in the steady state there are not shocks by definition, agents do not expect any future deviation of output and inflation from their natural levels. Therefore, the monetary union' economy is perfectly in equilibrium, $\boldsymbol{x_{j,t} = 0}$ and $\boldsymbol{\pi_{j,t} = 0}$.

3 The policymakers' utility function

We assume that n+1 policymakers aim to maximize a discounted value of its respective instantaneous quadratic utility function. In our analysis, we do not consider a social utility. Some have formalized specific welfare utility function: Benigno et al., (2005), point out that welfare utility can be approximated by a quadratic utility function involving inflation and output gap; Dixit et al.,(2003), draw the same quadratic functions, to quantify both the utility of fiscal policymaker and social welfare. Instead, we limit our study to the evaluation of the optimal policy, exclusively from policymakers' point of view.

In particular, central bank has to maximize its utility function. We assume that any disequilibrium of output, inflation, and risky ratio from their natural levels is costly. Formally, the utility of the central bank is:

$$L_{CB} = E_1 \sum_{t=1}^{3} \sum_{j=1}^{n} \frac{\beta^{t-1}}{n} (-b_1 x_{j,t}^2 - \pi_{j,t}^2) - b_2 r u_1{}^2 \qquad (4)$$
$$s.t. \quad (2)-(3)$$

where $b_1$is the preference for the output versus the price-level target and b_2 is the cost of the deviation of financial risky ratio from its steady state level. The cost of the forward guidance operations is expressed by the discounted cost of the expected inflation and output deviations in the medium run. In other words, an announced change of the policy rate will affect the current output and inflation, at a cost of an unnecessary future disequilibrium. Thus, the central bank must trade-off between current marginal benefits and discounted future marginal costs. Furthermore, to maximize her utility, central bank must consider averaged output' and inflation' deviation registered in all the Union area.

Similarly, the fiscal authorities' problem consists in maximizing their quadratic utility function. Formally, the utility of each fiscal policymaker is:

$$L_{F_j} = E_1 \sum_{t=1}^{3} \beta^{t-1}(-b_3 x_{j,t}^2 - \pi_{j,t}^2) - \chi g_{j,1}^2, \quad \text{with } j = 1..n \quad s.t. \ (2)-(3) \tag{5}$$

In order to maximize its utility function, each government can adopt a specific fiscal policy. Public expenditure measure, implemented at time t, exhausts its effect during the same period t, without any impact in the medium and long run.

It is important to note that if fiscal policy adopted abroad impacts on domestic demand ($\lambda \neq 0$), for government it is convenient to persuade other fiscal authorities to implement specific national fiscal policy having internal positive spillover. Thus, foreign fiscal policy can be considered an additional instrument on which each government aims to have a sort of influence, in the case of a coordination game.It is worth noting that differently from Beetsma et al. (1998), the cost of public expenditure does not impact also on the utility function of the central bank.

4 Times and rules of the policy intervention

Our model has a New Keynesian flavor; however, in order to formalize the strategic interactions between the fiscal and monetary authorities, we need to relax some features of DSGE models. Specifically, we simplify the model dynamics. We restrict our attention to three periods, which are enough to consider conventional and unconventional policies. Our model is characterized by a short, medium, and long run. We assume that the economy is initially at its natural equilibrium, then it is perturbed by some shocks in the short run; in the medium run, shocks vanish; finally, in the long run, the economy backs to the natural equilibrium. The inclusion of a medium run is crucial for our analysis: in fact, in the medium run, policy implemented after the shocks (in the short run) are still effective. This formalization permits to account for forward guidance in a simple way. Formally, we refer to t=1 as the short run, t=2 as the medium run and t=3 as the long run. Obviously, shocks are zero for t>1 and all deviations are zero in t=3.

5 Calibration

Our results will be often illustrated by graphical representations. As a benchmark, we use a quite standard calibration, described below.The time unit is meant to be a quarter. The subjective discount rate β=0.99 is consistent with a steady-state real rate of return of 3 percent per year (i.e., R=0.0075). We set σ=1, consistently with a log utility in consumption. We assume that the slope of the Phillips curve is κ=0.1. The financial part of the model is characterized by steady state risky ratio (RU=0), the average maturity of the private security (δ) equal to 0.812 (Falagiarda, 2013) and a coefficient for quantitative easing (θ) equal to 1.0033 (Chen et al., 2011). The former means that a 1% change in the policy rate affects the long run interest rate of 188 basis points. The latter means that the purchase of 1% Large-Scale Asset by the central bank reduces the risk premium by 33 basis points.

Regarding policy preference parameters, we assume that the sensibility of the central bank to the output deviations (b_1) relatively to inflation is 0.83 and the cost of quantitative easing in terms of inflation (b_2) is 0.5. The calibration of the cost of output deviations in terms of inflation is borrowed from Dixit et al. (2003). It is worth noting that our calibration implies that the central bank is conservative, i.e., $b_1<1$. Moreover, as b_2 is lower than the cost of output deviation, central bank prefers to intervene in the financial market, through quantitative easing operations, rather than tolerating a deviation of the output and inflation from its steady state. The fiscal spillover is equal to 0.5.

On the opposite side, governments are not conservative ($b_3=1$), but they support a specific cost in implementing public spending (χ), equal to 0.1 (Dixit et al., 2003a).

6 Policy design

At period 1, a shock hits the economy and determines deviations of output and inflation. Monetary and fiscal authorities can intervene and react to the shock. They can implement policies which have effects either during the same period (short run) or during both periods (short and medium run), according to the instruments adopted. Finally, in the long run, the economy will back to the steady state.

At time 1, central bank can implement the following strategies:

1. She can modify the current policy rate and/or implement costly quantitative easing operations by varying the risky ratio rate of financial markets.

2. She can announce a policy rate for t=2 (forward guidance). In such a way, She can affect the current status of the economy (i.e., at t=1) by the private sector expectations on t=2.

In the first case, the central bank affects the economy only in period 1 and the steady state will be reached since period 2. Moreover, note that changes in the policy rate are not per se costly. By contrast, changes in the risky ratio rate are. The changes in the policy rates are those considered in the textbook New Keynesian models.In the second case, the central bank affects the economy in both period 1 and 2, since the central bank should keep her commitment, and the steady state will be reached only at period 3. Forward guidance is per se costly. In fact, the announced change in the policy rate will determine an unnecessarily deviation from the steady state in period 2. Nevertheless, for the central bank, it can be more convenient to stabilize the economy in the current period, by postponing partially the effect of the shock until period 2.

In other words, forward guidance is a kind of credible commitment. After the shock occurs, the central bank can decide to commit her future policy to stabilize the economy by using her ability in manipulating expectations. The commitment is not a rule adopted ex ante, but a specific policy instrument reacting to the shock. Note that this differs from the standard definition of monetary commitment in policy game, where the commitment of monetary policy is a specific strategy which authority chooses to adopt, before the advent of the shock (e.g., Dixit et al.,2003a).

We assume that central bank is fully credible. In particular, we set that private agents expect the economy will be always at its steady state level. But if central bank commits her future monetary policy, operators will modify their expectations in order to fit them to central bank announcements. As in Di Bartolomeo et al. (2013), we assume that through policy announcement, monetary policymaker is able to control not only the current inflation and output, but also the expectations regarding future inflation and growth. Instead, Dixit et al. (2003) assume rational expectations which are formed before any type of shock occurs. In this case, the commitment of central bank impacts only on the strategy adopted by the fiscal policymakers.

On the other side, at time t, governments can implement fiscal policy. They can affect the economy only in period 1 and the steady state will be reached since period 2 ($\boldsymbol{g_{j,2} = 0}$).

7 The n-country monetary union

The benchmark model is useful to observe optimal fiscal and monetary interactions, in a monetary union, in different policy scenarios. When ZLB is binding, best policy mix can differ according to central bank can implement only conventional monetary policy (a), or, in addition, She can use quantitative easing (b), or forward guidance operations c) or, alternatively, all policies above described (d).

For the sake of the exposition, we set that there is not any fiscal expenditure spillover between member states (i.e., λ=0). We limit our analysis to the observation of the behavior of all n+1 policymakers, after a "large" financial shock hits the economy of the common monetary area, when the zero lower bound is binding.

We consider a fiscal leadership regime: government firstly move to maximize their utility, in knowing the monetary reaction policy rule. We assume that, regardless of the number, members countries do not coordinate ever their action. Per each scenario, the optimal policy mix reported represents the result of the adoption of the Nash strategy solution by governments. Instead, when governments coordinate their fiscal policies, they act as a single policymakers. Formally, the analytical result is the same observed in the Nash' scenario, by setting n=1.

Next subsections are devoted to illustrate results of our analysis, according to the monetary policies central bank can use. Per each scenario, we aim to investigate how instruments and utility of policymakers vary in correspondence with the number of monetary union Members States. The focus of our analysis can be formally written as follows:

$$\frac{\partial L_{CB}}{\partial n} = -\sum_{t=1}^{3}\sum_{j=1}^{n}\frac{\beta^{t-1}}{n}\left(b_1\frac{\partial E_1 x_{j,t}^2}{\partial n}(1+\kappa^2)+\frac{\partial E_1\pi_{j,t}^2}{\partial n}\right) - b_2\frac{\partial ru_1^2}{\partial n} \quad (6)$$

$$\frac{\partial L_{F_j}}{\partial n} = -\sum_{t=1}^{3}\beta^{t-1}\left(b_3\frac{\partial E_1 x_{j,t}^2}{\partial n}(1+\kappa^2)+\frac{\partial E_1\pi_{j,t}^2}{\partial n}\right) - \chi\frac{\partial g_{j,1}^2}{\partial n} \quad (7)$$

8.1 Scenario 1: Short term policy rate and quantitative easing

When central bank can use only monetary and quantitative easing to maximize (4), optimal policies formally are:

$$g_{j,1} = \frac{\Omega_5(\varepsilon^i - \Sigma R)}{\Omega_5 + n\chi\omega_8^2}, \text{ for any } j \quad (8)$$

$$\rho_t = 0, \text{ for } t = 1 \quad (9)$$

$$\rho_t = R, \text{ for any } t > 1 \quad (10)$$

$$ru_1 = \frac{\theta\chi n\omega_8^2\omega_2(R\Sigma - \varepsilon^i)}{(\Omega_5 + n\chi\omega_8^2)\omega_8} \quad (11)$$

where $\Sigma=1-\delta$, $\Delta=\Sigma\kappa+1$, $\omega_1=\kappa^2+b_3$, $\omega_2=\kappa^2+b_1$, $\omega_8=\theta^2\omega_2+b_2$, $\Omega_5=b_2\omega_1(\omega_8(n-1)+b_2)$.

By substituting (8)-(11) into (4) and (5) we can differentiate the policymakers' utility in respect to n. For the sake of the exposition the derivatives to consider can be formally written as follows:

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$$\frac{\partial x_{j,1}^2}{\partial n} = \chi n(\omega_2\theta^2 - \omega_8)^2 \cdot \Omega_6; \frac{\partial E_1 x_{j,2}^2}{\partial n} = 0 \quad (12)$$

$$\frac{\partial ru_1^2}{\partial n} = \chi\theta^2 n\omega_2^2 \cdot \Omega_6; \quad (13)$$

$$\frac{\partial g_{j,1}^2}{\partial n} = -b_2\omega_1(\omega_8(n-1) + b_2) \cdot \Omega_6; \quad (14)$$

where $\Sigma=1-\delta$, $\Delta=\Sigma\kappa+1$, $\omega_1=\kappa^2+b_3$, $\omega_2=\kappa^2+b_1$, $\omega_8=\theta^2\omega_2+b_2$, $\Omega_5=b_2\omega_1(\omega_8(n-1)+b_2)$, $\Omega_6=((2\chi\omega_8{}^2 b_2\omega_1(b_2-\omega_8))/((\Omega_5+n\chi\omega_8{}^2)^3))\cdot(R\Sigma-\boldsymbol{\varepsilon}^{i})^2$.

In particular, each government expects that after the shock the central bank will be inclined to maximize her utility function, by reducing short term policy rate and the risky ratio of financial markets.

Each government knows that monetary policy reaction function is responsive to fiscal spending implemented before. Central bank has to maximize her utility function: averaged output' and inflation' deviation, registered in all the monetary union area, weighs on her utility function. If more governments stabilize autonomously their internal economy, the expansionary intervention of central bank will be less strong.

When governments move, they consider that greater is the number of members countries, less expansionary will be the following intervention of central bank; thus, in order to compensate the missed monetary stimulus, each one will introduce an high public spending level. It follows that, without any fiscal coordination, more are members countries, greater will be the domestic fiscal spending implemented by each government. Instead, if all members countries coordinate their policies (n=1), they will agree to introduce a lower domestic public spending to leave to the central bank the task and cost of stabilization. It is worth noting that when the number of the countries overpasses the threshold of 10, the influence of n on the definition of the optimal level of fiscal and quantitative easing policies almost disappears (Figure 1).

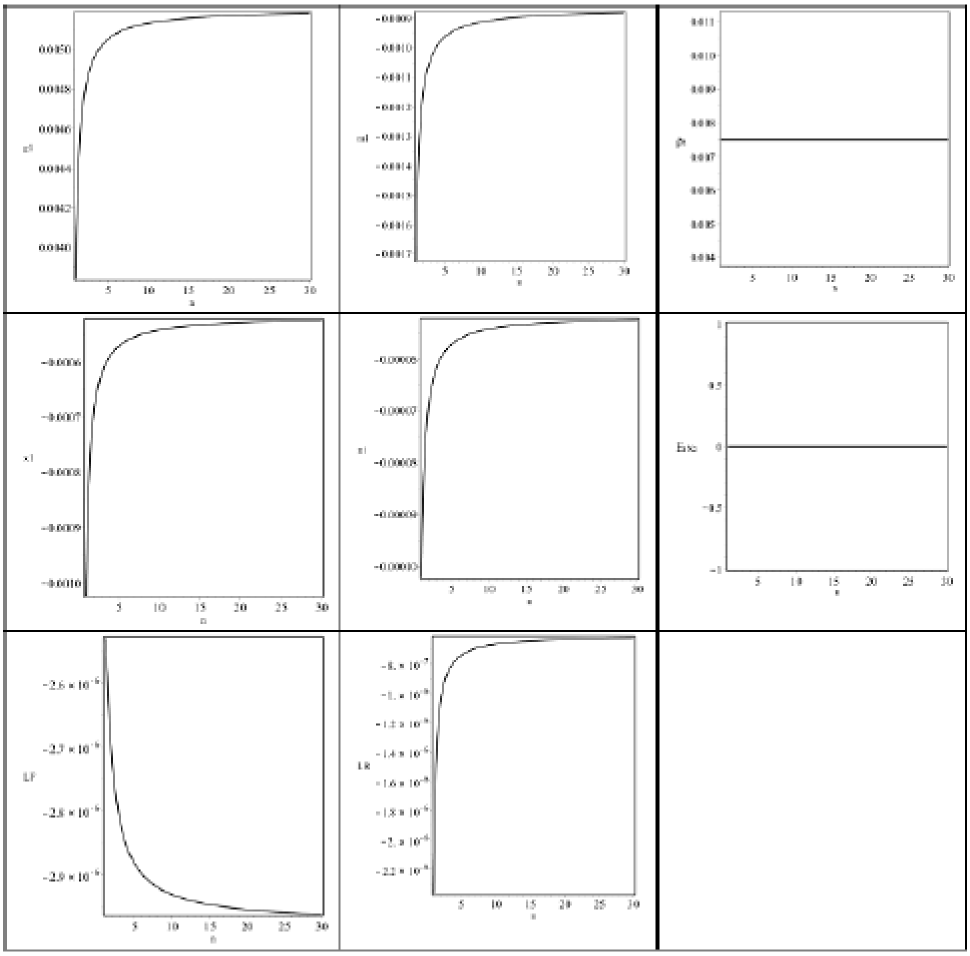

Figure 1: Variable results per n membries countries (Policy rate and QE, ε^i0.008, g_1, ru_1, ρ_2, x_1, π_1, E_1x_2, LF, LB)

We can see that greater is the number of member states, lower will be the output' and inflation' deviation in the short term: in fact, a more expansionary fiscal policy contributes strongly to the recovery of all the monetary area. But, in this case, stabilization is mostly at the expense of fiscal policymakers: greater is the decentralization of fiscal policy-making, greater will be the cost sustained by each government and smaller will be the monetary policy cost.

8.2 Scenario 2: Short term policy rate and forward guidance

When central bank can use only monetary and quantitative easing to maximize (4), optimal policies formally are:

$$g_{j,1} = -\frac{\Omega_7(R\Sigma - \varepsilon^i)}{\Omega_7 + \chi n\omega_{10}^2} \tag{15}$$

$$\rho_1 = 0 \tag{16}$$

$$\rho_2 = R - \frac{\chi n\omega_{10}\omega_5(R\Sigma - \varepsilon^i)}{\Omega_7 + \chi n\omega_{10}^2} \tag{17}$$

$$ru_t = RU, \text{for any } t \tag{18}$$

where $\Sigma=1-\delta, \Delta=\Sigma\kappa+1, \omega_1=\kappa^2+b_3, \omega_2=\kappa^2+b_1, \omega_5=\Delta\omega_2+\Sigma\kappa^2$, $\omega_6 =(\Sigma\kappa^2+\Delta\omega_1)\omega_5$, $\omega_{10}=\Delta^2 b_3+\Sigma^2\beta\omega_2+\kappa^2(\Delta+\Sigma)^2, \Omega_7=(\omega_{10}\omega_1 n-(n+1)\omega_6)\omega_{10}+\omega_{11}$

By substituting (15-18) into (4)-(5), we can differentiate the policymakers' utility in respect to n. For the sake of the exposition, derivatives to consider can be formally written as it follows:

$$\frac{\partial x_{j,1}^2}{\partial n} = n\chi(\Delta\omega_5 + \omega_{10})^2 \cdot \Omega_8; \tag{19}$$

$$\frac{\partial E_1 x_{j,2}}{\partial n} = n\chi\Sigma^2\omega_5^2 \cdot \Omega_8 \tag{20}$$

$$\frac{\partial \pi_{j,1}^2}{\partial n} = n\chi\kappa^2((\Delta + \Sigma)\omega_5 + \omega_{10})^2 \cdot \Omega_8; \tag{21}$$

$$\frac{\partial g_{j,1}^2}{\partial n} = (\omega_{10}\omega_6 - \omega_{11}) \cdot \Omega_8 \tag{22}$$

where $\Sigma=1-\delta$, $\Delta=\Sigma\kappa+1$, $\omega_1=\kappa^2+b_3$, $\omega_2=\kappa^2+b_1$, $\omega_5=\Delta\omega_2+\Sigma\kappa^2$, $\omega_6=(\Sigma\kappa^2+\Delta\omega_1)\omega_5$, $\omega_{10}=\Delta^2 b_3+\Sigma^2\beta\omega_2+\kappa^2(\Delta+\Sigma)^2, \Omega_7=(\omega_{10}\omega_1 n-(n+1)\omega_6)\omega_{10}+\omega_{11}$, $\Omega_8=((2\chi\omega_{10}^2\Omega_7(R\Sigma-\varepsilon^{i})^2)/((\Omega_7+\chi n\omega_{10}^2)^3))$.

In this case, when government move firstly, they know, that central bank will certainly reduce short term policy rate. Furthermore, She will evaluate net benefit from an additional forward guidance operation, on the basis on the actual fiscal stimulus implemented by governments. Governments know that the intervention of central bank will determine an increase of the expected inflation. In order to avoid that, each one is inclined to introduce an high public spending level. It follows that greater is the number of member countries, stronger will be the overall fiscal stimulus and, thus, weaker will be the use of forward guidance by central bank. In this case, it emerges that more are the monetary union members states, greater will be the utility of each one (Figure 2).

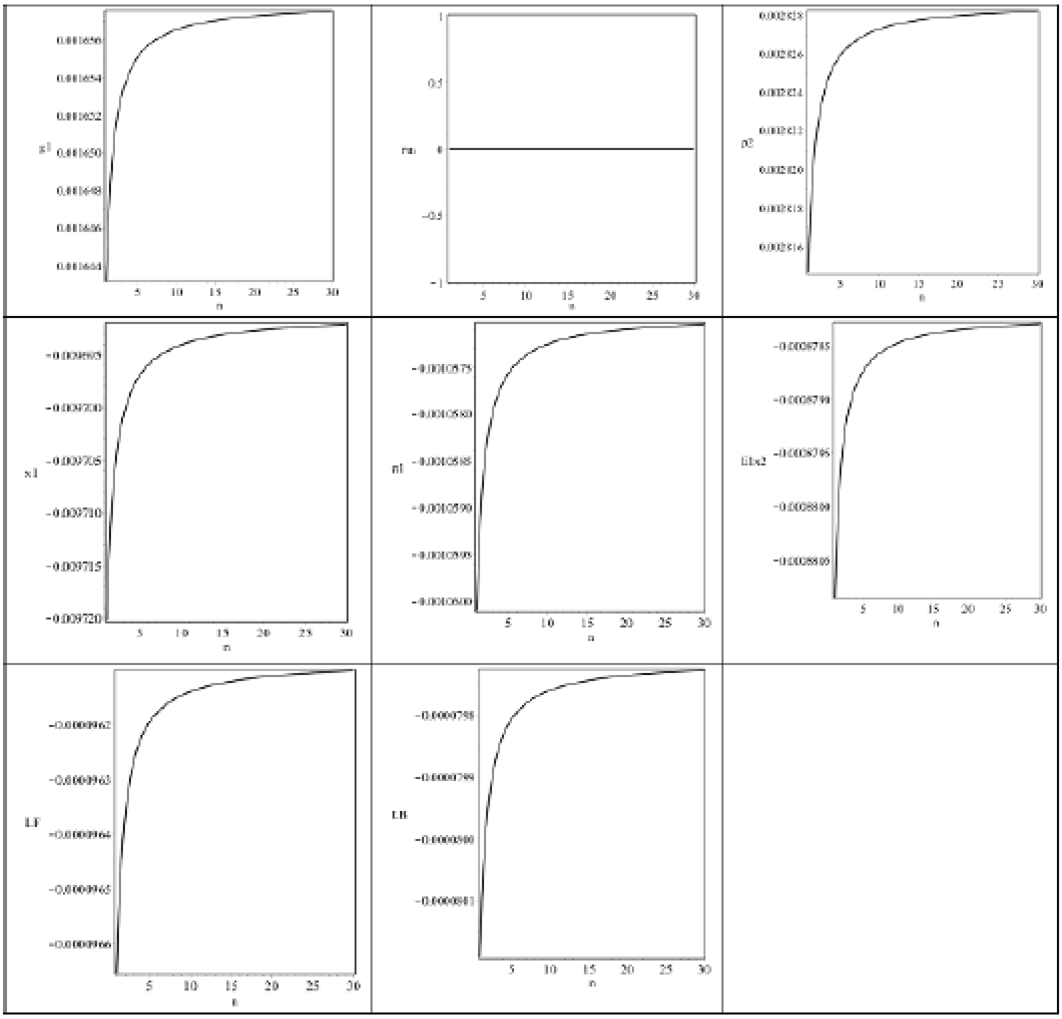

Figure 2: Variable results per n membries countries (Policy rate and FG, ε^{i}0.008, g_1, ru_1, ρ_2, x_1, π_1, E_1x_2, LF, LB)

Summing up, in this case, the use of public expenditure is more efficient than forward guidance intervention. It follows that it is more preferable the implementation of fragmented fiscal policies than the introduction of a more expansionary uniform monetary policy.

8.3 Scenario 3: All policies

In case the central bank can use all conventional and unconventional policies above described, the optimal policies are formally written as:

$$g_{j,1} = -\frac{\Omega_9(R\Sigma - \varepsilon^i)}{\Omega_9 + (b_2\omega_{10} + \omega_7\theta)^2 n\chi} \tag{23}$$

$$\rho_1 = 0 \tag{24}$$

$$\rho_2 = R + \frac{b_2\omega_5 n\chi(b_2\omega_{10} + \omega_7\theta)(R\Sigma - \varepsilon^i)}{\Omega_9 + (b_2\omega_{10} + \omega_7\theta)^2 n\chi} \tag{25}$$

$$ru_1 = \frac{\omega_7 n\chi(b_2\omega_{10} + \omega_7\theta)(R\Sigma - \varepsilon^i)}{\Omega_9 + (b_2\omega_{10} + \omega_7\theta)^2 n\chi} \tag{26}$$

where $\Sigma=1-\delta$, $\Delta=\Sigma\kappa+1$, $\omega_1=\kappa^2+b_3$, $\omega_2=\kappa^2+b_1$, $\omega_5=\Delta\omega_2+\Sigma\kappa^2$, $\omega_6=(\Sigma\kappa^2+\Delta\omega_1)\omega_5$, $\omega_7=\Sigma^2\theta(\beta\omega_2^2+b_1\kappa^2)$, $\omega_{10}=\Delta^2 b_3+\Sigma^2\beta\omega_2+\kappa^2(\Delta+\Sigma)^2$, $\omega_{10}=\Delta^2 b_3+\Sigma^2\beta\omega_2+\kappa^2(\Delta+\Sigma)^2$, $\omega_{11}=((\Sigma^2\beta+\Delta^2)\omega_1+\Sigma\kappa^2(2\Delta+\Sigma))\omega_5^2$, $\Omega_7=(\omega_{10}\omega_1 n-(n+1)\omega_6)\omega_{10}+\omega_{11}$, $\Omega_9=b_2[\omega_7\theta(n-1)(\omega_1\omega_{10}-\omega_6)+b_2\Omega_7]$.

By substituting (23-26) into (4) and (5), we can differentiate the policymakers' utility in respect to n. For the sake of the exposition, the derivatives to consider are formally:

$\frac{\partial x_{j,1}^2}{\partial n} = -n\chi(b_2(\Delta\omega_5 - \omega_{10}))^2 \cdot \Omega_{10};$	(27)
$\frac{\partial E_1 x_{j,2}}{\partial n} = -n\chi\Sigma^2 b_2^2\omega_5^2 \cdot \Omega_{10};$	(28)
$\frac{\partial \pi_{j,1}^2}{\partial n} = -n\kappa^2\chi b_2^2((\Delta + \Sigma)\omega_5 - \omega_{10})^2 \cdot \Omega_{10};$	(29)
$\frac{\partial g_{j,1}^2}{\partial n} = \Omega_9 \cdot \Omega_{10}$	(30)
$\frac{\partial ru_1^2}{\partial n} = -\omega_7^2 n\chi \cdot \Omega_{10};$	(31)

where $\Sigma=1-\delta$, $\Delta=\Sigma\kappa+1$, $\omega_1=\kappa^2+b_3$, $\omega_2=\kappa^2+b_1$, $\omega_5=\Delta\omega_2+\Sigma\kappa^2$, $\omega_6=(\Sigma\kappa^2+\Delta\omega_1)\omega_5$, $\omega_7=\Sigma^2\theta(\beta\omega_2^2+b_1\kappa^2)$, $\omega_{10}=\Delta^2 b_3+\Sigma^2\beta\omega_2+\kappa^2(\Delta+\Sigma)^2$, $\omega_{10}=\Delta^2 b_3+\Sigma^2\beta\omega_2+\kappa^2(\Delta+\Sigma)^2$, $\omega_{11}=((\Sigma^2\beta+\Delta^2)\omega_1+\Sigma\kappa^2(2\Delta+\Sigma))\omega_5^2$, $\Omega_7=(\omega_{10}\omega_1 n-(n+1)\omega_6)\omega_{10}+\omega_{11}$, $\Omega_9=b_2[\omega_7\theta(n-1)(\omega_1\omega_{10}-\omega_6)+b_2\Omega_7]$, $\Omega_{10}=((2b_2\chi(b_2\omega_{10}+\omega_7\theta)^2(\omega_7\theta(\omega_1\omega_{10}-\omega_6)+b_2(\omega_{10}\omega_6-\omega_{11}))(R\Sigma-$ ε^{i})²)/((Ω₉+(b₂ω₁₀+ω₇θ)²nχ)³)).

Results are intermediate in respect to the previous scenarios' ones. Greater is the number of member countries, more expansionary will be the fiscal policy and weaker will be the monetary stimulus (Figure 3).

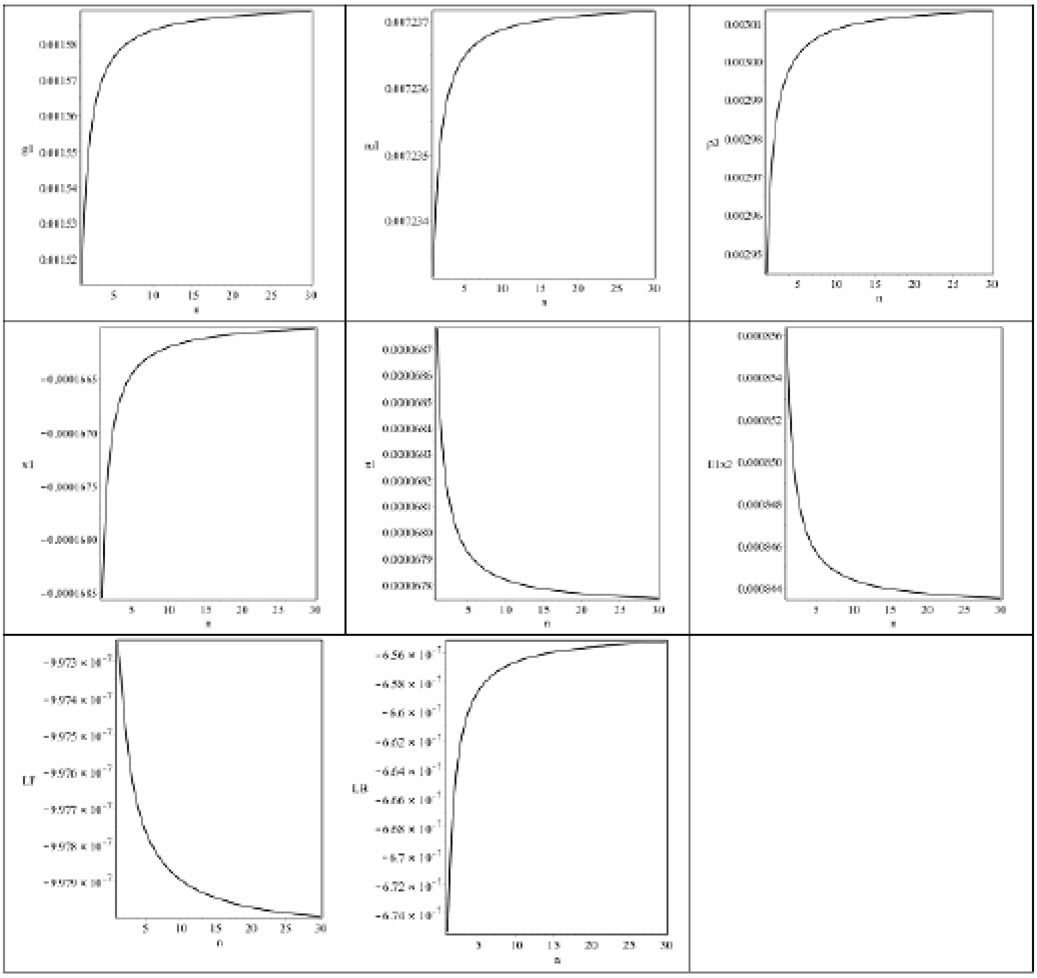

Figure 3: Variable results per n members countries (Policy rate, QE and FG, $\boldsymbol{\varepsilon^i}$ =0.008, g_1, ru_1, ρ_2, x_1, π_1, E_1x_2, LF, LB)

Compared to the other scenarios results, the level of fiscal spending is the lowest one per each n value. At the same time, in the mix scenario, the use of forward guidance and quantitative easing is the lowest amongst all scenarios. It follows that policymakers can coordinate better their policies.In this situation, greater is the number of member states, lower is the demand and inflation deviations. But, once again, governments support all the cost of the stabilization, whereas central bank benefits it, at lower policy cost.

Conclusions

In this paper we set a simple n-country monetary union based on the GNKM, in order to observe the optimal policy mix implemented by fiscal and monetary authorities, after the occurrence of a shock on the demand side, when ZLB is binding. Independent local authorities manage domestic fiscal policies, but all the countries share the same financial markets and the same monetary policy. In each scenario considered, all policymakers play the game under a fiscal leadership regime; governments move firstly, by knowing the monetary policy reaction rule.

We pointed out that in all cases, governments can improve their utility, if they coordinate fiscal policies. These results compliant with what emerges in traditional literature. In Dixit et al., (2001), if governments do not cooperate, each one fails to internalize the effect of foreign fiscal policy on domestic GDPs and on the economy of the monetary area.

In a n-country monetary union, without any spillover between member states' fiscal spending, public expenditure increases as fiscal policy-making is fragmented.

In particular, more are the fiscal authorities involved in the game, less expansionary must be the optimal monetary policy, and, thus, higher will be the optimal public expenditure level to implement. This situation is inefficient from the fiscal policymakers' point of view, but it may be advantageous in terms of welfare. In general, the fiscal stimulus is more effective in stabilizing the economy compared to the unconventional monetary policy.

Clearly, strength of the fiscal stimulus and (or) utility got by monetary union membership do not depend onlyon the number of member countries, but rather on the fulfillment of the optimal currency union conditions.

We pointed out that deviations in output and inflation reduce with the enlargement of the monetary union. Otherwise, the use of the unconventional policies can determine a negligible increase of the inflation' deviation in the current and future period. In conclusion, larger is the monetary union, greater will be the recovery after the shock. This result complaints with Beetsma et al. (1998), despite they proved it from an opposite point of view. In general, they pointed out that, governments benefit from more inflation. Therefore, they are willing to raise tax rates in order to push the central bank to boost the inflation. But, when the number of member states increases, the influence of each one on the central bank strategy reduces. It follows that larger is the number of monetary union, lower are the inflation, taxes and public spending. Instead, in our model, inflation' and output' deviation decrease, but not the public spending, which may weigh negatively on the welfare.

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