LUISS Guido Carli
School of European Political Economy

Sovereign Debt Crisis, Fiscal Consolidation and Quantitative Easing in a Monetary Union

Paolo Canofari
Giovanni Di Bartolomeo
Marcello Messori

Working Paper
9/2018

Sovereign Debt Crisis, Fiscal Consolidation and Quantitative Easing in a Monetary Union

Paolo Canofari
LUISS School of European Political Economy
pcanofari@luiss.it

Giovanni Di Bartolomeo
Sapienza University
giovanni.dibartolomeo@uniroma1.it

Marcello Messori
LUISS School of European Political Economy
mmessori@luiss.it

Abstract. In a stylized model of the EMU, where centralized and national policy authorities strategically interact, we show that 'quantitative easing' (QE) operates as an indirect risk-sharing mechanism that could improve EMU stability and the welfare of (a part of the) member states. We consider global financial instability and its impact on the sovereign debts of peripheral countries. On the one hand, QE reallocates a part of the cost of stabilizing the EMU from the periphery to the core; on the other hand, it partially internalizes the fact that monetary union stabilization is a public good. The rationale of our finding is that QE policies reduce the cost of fiscal adjustment in the peripheral countries and incentivize consolidation of their public balance sheets. Conversely, QE is not required in the core; it thus comes at a cost for central countries.

Keywords: core-periphery models, stability in a monetary union, risk sharing, monetary union institutions, liquidity trap, unconventional policies.

1. Introduction

The financial turmoil of 2007-2009 proved to be a strong element of instability for an incomplete economic union such as the European Economic and Monetary Union (EMU). This instability has become evident through the difficulties of the European banking sector, the limited effectiveness of conventional monetary policies due to new forms of the Keynesian 'liquidity trap' (see Hicks 1937; Blanchard 2009) and/or lower bound of interest rates, and the vicious circle between the sovereign debt crisis and the crisis of the banking sector (the so-called doom-loop). At different peaks of EMU instability, the union was on the brink of a breakdown. Throughout the last few years, a lively economic and political debate has been developing to address a number of these issues.

Our paper aims to contribute to the debate at a theoretical level, analyzing the coordination problems between centralized monetary policies and national fiscal policies in a monetary union such as the EMU. It points out that ECB 'quantitative easing' (QE) can operate as an indirect risk-sharing mechanism between the 'core' and the 'periphery' of the euro area. Therefore, QE can decrease instability and the related union breakup probability which are associated with sovereign debt shocks in the EMU periphery. The rationale is that QE policies reduce the cost of fiscal adjustment in the periphery and incentivize consolidation plans. We aim to explore the properties of QE as an indirect risk-sharing mechanism, its feasibility, and the associated welfare effects for the core and the periphery of the EMU.

The rest of the paper is organized as follows. Section 2 shows that our analysis contributes to the literature devoted to the relations between a centralized monetary policy and decentralized fiscal policies in a monetary union such as the EMU; Section 3 briefly discusses the actual European policy response to the financial and sovereign debt crises; Section 4 illustrates the analytical setup of our two-country monetary union model; Section 5 introduces the policy regimes; Sections 6 and 7 illustrate how our various indirect risk-sharing mechanisms work and their implications; they also provide some suggestions on welfare and their viability. Finally, Section 8 concludes the paper.

2. Policy coordination in a monetary union: the literature

A large part of the literature on European monetary policy is focused on the possibility that the ECB may be forced to prevent a sovereign debt default due to the inadequacy or ineffectiveness of national fiscal policies. However, stating that the ECB would intervene in the event of an otherwise unavoidable bankruptcy leads to a moral hazard problem, in which governments take too much risk

in their sovereign debt policies.[1] Although this issue is important, our paper bypasses it to focus on a different and more original matter: the effects of the global financial turmoil on sovereign debts. Hence, in the following model debt shocks are not induced by the irresponsible conduct of national fiscal policy authorities; conversely, the latter operate in a benevolent way to stabilize the public debt under a trade-off between financial stability and economic recovery. Moreover, our model compares the welfare results derived from the management of this trade-off, but it does not account for strategic default and domino effects. The latter issues are largely investigated in a different strand of literature (see Aguiar and Gopinath, 2006; Arellano, 2008; Yue, 2010; Chatterjee and Eyigungor, 2012; Arellano and Ramanarayanan, 2012; Mendoza and Yue, 2012; Canofari *et al*., 2015, 2017; Eijffinger *et al*., 2018).

We build a stylized core-periphery representation of the EMU, where three policymakers strategically interact: a single central bank and two fiscal national authorities that belong – respectively – to a representative core member state and a representative peripheral member state. We assume that the stability of the EMU is a common public good, which can be undermined by idiosyncratic sovereign debt shocks. Specifically, we consider a shock hitting the peripheral country and generating an excess deviation of its government debt from a given threshold. This shock is also associated with the Keynesian 'liquidity trap' situation which prevents the efficacy of conventional monetary policies. Thus, the idiosyncratic sovereign debt shock directly undermines the stability of the monetary union as a whole, and – directly or indirectly – has a negative impact on the welfare of both the core and the peripheral country. The policymakers interact in a non-cooperative way, and consequently they are not able to internalize all the policy externalities implied by the public good nature of the monetary union's stability. In the end, the outcomes of their interaction are suboptimal.

We define conventional monetary policies as the central bank's control of interest rates through, for example, operations in the overnight market. These rates mainly affect the asset-liability management of the banks' balance sheet so that liquidity can be injected into the economy through the banking channel. By contrast, we define unconventional monetary policies (QE) as the case where the central bank injects liquidity into the economy by purchasing given amounts of government bonds, which are sold in the secondary financial markets of peripheral and core countries. The central bank's purchased amounts of government bonds are fixed by a pre-determined program (monetary channel).[2] The simplified institutional setup of our stylized model

[1] The debate is illustrated in, e.g., Beetsma and Giuliodori (2010).

[2] Our terminology is consistent with the past and current management of monetary policy. During the 1980s and 1990s, a rich theoretical and policy debate led almost all central banks to switch from direct purchases of government bonds in

does not allow to fully analyze these two policy channels. However, the essence of their differences can be illustrated by assuming that only conventional policies are constrained by the recent form of the Keynesian 'liquidity trap' (see Blanchard 2009): the trap which hinders the injection of liquidity into the economy.[3]

Cooperative equilibria are currently unfeasible in the EMU due to the lack of a fiscal union. Thus, we explore alternative non-cooperative solutions by analyzing the possible effects of the implementation of either conventional monetary policies or QE initiatives aimed at overcoming disequilibria in the government balance sheet of the peripheral country. Specifically, we compare the effects of three different monetary policy responses (or regimes) to a sovereign debt crisis in the peripheral country: expansionary conventional monetary policies, quantitative easing, and announced quantitative easing.

Our main findings are that, under reasonable conditions, quantitative easing operates as an indirect risk-sharing mechanism that improves the stability of the EMU and the welfare of its different member states. On the one hand, QE distributes a part of the cost of stabilizing the EMU from the periphery to the core; on the other hand, it partially internalizes the public good nature of monetary union stabilization. The positive effects of stabilizing the EMU in response to a sovereign debt crisis in a peripheral member state are larger when a quantitative easing plan is announced *ex-ante*. The *ex-ante* signal facilitates the implementation of fiscal consolidation, since the ECB expects the peripheral country to react to monetary expansions with more fiscal consolidation. An announced quantitative easing program thus tends to imperfectly mimic a cooperative solution. We show that improving the feasibility of such a solution may require coordination between the fiscal authority in the core country and the ECB.

---

the secondary financial markets to interest rate targeting as usual procedures. This targeting was mainly based either on the central bank's window or on open market operations reserved to (specific) banks. Hence, the banking channel became the conventional tool of monetary policy. See: Bernanke and Blinder (1988, 1992), Romer and Romer (I990), Ramey (1993), Galì and Gertler (1999), Galì *et al*. (2000), and Ramey and Barth (2002).

[3] The current liquidity trap in the EMU is mainly due to the European banking sector. A necessary condition to avoid this trap is, thus, the implementation of a monetary policy through non-banking channels. QE meets this condition since, as shown in the United States (2009-2014) and in the euro area (2015-today), the huge amount of government bonds monthly purchased by the Fed and the ECB on the secondary financial markets and the related increase in the amount of liquidity injected into the economic system reduced the interest rates, despite the high liquidity preference of the banking sector. However, we know that a necessary condition is not equivalent to a sufficient one. Hence, even in the QE case, the sellers of government bonds could cause a liquidity trap or, more likely, could limit the central bank's control on interest rates. As it will become clearer below, our simplified transmission mechanism does not refer to these problems.

Our model is part of a large strand of literature on risk-sharing mechanisms and their design in currency areas.[4] Several works compare different forms of sharing the debt risk in the EMU. One of the main results is that the effects of risk-sharing mechanisms are very sensitive to their specific designs.

By comparing the empirical performance of different risk-sharing mechanisms, Furceri and Zdzienicka (2015) find that a supranational fiscal stabilization mechanism financed by a relatively small contribution could fully insure member states against very severe, persistent and unanticipated downturns. Beetsma and Mavromatis (2014) refer to a small country in a currency union. They show that the government of this country will find it convenient to reduce its debt (and thus raise the union's welfare), only if a suitably chosen and limited guarantee is introduced. They add that the union's welfare could further improve by making the guarantee conditional to policy actions. Therefore, Beetsma and Mavromatis (2014) support the introduction of eurobonds under the condition that the latter do not offer a full and unconditional guarantee to the small country. The maximum guaranteed should balance the *ex-ante* and *ex-post* incentives of the small country to leave its government debt without any control.

Favero and Missale (2012) examine the potential role of the eurobonds to solve crises in a monetary union from an empirical perspective. The two authors use a Global VAR to test the main determinants of sovereign spreads during the recent European crises. They conclude that, if properly designed, eurobond could contribute to mitigating these crises by protecting the member states of the euro area against contagion. However, Issing (2009), CESifo (2011), and Corsetti *et al*. (2011) express critical remarks towards eurobonds. Their different views depend on the weight assigned to ex-ante vs. ex-post incentives. For instance, using the well-known 'moral hazard' arguments, Issing (2009) argues that eurobonds would be too costly for taxpayers in the least indebted countries and would represent just a placebo for the most indebted ones.

From a fresh perspective stimulated by recent events, our paper also contributes to the traditional, general debate on the macroeconomic costs and benefits of monetary unification and its institutions, which are well examined by Beetsma and Giuliodori (2010). In this vein, it complements the recent literature on endogenous default and domino/contagion effects, already mentioned in this section,

[4] Pioneering studies include, among others: Melitz and Vori (1992), Wildasin (1996), Persson and Tabellini (1996a and 1996b), Asdrubali *et al*. (1996), Lockwood (1999), Mélitz and Zumer (1999 and 2002), von Hagen (2000), and Alfonso and Furceri (2008). These studies focus on the balance of national governments or on explicit mechanisms of fiscal equalization. The European policy debate on the same topic paralleled the first steps in the European monetary integration during the 1970s (cf. European Commission, 1977 and 1979).

and other theoretical models exploring the dynamics of the eurozone crisis (e.g., Aguiar *et al*. 2015; Corsetti *et al*., 2014; Corsetti and Dedola, 2016; and Broner *et al*., 2014).[5]

3. Actual policies during the European crises

On the construction of the euro area (1997), the members of the European Union (EU) agreed on the need of imposing common constraints to prevent free-riding among national fiscal authorities and the related instability in the monetary union. The Stability and Growth Pact (SGP) was the centralized tool aimed at imposing this fiscal discipline (cf. Buti *et al.*, 1998; Beetsma and Uhlig 1999). It is well known that the evolution of the SGP in the first decade of the new century was bumpy (cf., e.g., Schuknecht *et al.* 2011). In any case, until the peak of the European crises (2011-2012), this centralized mechanism was sufficient to confine the sovereign default of an EMU member state to an extreme event in the negative tail of the distribution function; whereas after the Greek crises, sovereign default was no longer seen as a 'black swan' in the EMU. This dramatic change is due to the fact that fiscal coordination among EMU member states was, at the same time, too rigid and too fragile to absorb the impact of external symmetric and asymmetric shocks coming with the European crises.

The last statement specifically applies to EMU peripheral member states characterized by structural macroeconomic disequilibria, such as an excess government debt and/or negative imbalances in their current account. These disequilibria inside the euro area remained manageable until the international crisis caused a 'sudden stop' in financial capital transfers from core to periphery and a sharp increase of the sovereign debt yields, putting the stability of the entire euro area at risk. The consequent European crisis asked for the introduction of new macroeconomic stabilization tools and risk-sharing mechanisms. On the other hand, in order to avoid moral hazard problems, there was growing pressure to counterbalance these initiatives by means of tougher enforcement of centralized fiscal rules and the activation of risk-reduction mechanisms at the national level. The opposition between risk sharing and risk reduction led to a stalemate in the euro area characterized by the recourse to more market discipline and decentralized responsibility at the national level. The dominance of market discipline increased EMU instability and ignited a recession which threatened the survival of the euro area. Monetary policy played a crucial role in temporarily overcoming this critical situation.

[5] Aguiar and Amador (2014) use a benchmark limited-commitment model to explore key issues in the economics of sovereign debt: default and renegotiation; self-fulfilling debt crises; incomplete markets and their quantitative implications. Hence, they contribute to highlighting the debt default issues.

The long recession and the unbalanced recovery stimulated a long debate in the policy arena about the institutional design of the EMU and the direction that reforms should take. Recently, this debate was based on a theoretical framework aimed at avoiding the barren opposition between risk sharing and risk reduction.[6] On the other hand, the problems of the EMU's peripheral member states stimulated a debate on the limits of monetary policy and its interaction with decentralized fiscal policies. Here we are not interested in examining either the possible evolution in European governance or the possible adjustments in peripheral countries based on internal devaluations and fiscal or basic reforms. We are instead interested in analyzing the actual impacts of a centralized monetary policy on national fiscal policies.

The recent crises undoubtedly reduced the effectiveness of orthodox monetary policies, which had become fashionable in the wake of the Great Moderation and were centered on the control of short-term interest rates. Hence, since 2008 ECB's and other central banks' efforts have first been concentrated on stressing the tools of conventional monetary policies, and then on (re)discovering new forms of the old tools neglected in the last thirty-five years. In the EU and EMU these two stages are well illustrated by – respectively – the Long-Term Refinancing Operations (LTRO: December 2011-February 2012) and the different programs of unconventional monetary policy labeled as Quantitative Easing (QE1: September 2014; and QE2: March 2015).

LTRO was effective in temporarily overcoming the liquidity crisis of European banks which reached its peak in the fall of 2011. QE1 was justified by the aim of counterbalancing deflation risks and by pushing the euro-area average inflation rate close to – but below – 2% (Draghi, 2014). This new monetary policy did not immediately include the ECB purchasing EMU government bonds. However, it created a widespread expectation of this purchase in the future. QE1 was, in fact, just the prelude to a stronger unconventional monetary policy program. In mid-January 2015, the ECB decided to launch the second stage of QE (QE2) to be implemented in March 2015. QE2 centered on the monthly purchase of 60 billion euro of government bonds by the European System of Central Banks (ESCB). The ESCB's purchases were composed by the national bonds of all the EMU's member states not included in a European aid program; and the average weight of each national bond in these purchases was fixed by the key-capital share of the corresponding member state, i.e. by the share held in the ECB's capital.

In March 2016, besides deciding to increase – since June 2016 – the amount of the ESCB's monthly purchases of government bonds in the secondary markets to 80 billion euro, the QE2 program was strengthened by fixing negative interest rates on ECB's loans to European banks (a new form of the

[6] See, e.g., Bénassy-Quéré *et al*. (2018). For a critical comment: Messori and Micossi (2018).

targeted long-term financing operations started in Fall 2014: T-LTRO2). In December 2016, the ECB decided to reduce the ESCB monthly purchases of government bonds to 60 billion euro starting from April 2017. The ECB also prolonged its purchases until (at least) the end of 2017 and decided to leave the policy interest rates unchanged for a longer time, despite the EMU's recovery. Moreover, it tacitly introduced some flexibility with respect to the key-capital rule in order to overcome the binding shortage in the supply of specific national government bonds. More recently, the ECB has signaled a further reduction of its purchases by September 2018, and the end of QE2 by December of the same year.

These new monetary policies interacted with national fiscal policies in the deep water of the EU and EMU framework, stimulating a discussion on its optimal configuration. In 2011-2012, the LTRO did not overcome the euro-area recession by increasing bank loans to the real economy (see below, sec. 5.2). However, it solved the bank liquidity crisis and put the doom-loop between bank and sovereign crises under temporary control, thus avoiding the bankruptcy of Italian and Spanish government debt and easing fiscal adjustments. Unfortunately, the solution of the bank liquidity crisis and the related stabilizing effects were inadequate to solve the fiscal problems. European QE1 and QE2 were not so effective in increasing inflation rates in the EMU from 2015 to 2017;[7] however, QE2 and its corollaries were successful in sterilizing the risks that the public debt/GDP ratio of the most vulnerable member states in the euro area was becoming unsustainable. Unfortunately, some of these fragile countries (e.g., Italy) did not exploit the opportunity to overcome the disease of their excessive government debts. In our view, which maintains that QEs operate as an indirect risk-sharing mechanism, it follows that the unconventional monetary policies implemented in the EMU did not lead to adequate risk reduction.

Our model is too simple to analyze the needed adjustments of national fiscal disequilibria inherited from the past as well as the hidden incentives of national fiscal authorities to disregard the European rules. Hence, below we assume that, both, the representative central country and the representative peripheral country start with a government budget in equilibrium. This is equivalent to stating that we do not analyze either legacy or moral hazard problems. Although these two problems are not the issue of the analysis, there are still crucial policy questions that should be examined theoretically. It can happen that there are external asymmetric shocks that hit the peripheral country and determine

[7] According to Blanchard (2016), market internationalization and the prolonged recession could have implied a flattening of the Phillips curve, so that increases in output and decreases in the unemployment rate are associated with smaller and delayed increases in monetary wages. Moreover, Draghi stated several times that the EMU's average inflation rate remained largely below 2% for a long time since nominal wages did not increase (e.g., Draghi, 2017).

an excess government deficit in this country;[8] and this disequilibrium tends to undermine the stability of a common good (EMU). Hence, two questions arise: is this instability a *private* or a *common* problem? Are expansionary conventional monetary policies or different forms of QE effective in producing adjustments from asymmetric shocks in the peripheral member state?

4. A model of a stylized monetary union

Let us now introduce our formal model, which refers to a stylized core-periphery monetary union characterized by a single central bank and two member states that represent – respectively – the core and the peripheral countries belonging to this area. Both member states control their national fiscal policies. The model is described by the following block of equations, in which the index $i \in \{C, P\}$ applies to either the core (*C*) or peripheral (*P*) country:[9]

(1) $$y_i - \bar{y} = (y_i^e - \bar{y}) - (r_i - \pi_i^e - \bar{r}) - f_i$$

(2) $$\pi_i = \beta\pi_i^e + \mu(y_i - \bar{y})$$

(3) $$d_i - \bar{d} = \varepsilon_i - f_i$$

where: y_i and π_i are, respectively, the actual output and inflation rate for country *i*; and y_i^e and π_i^e are the expected values of the previous two variables; $\bar{y}$ is the natural output in both countries, that is, the output fitting the long-run equilibrium; r_i is the actual nominal interest rate for country *i* and $\bar{r}$ is the natural one in both countries, that is, the interest rate consistent with the natural output when expectations are correctly forecasted (long-run equilibrium); d_i and f_i are, respectively, the real structural government debt and a measure of the fiscal stance; $\bar{d}$ is the long-run fiscal target in both countries; and ε_i is an idiosyncratic stochastic debt shock.[10]

Equations (1) and (2) are a conventional representation of the macroeconomic behavior in the short run. The former equation describes the demand side for country *i* in terms of a percentage deviation from its natural output ($\bar{y}$), which depends on its fiscal policy stance and on the difference between

[8] Our model also ignores symmetric shocks hitting peripheral as well as core countries. Despite empirical evidence offered by De Grauwe and Ji (2016) that the main euro-area shocks are the results of business-cycle movements, the asymmetric shocks remain the most interesting case to be theoretically analyzed by our type of model.

[9] All variables are expressed in logs.

[10] To model country specific liquidity traps, which are an important feature of our model, we assume that the single central bank controls the aggregate money supply for the monetary union as a whole. In the short run, idiosyncratic liquidity preferences may, however, affect the working of incomplete money markets implying temporary but specific differences between actual and natural interest rates in each of the two countries. Given that the latter have the same productive size in equilibrium and are submitted to a common monetary policy, we can assume that the natural interest rate is equal in core and peripheral countries. Hence, the temporary specific differences between the actual and natural interest rates in the two countries can be interpreted as temporary differences between the core and the peripheral actual interest rates. Let us add that, in the long run, we assume full symmetry so that common inflation and interest rates are observed.

the expected nominal interest rate and its natural level. Equation (2) describes the supply side of our stylized economy. In a New Keynesian fashion, it relates the actual inflation rate to the output gap and includes the expected future inflation rate because of price stickiness.

Equation (3) describes the government debt deviations from their long-run target ($\bar{d}$). We assume that this target, being compliant with the monetary union's rules, represents a benchmark consistent with country *i*'s fiscal stability so that we can interpret ε_i as a sovereign debt shock. In our model, government debt is not affected by policy changes in nominal interest rates. In fact, being interested in the costs and benefits of a different channel (i.e., the indirect effects of monetary policy on periphery fiscal consolidation), we assume that – in the wake of a debt sovereign crisis – the central bank cannot or does not want to directly affect the cost of the government debt.[11]

As already stated, we assume that the central bank is capable of controlling the aggregate money supply for the whole union. Together with the liquidity preference functions, the aggregate money supply determines the actual nominal interest rates of each of the two countries as follows:

(4) $$r_i = \bar{r} - \gamma\,(m - m_n) + \delta\left(\ell_i - \bar{\ell}\right)$$

where *m* is the actual aggregate money supply, and m_n is its natural (long–run) level; ℓ_i is the portion of *m* hoarded in country *i* at the different values of r_i, so that $\left(\ell_i - \bar{\ell}\right)$ represents the short–run deviations of this portion from its natural level $\bar{\ell}$ which is consistent with $\bar{r}$ when $m = m_n$; γ and δ are two positive parameters.

Given (4), equation (1) can be rewritten as:

(5) $$y_i - \bar{y} = (y_i^e - \bar{y}) + \gamma\,(m - m_n) - \delta\left(\ell_i - \bar{\ell}\right) + \pi_e - f_i$$

Equation (5) shows that the common central bank can inflate the economy by increasing the actual money supply above m_n; however, the impact of this increase on the actual output of country *i* can be partially offset by a positive increase in the deviation of the actual liquidity preference from its natural level. The latter increase is equivalent to state that a larger portion of the excess of *m* with respect to m_n would be hoarded so that the expansionary monetary policy would have a reduced effect on the actual inflation rate. In the case of the so-called Keynesian 'liquidity trap' (see Hicks 1937), where the liquidity preference becomes infinite for a given level of the interest rate, an expansionary monetary policy does not inflate the economy.

Subsequently, for the sake of simplicity, we assume that ℓ_i can just take two polar values which are based on equation (4). In each country, conditional to the central bank's rescue initiative, we can have either (6a) or (6b):

[11] Canofari *et al*. (2017) discuss the effects that a direct risk-sharing mechanism can produce in a similar context.

(6a) $$\ell_i = \bar{\ell} + \frac{\gamma}{\delta}\,(m - m_n)$$

(6b) $$\ell_i = \bar{\ell}$$

where $i \in \{P, C\}$.

Equation (6a) implies that country *i* is characterized by the ineffectiveness of monetary policy due to the liquidity trap; by contrast, equation (6b) implies that deviations of the money supply from the natural level have full short–run real effects on the economy.

5. Policymakers' preferences and debt shocks in different policy regimes

5.1 Policymakers' preferences, monetary union's stability, and sovereign debt shocks

The single central bank has two targets: it aims to guarantee price stability, but it is also interested in avoiding the breakup of the monetary union.[12] Formally, the central bank loss function is:

(7) $$B = \frac{1}{2}\,\pi^2 + \frac{\mathrm{c}}{2}\,prob_B^2$$

where: *c* is the weight that the central bank assigns to the probability of the monetary union's breakup ($prob_B$) relatively to the inflation goal, which will be defined later.

Each of the two national fiscal authorities focuses on its domestic outcomes: its output gap, its inflation rate, and its fiscal stability. Moreover, they are also concerned that the monetary union does not breakup, since this union represents a public good. Formally, the loss of country *i's* fiscal authority ($i \in \{P, C\}$) is defined by: [13]

(8) $$F_i = \frac{1}{2}\,(y_i - \bar{y})^2 + \frac{a_i}{2}\,{\pi_i}^2 + \frac{b_i}{2}\left(d_i - \bar{d}\right)^2 + \frac{c_i}{2}\,prob_B^2$$

where: a_i and b_i are positive parameters assessing the weights that fiscal authority *i* assigns to the deviations of – respectively – its inflation rate and its real structural government debt from their equilibrium values relatively to the deviation of its actual output from the target level;[14] and c_i is the weight that fiscal authority *i* assigns to the probability of the monetary union's breakup relatively to the latter deviation.[15]

---

[12] The former assumption derives from the European Treaties. The latter is compliant with the Outright Monetary Transactions (OMT) program, announced by Draghi at the end of July 2012 and launched by the ECB at the beginning of the following September.

[13] The representation of the fiscal authorities' preferences is in line with the existing literature (see, e.g., Dixit and Lambertini, 2001, 2003a and 2003b; Demertzis *et al*., 2004; Buti *et al*., 2009; Di Bartolomeo and Giuli, 2011). For a general discussion about the model strategies that introduce fiscal policy in policy games, see Ciccarone *et al*. (2007); Beetsma and Giuliodori (2010).

[14] We assume that the output target coincides with the natural level, and we normalize the target inflation rate to zero.

[15] It is evident that c_i ($i \in \{P, C\}$) is different from *c* in equation (8) since it refers to different policymakers and is weighted relatively to a different benchmark.

Equations (7) and (8) emphasize the importance that policymakers attribute to the stability of the monetary union. Hence, it is necessary to specify the determinants of $prob_B$. We assume that the structural fragility of the peripheral country implies that its domestic fiscal instability immediately becomes a national debt crisis. Moreover, we assume that a sovereign debt crisis in the periphery implies the breakup of the common currency. It follows that the monetary union breakup probability ($prob_B$) can be formalized as:

(9) $$prob_B = \max\{d_P - \bar{d}, 0\}$$

It is worth noting that the peripheral country can avoid fiscal instability by adopting a restrictive fiscal policy (debt consolidation: $f_P > 0$) whenever $d_i > \bar{d}$. This is equivalent to stating that the fiscal authority of country *p* is potentially able to offset the consequences of a sovereign debt shock ($\varepsilon_P > 0$) on the stability of the monetary union as a whole.

In this stylized monetary union model, equilibrium can be easily obtained in the absence of disturbances (natural equilibrium). Formally, natural equilibrium implies $f_i = 0$ and $\ell_i = \bar{\ell}$ for $i \in \{P, C\}$ as well as $m = m_n$. Given equations (4) and (1), this leads to: $r_i = \bar{r}$, $\pi_i = \pi^e = 0$, and $y_i = y_i^e = \bar{y}$. The result is equivalent to stating that, if $\varepsilon_i = 0$, no action from policymakers will be required since all the targets are met. By contrast, policymakers would have to be active when a debt shock hits the economy.

Here we are interested in formalizing the policy initiatives that can counter the effects of a financial turmoil and a sovereign debt crisis in a monetary union. Given our previous assumptions, a fiscal shock ($\varepsilon_P = \bar{\varepsilon}_P > 0$ and $\varepsilon_c = 0$) triggers a sovereign debt crisis in the periphery which undermines the stability of the monetary union (see equation (9)). Hence, to analyze the effectiveness of different policy initiatives, we can restrict our attention to the effects that a peripheral government debt, becoming out of control due to an exogenous and idiosyncratic fiscal shock, produces in terms of sovereign debt crisis in the periphery and financial turmoil in the monetary union as a whole, thus increasing the breakup probability.

5.2 Policy regimes

We compare the effects of three different monetary policy responses to a sovereign debt crisis in the periphery:

1. Conventional monetary policies (*LT*)
2. Quantitative easing (*QE*)
3. Announced quantitative easing (*QEA*)

Each of these policies determines the various strategic interactions between the peripheral fiscal authority, the core fiscal authority, and the central bank.

In the case of conventional monetary policies, we stylize the poor impact of the expansionary LTRO on the European real economy by assuming that the single central bank cannot actively pursue the control of the inflation rate and the stability of the monetary union because of the 'liquidity trap'.[16] This implies that any change in the amount of money injected into the real economy cannot modify the amount of money in circulation. Hence, any deviation of m from m_n cannot affect the nominal interest rate. Formally, when the central bank adopts expansionary but conventional policies, (6a) holds. In such a case, $r_i = \bar{r}$ independently of the initiatives taken by the common central bank, and the policy game equilibrium is determined by the interactions between the two fiscal authorities.

In the case of *QE*, in which the central bank directly purchases given amounts of government bonds issued by the peripheral and core countries according to a specific program, as in the actual QE2 implemented in the euro area, we assume that this non-conventional monetary policy is not constrained by the 'liquidity trap' (see fn. 3). Hence, the interest rate is determined by

$$r - \bar{r} = -\gamma\,(m - m_n) \tag{10}$$

Equation (10) obviously means that the central bank is capable of reducing the actual nominal interest rate below its natural rate by supplying an amount of money that is higher than its natural level. In implementing the *QE* program, the central bank minimizes (7) subject to (1)-(3) and (10). This emphasizes that the central bank cannot directly affect the management of the sovereign debt in the two countries, since the possible deviations of the real structural government debts of these countries from the long-run fiscal target depend on the decisions taken by the national fiscal authorities, which are only indirectly influenced by the monetary stance. Thus, the central bank can just focus on the inflation target.

In the case of the announced *QE* regime, the central bank continues to directly purchase large amounts of government bonds issued by the peripheral and core countries – as in the actual QE2. Moreover, we continue to assume that the non-conventional monetary policy is not constrained by the 'liquidity trap'. However, differently from the *QE*, in *QEA* the central bank tries to anticipate the reaction of the peripheral fiscal authority to its non-conventional monetary policy.[17] Therefore,

[16] This is equivalent to stating that the modern form of the 'liquidity trap' is related to the banking sector (see Blanchard 2009).

[17] Roughly speaking, we could state that the announced *QE* strengthens the actual QE2 since the central bank signals to the national fiscal authorities that it is taking account of their specific reactions. In this sense, *QEA* stylizes a feature of the actual QE1, where the ECB anticipates that national fiscal authorities are waiting for its future purchase of government bonds. On the other hand, *QEA* also stylizes some corollaries of the actual QE2 since ECB anticipates the markets and policies' reaction to the negative interest rates. Announced *QE* can thus be interpreted either as a combination of actual QE1 and QE2, or as a combination of actual QE2 and the second form of T-LTRO labelled as T-LTRO2.

the optimal monetary policy of the central bank also internalizes its effects on the public debt of the peripheral country. Formally, the central bank minimizes (7) subject to (1)–(3) and (10) as well as to the reaction functions of the national fiscal authorities.[18]

6. Policy game equilibria and the conventional monetary policy

6.1. The general setting

In all the *LT*, *QE* and *QEA* regimes, the policy game equilibrium is determined by the strategic interactions between the fiscal and monetary authorities. In any case, policymakers minimize their losses under constraints (1)–(3) and (10), but each of the three regimes ascribes a different role to the 'liquidity trap', to the anticipations that the national fiscal authorities formulate with respect to the central monetary policy, and to the anticipation that the central bank formulates with respect to the reaction of the peripheral fiscal authority toward its monetary policy. To determine the outcomes of the strategic interactions in the different policy regimes, we first have to analytically specify the optimal choices of the different policymakers. In both steps, we use a compact and general form.[19]

In all policy regimes, the fiscal authorities' reaction functions can be written as

(11) $$f_i = \frac{g_i}{1+\mu^2 a_i+g_i}\varepsilon_i - \frac{1+\mu^2 a_i}{1+\mu^2 a_i+g_i}(r_i - \bar{r})$$

where: $i \in \{P, C\}$; $g_p = b_p + c_p$ and $g_c = b_c$.

Equation (11) implies that the national fiscal authorities always react to a fiscal shock ($\varepsilon_i > 0$) and to the related monetary expansion ($m > m_n$) by means of a public debt consolidation ($f_i > 0$). Let us recall that we focus on $\varepsilon_p > 0$ and $\varepsilon_c = 0$, i.e., on an idiosyncratic shock and on the consequent sovereign debt crisis in the periphery. Let also define $A_i = \frac{g_i}{1+\mu^2 a_i+g_i} < 1$ and $B_i = \frac{1+\mu^2 a_i}{1+\mu^2 a_i+g_i} < 1$, where these two expressions measure the reaction of the fiscal authorities to a debt shock and to the related monetary policy, respectively.

The equilibrium of the policy game is determined by the minimization problem of the central bank, by (11) and by an additional equation determining the interest rates. Generally speaking, the actual nominal interest rates are fixed by the optimal monetary policy of the central bank. However, in the case of a conventional monetary policy, it is easy to check that $r_i = \bar{r}$ since the central bank is

[18] Details on these reaction functions will be provided in the next section.

[19] The formal derivation of all policy game equilibria is provided in the Appendix.

constrained by the 'liquidity trap' (see equation 6a). Hence, the equilibrium of the policy game is determined only by (11).

In the cases of *QE* and *QEA*, the central bank is not constrained by the liquidity trap (that is, equation 6b holds). Hence, its optimal choice can be determined as:

$$\pi \frac{\partial \pi}{\partial m} + \mathrm{c}\left(d_p - \bar{d}\right) \frac{\partial d_p}{\partial f_p} \frac{\partial f_p}{\partial m} = 0 \tag{12}$$

Equation (12) does not hide the differences between the two *QE* regimes. Let us first refer to *QE*. If the central bank does not announce its optimal monetary policy and the related rescue plan, this policy cannot affect the fiscal policy of the peripheral authority. It follows that: $\partial f_p / \partial m = 0$. This implies that *QE* always leads to: $\pi = 0$. The rationale of this result is that the central bank cannot directly affect its second target, that is, the stability of the monetary union, since it utilizes its sole instrument (m) to efficiently achieve its first target: $\pi = 0$ (see fn. 14). Conversely, in the case of *QEA*, the central bank announces its optimal monetary policy. This policy incorporates its expected impact on the choices of the peripheral fiscal authority, that is, it already takes into account that the peripheral authority will react to the expansionary monetary policy by strengthening its fiscal consolidation policy (see equation (11)). Therefore, $\partial f_p / \partial m > 0$, and hence $\pi > 0$. The rationale of this result is that the central bank has still only one instrument (m) but tries to pursue both targets ($\pi = 0$, and the stability of the monetary union). Hence, it has to find a balance between these targets.

Equations (11) and (12) lead to the specification of the different optimal policies associated with the three different regimes. To determine the policy outcomes of the three related games, it is necessary to plug these policies into equation (7) subject to equations (1)–(3) and (10). We describe and compare the outcomes of the strategic interactions in each of the different policy regimes in the following sub-sections.

6.2 Conventional monetary policies: The liquidity trap equilibrium

We know that, in the policy game centered on the conventional monetary policy, the equilibrium is determined only by (11). The behavior of the single central bank is ineffective, so that $r_i = \bar{r}$. Given the fiscal shock affecting the periphery, the outcomes thus depend on the reactions of the two national fiscal authorities.

This shock produces negative effects in the core country since it increases the breakup probability of the monetary union. However, the core fiscal authority cannot influence the peripheral fiscal policy and its related public debt. Therefore, it does not take any action, meaning that the output gap and the inflation rate of the core country are unaffected. Formally, equation (1) implies that:

$$f_c^{LT} = y_c - \bar{y} = \pi_c^{LT} = 0.$$ [20]

Conversely, this same shock determines the reaction of the peripheral fiscal authority. The increase in the deviation of the periphery's real structural government debt from the long-run fiscal target leads to a fiscal policy aimed at government debt consolidation. This consolidation plan has a recessionary and deflationary impact. Hence, it is carried out to equalize its marginal benefits, measured by the reduction in the deviation of the national public debt and in the breakup probability of the monetary union, and the marginal costs, measured by the increase in the output gap and in the negative sign of the actual inflation rate. Formally, the government debt consolidation in the periphery that meets the latter equalization condition is expressed by:

(13) $$f_p^{LT} = A_p \varepsilon$$

The corresponding outcomes for the peripheral countries are:

$$\left(y_p - \bar{y}\right)^{LT} = -A_p \varepsilon_p,\ \pi_p^{LT} = -\mu A_p \varepsilon_p, \text{ and } \left(d_p - \bar{d}\right)^{LT} = \left(1 - A_p\right)\varepsilon_p.$$

It is worth noting that the inflation rate in the monetary union is proportional to the inflation rate in the peripheral country, $\pi^{LT} = -\mu A_p \varepsilon_p / 2$, so that the union as a whole is in deflation. It is also worth noting that $\left(1 - A_p\right)\varepsilon_p$ is a measure of monetary union instability. These elements emphasize that the policy of government debt consolidation, implemented by the peripheral fiscal authority, is suboptimal for the monetary union. The rationale is that the periphery's policymaker is unable to anticipate the externalities that its fiscal policy will produce in the core country.

7. Policy game equilibria: the unconventional monetary policies

7.1 Quantitative easing

We can approach the policy game centered on quantitative easing by referring to the last equilibrium feature of the previous policy game, centered on the conventional monetary policy: the deflation suffered by the monetary union as a whole (see section 6). We know that this deflation is caused by the reaction that the peripheral fiscal authority adopts when its country is hit by a fiscal shock. Differently from the previous regime, in the case of quantitative easing, the single central bank is not powerless because of the liquidity trap. Hence, it would like to pursue both its targets: an inflation rate equal to zero, and the minimization of the monetary union's breakup probability. However, just like the core fiscal authorities in the previous and the current policy game, the central bank is unable to influence the fiscal policy and the related management of government debt in the

[20] We use the *LT* apex to denote the equilibrium outcomes of the game centered on conventional monetary policies. Subsequently, apexes *QE* and *A* will refer to the games centered on quantitative easing and on announced quantitative easing, respectively.

peripheral country. Hence, its only instrument (the aggregate money supply) can only oppose the deflation, but it cannot affect the breakup probability.

The central bank reacts to the deflation caused by the peripheral fiscal authority by adopting an expansionary monetary policy. It increases the aggregate money supply above its natural (long-run) level until its target (zero inflation rate) is met. Formally, we have:

(14) $$(m - m_n)^{QE} = \frac{A_p}{\gamma(2-B_c-B_p)}\bar{\varepsilon} > 0$$

Note that the central bank's inflationary target is defined in average terms: $\pi^{QE} = 0$. Hence, equation (14) does not imply a zero-inflation rate in the peripheral country: it reduces the absolute value of the deflation rate in the periphery and, in the meantime, causes a positive inflation rate in the core. In short, the monetary expansion affects the previous zero inflation equilibrium in the core country.

The consequence is that core country's fiscal authority reacts with a fiscal contraction ($f_c^{QE} > 0$), aimed at returning to the zero-inflation rate. Formally, we have:

(15) $$f_c^{QE} = \frac{A_p B_c}{2-B_c-B_p}\bar{\varepsilon}$$

This reaction does not produce the expected results since $\pi^C = 0$ is incompatible with $\pi^{QE} = 0$, given the deflationary policy in the periphery implies that $\pi^P < 0$. Any attempt to contrast the central bank target is doomed to fail, since the central bank can expand the money supply until its target ($\pi^{QE} = 0$) is reached. The core country will thus be characterized by a positive inflation rate $\pi_c^{QE} = \frac{\mu(1-B_c)A_p\bar{\varepsilon}}{2-B_c-B_p} > 0$, and by a consequent undesired increase of its actual output above the natural output which will determine a positive output gap.

These partial outcomes of the policy game being examined show that the adoption of *QE* does not eliminate inefficiencies. The latter are due to a lack of coordination between the single central bank and the core fiscal authority, and the result is that the restrictive stance of the core fiscal policy is ineffective since its impact is fully offset by *QE*.

This monetary expansion also affects the periphery's fiscal policy. The peripheral fiscal authority finds it convenient to implement further public debt consolidation since the permissive monetary stance reduces the costs of fiscal restrictions in terms of output reductions. Formally, we have:

(16) $$f_p^{QE} = A_p \frac{2-B_c}{2-B_c-B_p}\bar{\varepsilon} > A_p\bar{\varepsilon} = f_p^{LT}$$ [21]

[21] It is easy to verify that the inequality of equation (16) holds, i.e. $2 - B_c > 2 - B_c - B_p$.

Equation (16) shows that *QE* implies a lower breakup risk for the monetary union with respect to the conventional policy game. Moreover, together with equations (2) and (3), it shows that *QE* mitigates the recession (and the deflation rate) in the peripheral country. Formally, we have:

$$\left(y_p - \bar{y}\right)^{QE} = -A_p \frac{1-B_c}{2-B_c-B_p}\bar{\varepsilon} > -A_p\bar{\varepsilon} = \left(y_p - \bar{y}\right)^{LT}.$$

Given that $B_p < 1$, it follows that $(1 - B_c)/(2 - B_c - B_p) < 1$; then, the previous inequality continues to hold.

The outcomes of the *QE* policy game in the peripheral and core countries emphasize that *QE* operates as an indirect risk-sharing mechanism. Although designed to eliminate deflation, *QE* facilitates the implementation of debt consolidation in the peripheral country at the cost of imposing a higher inflation rate on the core country. Therefore, it partially transfers the burden of stabilizing the monetary union from the periphery to the core. The inefficiencies of *QE* depend on the fact that this form of risk sharing is the result of non-cooperative interaction between the three policymakers. In particular, coordination between the core fiscal authority and the single central bank would eliminate the costly consolidation of government debt in the core country, and it would thus increase the likelihood that *QE* will become a Pareto improving policy compared to an expansionary but conventional monetary policy. As long as the core country is sufficiently concerned about the stability of the monetary union as a whole, this could hold true even without cooperation. In terms of welfare effects, the ECB and the peripheral country are always better off in the case of *QE*, and the core country would decrease or avoid its losses (inflation rate higher than 0 and useless public debt consolidation) by sufficiently caring for the minimization of the breakup probability of the monetary union.

7.2 Announced quantitative easing

The third policy game is based on a *QE* program that has a specific feature: the single central bank can influence the management of the peripheral public debt (and hence, monetary union stability) by anticipating the national fiscal authority's reaction to its announced monetary policy. For the sake of simplicity, here we assume that the central bank's expectations are always fulfilled so that its anticipations are correct. In this situation, the central bank acquires a full control over the trade-off between its two targets (zero inflation rate and monetary union stability): it can calibrate each further increase of the inflation rate above the zero target in terms of its impact on strengthening government debt consolidation in the peripheral country. It can be intuited that, in this new policy game (*QEA*), the willingness of the central bank to raise the inflation rate above the target is stronger than in the *QE* regime. As a result, the central bank pursues a larger expansionary monetary policy generating a positive inflation rate $\pi^A > 0$ (where: $\pi^A > \pi^{QE}$).

To prove these results, we can formally determine the equilibrium value of the money supply and that of the government debt consolidation in the peripheral country. We have:

$$(17) \qquad (m-m_n)^A = \frac{1}{\gamma}\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon} > \frac{A_p}{\gamma(2-B_c-B_p)}\bar{\varepsilon}=(m-m_n)^{QE}$$

$$(18) \qquad f_p^A = A_p\frac{2\gamma-A_c}{2\gamma-A_c-A_p}\varepsilon > A_p\frac{2-B_c}{2-B_c-B_p}\bar{\varepsilon} = f_p^{QE} > f_p^{LT}.$$

Recalling the reaction of the core fiscal authority to $\pi^C > 0$ in the *QE* regime, it is obvious that this same fiscal authority will *a fortiori* react to $\pi^A > 0$. The core country will thus implement a more severe public debt consolidation. Formally, we have:[22]

$$(19) \qquad f_c^A = \frac{1}{\gamma}\frac{\gamma A_p B_c(2-B_c-B_p)\mu^2+4cB_cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon} > \frac{A_pB_c}{2-B_c-B_p}\bar{\varepsilon} = f_c^{QE}$$

Analogously to the *QE* regime, the announced QE (*QEA*) operates as an indirect risk-sharing mechanism. *QEA* facilitates the implementation of government debt consolidation policies in the peripheral country, and it partially transfers the cost of decreasing the probability of the monetary union's breakup to the core country. The equilibrium in the *QEA* policy regime, as stated by equations (17)–(19), is associated with the lowest breakup risk of the monetary union with respect to the other two policy regimes. However, the core country faces an undesired increase in its inflation rate ($\pi^C > 0$) and a consequent undesired increase in its actual output above the natural output. It is worth noting that these increases are greater than the corresponding increases in the case of *QE*; on the other hand, the recession in the peripheral country is smaller.

In terms of welfare analysis, we can thus state that the peripheral country and the ECB are better off in *QEA* than in *LT* and even in *QE*. The core country may also prefer *QEA*, if it is sufficiently concerned about the stability of the monetary union. This result allows us to state that *QEA* mimics a cooperative solution aimed at internalizing the cost of monetary union stabilization, since the cost of government debt consolidation is counterbalanced by the ECB's monetary policy. On the other hand, in the *QEA* policy regime, this cost is fully imposed on the core country, and it can be so high as to decrease the welfare in the core country with respect to *LT* and *QE*. Therefore, coordination between the core fiscal authority and the ECB would increase the welfare of the monetary union. Once the costs of the restrictive fiscal policy in the core country are internalized, the latter country would probably support the implementation of the *QEA* policy game. Even if it seems paradoxical, the core country can maintain that the amount of money supplied by the ECB to support public debt consolidation in the periphery is too prudent. To obtain this result, it is sufficient to consider that

[22] A proof of the inequality in (19) can be obtained by cumbersome algebra by expanding A_p and B_p. Mathematical passages are available upon request.

coordination meets two conditions: the costs of the core country could also be internalized, and this country's actual concern about monetary union stability and the zero-inflation rate could be aligned with the ECB's preferences.

8. Discussion and conclusion

Since the launch of the euro area in 1999 the European institutional and governance design has been a construction site. The tension between risk sharing and risk reduction remains unresolved, tending to produce a stalemate in this design and the consequent recourse to market discipline. The latter hinders the convergence between the core and the peripheral EMU member states, thus worsening their relationships and feeding a growing lack of reciprocal trust. The same applies to the attitude of national governments and populations towards European institutions. A possible exit from this dangerous situation would be a strengthened coordination between European and national policy authorities. If this coordination had been operative in the recent past, there would have been a dramatic reduction in the costs paid to overcome the European banking and sovereign debt crises. The European economic recession would have been shorter and less severe. Today, the existence of this same coordination could improve the stability of the euro area as well as its actual growth rate.

In this paper, we have considered the impact of financial instability on sovereign debts of a representative peripheral country. The aim was to show that quantitative easing might operate as an indirect risk-sharing mechanism that could improve EMU stability and the welfare of (some of the) member states. The rationale of our finding is twofold. First, quantitative easing reduces the cost of fiscal adjustment in the periphery, incentivizing consolidation policies that decrease the default probability and stabilize the EMU. Secondly, although the representative core country benefits from the euro area stabilization (which is a public good), it has to face some costs; hence, quantitative easing is not compatible with the optimal core equilibrium. It results that, although it is certainly true that the periphery improves its welfare, the government of the core country faces a trade-off between the improved stability of the euro area and its national cost; and it is impossible to state, as a general rule, that the expected gain of improved stability is higher than the expected related costs. We can only note that, if a quantitative easing plan in response to a sovereign debt crisis in a peripheral country is announced, this *ex-ante* signal will facilitate the implementation of fiscal consolidation in this member state.

In order to specify these results, we focused on the potential costs of the lack of coordination when an indirect risk-sharing mechanism is introduced through the ECB's monetary policy reaction to sovereign debt shocks. We compared the effects of three different monetary policy responses to a

shock in the peripheral country: conventional monetary policies, quantitative easing, and announced quantitative easing. These three regimes provide three different levels of risk sharing.

1. In the case of an expansionary conventional monetary policy, the entire burden of EMU stabilization falls on the periphery. An expansionary monetary policy can have no impact due to the liquidity trap. Moreover, fiscal consolidation in the periphery cannot be influenced by the core and has no effect on the core, so that the fiscal authority of the core country does not take any action. However, if we recognize that the stability of the euro area is a public good, in principle the core country will be willing to pay a moderate cost for more consolidation and to look for cooperative solutions. This implies that the *LT* solution is suboptimal. In a sort of prisoner dilemma, the core fiscal authority does not play an active role only because of the non-cooperative nature of the interactions.

2. In the quantitative easing case, the monetary policy will become effective even if it cannot influence the peripheral country's decisions on fiscal consolidation. *QE* can only react to the deflationary and recessionary effects of this consolidation at the national level and, as a byproduct, at the monetary union level. The ECB's monetary expansion leads to an average inflation rate of the union equal to zero. This expansion has a beneficial effect on the peripheral country because it reduces the cost of fiscal consolidation and allows for more severe fiscal adjustments. However, this greater stability has a cost for the core country, since the latter suffers an undesired expansion and, therefore, an undesirable positive inflation rate (see fn. 14). Moreover, if the core country does not internalize the effects of the unconventional monetary policy (by means of coordination with the ECB), it will react to its inflation rate by reducing its public spending. This fiscal adjustment is useless, since it is always fully offset by the ECB; it generates an additional cost for the core country.

   From the welfare point of view, *QE* acts as a risk-sharing mechanism that replaces the cooperative solution by shifting the cost of stabilization from the peripheral to the core country. The welfare of the periphery undoubtedly increases, whereas the welfare of the core depends on the relative weight attributed by the latter to the costs of higher inflation and lower government spending with respect to the benefits deriving from greater stability of the monetary union. It seems reasonable to assume that, in the EMU's recent crises, the stability benefits would have been higher than the inflation's costs. However, the core country also suffers the costs of a "useless" spending reduction. Hence, it will be difficult to assess if *QE* improves or reduces the welfare of the core country. An appropriate policy intervention could tip the scale in favor of a

welfare improving *QE*: it would be sufficient to have coordination between the fiscal authority in the core country and the ECB.

3. Announced quantitative easing works more efficiently. In this regime, the ECB anticipates that the peripheral country will react to an expansive monetary policy with fiscal consolidation. Then, the ECB will choose the inflation rate that equalizes the marginal benefits (EMU stability) and the marginal costs (higher inflation) of the monetary expansion, giving up the (zero) inflation target. The result is a greater monetary expansion and stronger EMU stability. This mechanism fully reproduces that of the previous *QE*, except that the policy's aim is not to achieve a zero inflation rate but to optimize the tradeoff between EMU stabilization and the EMU inflation rate. The welfare effects are also similar to those discussed in the *QE*'s case. Let us just add that the ECB acts in the interest of EMU countries. Hence, the ECB's tradeoff between the inflation rate and stabilization would have to coincide with that of the core country. Consequently, if it is possible to eliminate spending reductions costs, it will follow that announced quantitative easing comes very close to the cooperative solution.

Our conclusion is that the announced quantitative easing program tends to imperfectly mimic a cooperative solution: this program implies risk sharing between the periphery and the core. However, to improve its feasibility, announced quantitative easing requires coordination between the core country and the ECB. In that case, it is reasonable to state that there is a high probability that announced quantitative easing can also increase the core country's welfare.

Appendix – Full derivation of the regime equilibria

A1. Conventional monetary policy

The liquidity trap implies that $\ell_i = \bar{\ell} + \frac{\gamma}{\delta}(m - m_n)$ in both countries, and thus $r_i = \bar{r}$. Under this condition, fiscal authorities minimize (8) constrained by (1)–(3) and (7). Corresponding reaction functions are:

(A1) $$f_p = A_p \varepsilon_p$$

(A2) $$f_c = 0$$

Equations (A1) and (A2) are also the equilibrium policy (i.e., $f_p^{LT} = A_p \varepsilon_p$ and $f_c^{LT} = 0$). Substituting the previous (1)–(3) with these two equations, we obtain the outcome equilibrium:

(A3) $$\left(y_p - \bar{y}\right)^{LT} = -A_p \varepsilon$$

(A4) $$\pi_p^{LT} = -\mu A_p \varepsilon$$

(A5) $$\left(d_p - \bar{d}\right)^{LT} = \left(1 - A_p\right)\varepsilon_p$$

(A6) $$(y_c - \bar{y})^{LT} = \pi_c^{LT} = 0$$

A2. Quantitative easing

In this case, the liquidity trap does not hold so that: $r_i - \bar{r} = -\gamma\,(m - m_n)$. All the policymakers minimize their losses under constraints (1)–(3) and (7). The resulting reaction functions are:

(A7) $$f_p = A_p\bar{\varepsilon} + \gamma B_p(m - m_n)$$

(A8) $$f_c = \gamma B_c(m - m_n)$$

(A9) $$m - m_n = \frac{1}{2}\left(f_p + f_c\right)$$

Solving system (A7)–(A9), we get:

(A10) $$f_p^{QE} = A_p\,\frac{2-B_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A11) $$f_c^{QE} = \frac{A_pB_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A12) $$(m - m_n)^{QE} = \frac{A_p}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A10)-A(12) can also be expressed as:

(A10 bis) $$\left(y_p - \bar{y}\right)^{QE} = -A_p\,\frac{1-B_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A11 bis) $$\pi_p^{QE} = -\mu A_p\,\frac{1-B_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A12 bis) $$\left(d_p - \bar{d}\right)^{QE} = \bar{\varepsilon} - A_p\,\frac{2-B_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

The same three equations can also become:

(A10 ter) $$(y_c - \bar{y})^{QE} = A_p\,\frac{1-B_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A11 ter) $$\pi_c^{QE} = \mu A_p\,\frac{1-B_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

(A12 ter) $$\left(d_c - \bar{d}\right)^{QE} = -\frac{A_pB_c}{2-B_c-B_p}\,\bar{\varepsilon}$$

The aggregate inflation rate is:

(A13) $$\pi^{QE} = 0$$

A3. Announced QE

Now, the fiscal authorities behave as stated in the previous equations (i.e., (A10) and (A11)), whereas the central bank minimizes (7) subject to (A10) and (A11). Its optimal policy then implies:

(A14) $$(m-m_n)^A = \frac{1}{\gamma}\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon}$$

It follows (by using (A10) and (A11)) that:

(A15) $$f_p{}^A = A_p\bar{\varepsilon} + B_p\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon}$$

(A16) $$f_c{}^A = B_c\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon}$$

By using (A14), (A15), and (A16) in (1)–(3), we get

(A17) $$(y_p-\bar{y})^A = -\left[1-(1-B_p)\frac{(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\right]A_p\bar{\varepsilon}$$

(A18) $$\pi_p^A = -\mu\left[1-(1-B_p)\frac{(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\right]A_p\bar{\varepsilon}$$

(A19) $$(d_p-\bar{d})^A = \left[1-A_p+B_p\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\right]\bar{\varepsilon}$$

(A20) $$(y_c-\bar{y})^A = (1-B_c)\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon}$$

(A21) $$\pi_c^A = \mu(1-B_c)\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon}$$

(A22) $$(d_c-\bar{d})^A = -B_c\frac{A_p(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\bar{\varepsilon}$$

It's easy to check that $\left[1-(1-B_p)\frac{(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\right] > 0$.

The aggregate inflation is:

(A23) $$\pi^A = \frac{A_p}{2}\left(1+\frac{(B_p+B_c)(2-B_c-B_p)\mu^2+4cB_p(1-A_p)}{(2-B_c-B_p)^2\mu^2+4cB_p{}^2}\right)\bar{\varepsilon}$$

References

Aguiar, M., G. and Gopinath (2006), "Defaultable debt, interest rates and the current account," *Journal of International Economics*, Vol. 69, No. 1, pp. 64–83.

Aguiar, M., and M. Amador (2014), "Sovereign debt," in *Handbook of International Economics*, North-Holland, Amsterdam, Vol. 4, pp. 647–87.

Aguiar, M., M. Amador, E. Farhi, and G. Gopinath (2015), "Coordination and crisis in monetary unions," *Quarterly Journal of Economics*, Vol. 33, No 2, pp. 1727–1779.

Alfonso, A., and D. Furceri, 2008, "EMU enlargement stabilization costs and insurance mechanisms," *Journal of International Money and Finance*, Vol. 27, pp. 169–187.

Arellano, C. (2008), "Default risk and income fluctuations in emerging economies," *American Economic Review*, Vol. 98, No. 3, pp. 690–712.

Arellano, C. and A. Ramanarayanan (2012), "Default and the maturity structure in sovereign bonds," *Journal of Political Economy*, Vol. 120, No. 2, pp. 187–232.

Asdrubali, P., B.E. Sorensen and O. Yosha, 1996, "Channels of interstate risk sharing: United States 1963-90," *Quarterly Journal of Economics*, Vol. 111: 1081–1110.

Beetsma, R., and H. Uhlig (1999), "An analysis of the Stability and Growth Pact", *Economic Journal*, Vol. 109, pp. 546–571.

Beetsma, R., and M. Giuliodori (2010), "The macroeconomic costs and benefits of the EMU and other monetary unions: An overview of recent research," *Journal of Economic Literature*, Vol. 48, pp. 603–641.

Beetsma, R., and K. Mavromatis (2014), "An analysis of Eurobonds," *Journal of International Money and Finance*, Vol. 45(C), pp. 91–111.

Bénassy-Quéré, A., M. Brunnermeier, H. Enderlein, E. Farhi, M. Fratzscher, C. Fuest, P.O. Gourinchas, P. Martin, J. Pisani-Ferry, H. Rey, I. Schnabel, N. Véron, B. Weder di Mauro, and J. Zettelmeyer (2018), "Reconciling risk sharing with market discipline: A constructive approach to euro area reform," *CEPR Policy Insight*, No. 91, Centre for Economic Policy Research, London.

Bernanke, B. S., and A. S. Blinder (1988), "Money, credit, and aggregate demand," *American Economic Review*, Vol. 78, pp. 435–439.

Bernanke, B. S., and A. S. Blinder (1992), "The Federal Funds Rate and the transmission mechanism of monetary policy," *American Economic Review*, Vol. 82, pp. 901–921.

Blanchard, O. (2009), "The crisis: Basic mechanisms, and appropriate policies", *IMF Working Papers*, 09/80. April.

Blanchard, O. (2016), "The US Phillips Curve: Back to the 60s?," *Policy Brief*, No.1, Peterson Institute for International Economics, Washington.

Broner, F., A. Erce, A. Martin, and J. Ventura (2014), "Sovereign debt markets in turbulent times: Creditor discrimination and crowding-out effects," *Journal of Monetary Economics*, Vol. 61(C), pp. 114–142.

Buti, M., D. Franco, and H. Ongena (1998), "Fiscal discipline and flexibility in EMU: The implementation of the Stability and Growth Pact", *Oxford Review of Economic Policy*, Vol. 14 (n.3), pp. 81–97.

Buti, M., M. Larch, and F. Balboni (2009), "Monetary and fiscal policy interactions in the EMU when cyclical conditions are uncertain," *Empirica*, Vol. 36, No 1, pp. 21–44.

Canofari, P., and G. Di Bartolomeo (2017), "Regime switches under policy uncertainty in monetary unions," *European Journal of Political Economy*, Vol. 47, pp. 124–132.

Canofari, P., G. Di Bartolomeo, and G. Piersanti (2015), "Strategic interactions and contagion effects under monetary unions," *World Economy*, Vol. 38, pp. 1618–1629.

Canofari, P., G. Di Bartolomeo, and M. Messori (2017), "EMU stability: Direct and indirect risk sharing," *Open Economies Review*, Vol. 28, pp. 847–862.

CESifo (2011), "What will Eurobonds cost? Position of the ifo institute," *CESifo*, Munich, 17 August 2011.

Chatterjee, S. and B. Eyigungor (2012), "Maturity, indebtedness, and default risk," *American Economic Review*, Vol. 102, No. 6, pp. 2674–2699.

Ciccarone, G., G. Di Bartolomeo, and E. Marchetti (2007), "Unions. Fiscal policy and central bank transparency," *The Manchester School*, Vol 75, No. 5, pp. 617–633.

Corsetti, G., J. Hassler, G. Saint-Paul, H.-W. Sinn, J.-E. Sturm, X. Vives, and M. P. Devereux (2011), "A crisis mechanism for the euro," *www.voxeu.org*, 11 March 2011.

Corsetti, G., K. Kuester, A. Meier, and G. J. Müller, G. J. (2014), "Sovereign risk and belief driven fluctuations in the euro area," *Journal of Monetary Economics*, Vol. 61(C), pp. 53–73.

Corsetti, G., and L. Dedola (2016), "The mystery of the printing press: Monetary policy and self-fulfilling debt crises," *Journal of the European Economic Association*, 14, No. 6, pp. 1329–1371.

De Grauwe, P., and Y. Ji (2016), "Flexibility versus stability: A difficult trade-off in the Eurozone", CEPS Working Document, N. 422, April.

Demertzis, M., A. Hughes-Hallett, and N. Viegi (2004), "An independent central bank faced with elected governments," *European Journal of Political Economy*, Vol. 20, No. 4, pp. 907–922.

Di Bartolomeo, G., and F. Giuli (2011), "Fiscal and monetary interaction under monetary policy uncertainty," *European Journal of Political Economy*, Vol. 27, pp. 369–375.

Dixit, A., and L. Lambertini (2001), "Monetary fiscal policy interactions and commitment versus discretion in a monetary union," *European Economic Review*, Vol. 45, pp. 977–987.

Dixit, A., and L. Lambertini (2003a), "Interactions of commitment and discretion in monetary and fiscal policies," *American Economic Review*, Vol. 93, No. 5, pp. 1522–1542.

Dixit, A., and L. Lambertini (2003b), "Symbiosis of monetary and fiscal policies in a monetary union." *Journal of International Economics*, Vol. 60, No. 2, pp. 235–247.

Draghi, M. (2014), "Unemployment in the euro area," *Annual central bank symposium in Jackson Hole*, 22 August.

Draghi, M. (2017), "Accompanying the economic recovery," *Introductory speech at the ECB Forum on Central Banking*, Sintra, 27 June 2017.

Eijffinger, S. C. W., M. L. Kobielarz, and B. R. Uras (2018), "Sovereign default, exit and contagion in a monetary union," *Journal of International Economics*, Vol. 113, pp. 1–19.

European Commission (1977), *Report of the Study group on the role of the public finances in European integration* (MacDougal Report), Vols. 1 and 2, Brussels.

European Commission (1989), *Report on Economic and Monetary Union in the European Community* (Delors Report), Brussels.

Favero, C., and A. Missale (2012), "Sovereign spreads in the eurozone: which prospects for a eurobond?," *Economic Policy*, Vol. 27, pp. 231–273.

Furceri, D., and A. Zdzienicka (2015), "The euro area crisis: Need for a supranational fiscal risk sharing mechanism?," *Open Economies Review*, Vol. 26, pp. 683–710.

Galì, G., and M. Gertler (1999), "The science of monetary policy: A New Keynesian perspective", *Journal of Economic Literature*, Vol. 37, pp. 1661–1707.

Galì, G., R. Clarida, and M. Gertler (2000), "Monetary policy rules and macroeconomic stability: Evidence and some theory," *Quarterly Journal of Economics*, Vol. 65, pp. 147–180.

Hicks, J. (1937), "Mr. Keynes and the "Classics": A suggested interpretation," *Econometrica*, Vol. 5, pp. 147–159.

Issing, O (2009), "Why a common eurobond isn't such a good idea," *White Paper*, 3, Center for Financial Studies, University of Frankfurt.

Lockwood, B. (1999), "Inter-regional insurance," *Journal of Public Economics*, Vol. 72, pp. 1–37.

Melitz, J., and S. Vori (1992), "National insurance against unevenly distributed shocks in a monetary union," *CEPR Discussion Paper*, 697.

Mélitz, J., and F. Zumer (1999), "Interregional and international risk-sharing and lessons for EMU," *Carnegie-Rochester Conference Series on Public Policy*, Vol. 51, pp. 149–188.

Mélitz, J., and F. Zumer (2002), "Regional redistribution and stabilization by the center in Canada, France, the UK and the US: A reassessment and new tests," *Journal of Public Economics*, Vol. 86, pp. 263–286.

Mendoza, E. G., and V. Z. Yue (2012), "A general equilibrium model of sovereign default and business cycles," *Quarterly Journal of Economics*, Vol. 127, No. 2, pp. 889–946.

Messori, M., and S. Micossi (2018), "Counterproductive proposals on euro area reform by French and German economists," *CEPS Policy Insights*, No. 2018/04 (also published as LUISS School of European Political Economy, *Policy Brief*, February 13, 2018).

Persson, T., and G. Tabellini (1996a), "Federal fiscal constitutions: Risk sharing and moral hazard," *Econometrica*, Vol. 64, pp. 623–646.

Persson, T., and G. Tabellini (1996b), "Federal fiscal constitutions: Risk sharing and redistribution," *Journal of Political Economy*, Vol. 104, pp. 979–1009.

Ramey, V. A. (1993), "How important is the credit channel in the transmission of monetary policy," *Carnegie-Ronchester Conference Series on Public Policy*, Vol 39, pp. 1–45

Ramey, V. A., and M. J. III Barth (2002), "The cost channel in monetary transmission," in *NBER Macroeconomics Annual 2001*, Bernanke, B. S., and K. Rogoff (eds.), MIT Press, Cambridge. Vol. 16.

Romer, C. D., and D. Romer (I990), "New evidence on the monetary transmission mechanism," *Brookings Papers on Economic Activity*, pp. 149–213.

Schuknecht, L., P. Moutot, P. Rother, and J. Stark (2011)**,** "The Stability and Growth Pact: Crisis and reform", *Occasional Paper Series*, European Central Bank, n. 129, September.

von Hagen, J. (200), "Fiscal policy and international risk sharing,", in G. D. Hess. E. van Wincoop (eds.), *International macroeconomics*, Cambridge University Press, Cambridge.

Wildasin, D. E. (1996), "Introduction: Fiscal aspects of evolving federations," *International Tax and Public Finance*, Vol. 3, pp. 121–135.

Yue, V. Z. (2010), "Sovereign default and debt renegotiations," *Journal of International Economics*, Vol. 80, pp. 176–187.