

# Quantitative easing rules as a means to achieve optimal levels of structural reforms and government deficits in a monetary union

Juan Cristóbal Campoy | Juan Carlos Negrete 

Facultad de Economía y Empresa,  
Universidad de Murcia, Murcia, Spain

## Correspondence

Juan Cristóbal Campoy, Universidad  
de Murcia, Facultad de Economía  
y Empresa, Campus de Espinardo,  
Espinardo, Murcia 30100, Spain.  
Email: [juancris@um.es](mailto:juancris@um.es)

## Abstract

This paper uses a tractable game theory model to study the interactions of structural reforms and fiscal and monetary policies in the European Monetary Union (EMU). Considering the externalities that arise when interest rates have hit the lower bound and monetary policy is carried out through quantitative easing (QE), we show that the subgame perfect equilibrium is sub-optimal when structural reforms and fiscal policy are implemented at a national level. Then, we prove that the optimal outcome cannot be obtained if structural reforms are dictated by a supranational institution. By contrast, we establish that the first best can be obtained either by a full-fledged fiscal union or a rule on QE. Given the practical difficulties that the first of these two solutions have encountered in the EMU, a rule over QE provides a clear, easier and more credible way to make structural reforms and fiscal deficits achieve the levels that maximise the union's welfare.

## KEYWORDS

central bank design, fiscal policies, monetary union, structural reforms

# 1 | INTRODUCTION

The devastating impacts of the Great Recession and the COVID pandemic have underscored the need to improve the countries' resilience to shocks through structural reforms (OECD, 2021). This issue has been particularly important for euro area countries because their lack of reforms has given rise to more severe and frequent recessions relative to other advanced economies (Aiyar et al., 2019). Draghi (2015) has claimed that "The term "structural reforms" is actually mentioned in approximately one-third of all speeches by various members of the ECB Executive Board. By comparison, it features in only about 2% of speeches by governors of the Federal Reserve". Aiyar et al. (2019), Cœuré (2015), and Draghi (2015, 2017) have pointed out that structural reforms make the economy more flexible and, therefore, less dependent on fiscal and monetary stabilisation policies. On the other hand, the two aforementioned international economic crises have pushed monetary policy to the lower bound on interest rates. That has prompted central banks to resort to unconventional policies, the more usual being quantitative easing (QE), which takes place when monetary authorities buy assets, especially longer term government bonds. In fact, QE has allowed governments to increase their debts dramatically without raising bond yields, which has prevented instability in sovereign debt markets.

Our paper aims to make a contribution to the wide-ranging debate on institutional reforms in the euro area. With this purpose, we explore the interrelations of the conduct of structural reforms and fiscal and monetary policies in a currency union. We do so by making use of a tractable game-theoretic model that allows us to consider the strategic aspects of those three policies. As claimed by Fragetta and Kirsanova (2010, p. 856): "there is little doubt that authorities can act strategically".

With this objective, our game-theoretic approach allows us to focus our attention on the European Monetary Union (EMU) where structural and fiscal policies, in practice, are decided at national level, whereas monetary policy is conducted by a common central bank. In this setting, we show that budget deficits, the volume of QE and structural reforms cannot be optimal in the absence of an adequate institutional framework. Then, we establish that the first best cannot be obtained when structural reforms are dictated by a supranational European institution. By contrast, we show that collective welfare can be maximised by either a full-fledged fiscal union or by a rule on the volumes of sovereign debts purchased by the central bank. In the case of the EMU, the former solution has been shown not to be feasible in practice, since the enforcement of European fiscal rules has not gained credibility thus far: member countries that had not fulfilled them have never been fined. In contrast, we show that committing to a QE rule, as the one put forward in our paper, can provide a clear, easier and credible way to create the right incentives for member countries to carry out the national structural and fiscal policies which are optimal from the union's joint welfare point of view. Furthermore, that rule can help anchor the monetary authorities' independence and credibility.

In fact, our QE proposal is in line with the Transmission Protection Instrument (TPI) created on 21 July 2022 to tackle sovereign debt market fragmentation in the Eurozone. This mechanism makes the ECB's purchases of countries' sovereign debt conditional on the implementation of adequate fiscal policies and structural reforms.<sup>1</sup> Having said that, in our proposed rule, the central bank can be viewed as less exposed to political pressures than in the case of the TPI. The reason is that, in our mechanism, the monetary authorities are not required to assess whether

<sup>1</sup>For further details about the TPI see the ECB press release announcing it: <https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220721126973e6e7273.en.html>.



governments have carried out the “right” fiscal and structural reforms policies to “deserve” its debt support. In fact, in our scheme, the ECB can claim that its debt help is contingent only on the magnitude of the “external” shocks hitting the economy and not on any government policy. As Weidmann (2012) said: “One can question how independent monetary policy is when it links its actions in this way to economic and fiscal policy processes. How credible this conditional path is remains to be seen”. Besides, the magnitude of the shock on which our QE rule is based can be measured more easily (e.g., in terms of a percentage reduction in GDP), than the “level” of structural reforms required to implement the TPI. Finally, rules should be simple, and it is much more complex to apply the TPI to the fiscal policies and structural reforms of a group of 20 governments (as of 2023) than to set our single QE rule on just a single institution as the ECB, which is already independent from the governments in the union.

The remainder of this paper is organised as follows. Section 2 reviews this literature. Section 3 presents the model. Section 4 analyses the central bank's response to fiscal deficits and structural reforms. Section 5 characterises the first best. Section 6 studies the scenario where public deficits and structural reforms are decided by member governments unilaterally. Section 7 studies the optimality of rules on structural reforms, fiscal deficits and monetary policy. Section 8 concludes. Finally, the Appendix gathers the proofs of some of the results.

## 2 | LITERATURE REVIEW

The study of the euro area has generated a large literature which analyses how a common central bank's monetary policy interacts with national fiscal policies pursued by member countries of a monetary union. As might be expected, this literature had a flourishing period with the birth of the EMU. Subsequently, the Global Financial Crisis revealed critical ‘design failures’ in the architecture of the euro area (De Grauwe, 2012) and generated a broad debate on the objectives of the ECB and the degree of coordination of economic policies within the Eurozone. This reality has led to a renewed interest to study how the EMU institutions should be structured to achieve optimal outcomes.

In this context, the literature has focused on the need to design, on the one hand, a common central bank independent from governments and, on the other hand, rules that impose limits on fiscal deficits and debt of Eurozone countries. The creation of a single currency and a common independent central bank has been justified on the grounds that this system: (i) avoids competitive devaluations that, in equilibrium, fail to increase output but generate suboptimally high inflation (Martin, 1998); and (ii) tackles the inflation bias of government-dependent central banks due to the classical time inconsistency problem (Rogoff, 1985; Svensson, 1997; Walsh, 1995). These latter contributions do not consider an open economy nor the interactions of fiscal and monetary policy and the implementation of structural reforms.

Another branch of the literature has focused on studying the interrelations of monetary and fiscal policy in a monetary union. Its aim has been to highlight their political and institutional implications for a well-designed currency area. Dixit and Lambertini (2001, 2003) consider the case where policy targets can always be attained independently of any institutional structure, making any rule on fiscal policy or central bank design unnecessary. This optimistic conclusion has not been obtained in more complex settings which have underscored the need to design rules that constrain the fiscal policy of member states based on two arguments: monetary and fiscal authorities have different preferences, and government deficits generate external effects. The former applies to the EMU because its central bank is more inflation-averse than governments

which are more concerned with output stabilisation. In this context, the absence of cooperation between monetary and fiscal authorities may give rise to suboptimal outcomes. This possibility provides a rationale for imposing fiscal constraints (Lambertini & Rovelli, 2004; Lambertini et al., 2007). As for the second argument, it has been claimed that fiscal expansions may produce negative spillovers (Faini, 2006) on the following grounds: (a) an increase in government spending increases the demand for domestic and foreign products, raising inflation and prompting the ECB to conduct a restrictive monetary policy that will affect the whole union; (b) a fiscal expansion in one country may raise the interest rates of national debt which can be spread to other member countries (see Beetsma & Giuliodori, 2010).

Despite the importance of structural reforms, very few studies have analysed the relationships between them and fiscal or monetary policies. Papageorgiou and Vourvachaki (2017), Sajedi (2018), and Sajedi and Steinbach (2019) show that structural reforms give rise to significant GDP gains and positive effects on public finances in the long run. However, when those reforms are implemented together with fiscal consolidations, the fiscal tightening becomes more costly in the short run. Thus, relaxing fiscal austerity in the short run can be desirable when structural reforms have a positive long run effect on public finances. A similar argument can be found, but now relating monetary policy and structural reforms. To wit, an expansionary monetary policy can reduce the short-term costs associated to those reforms because it may spur demand (see Lastauskas & Stakėnas, 2020; Rieth & Wittich, 2020). Finally, recent studies (Fatouh, Giansante & Ongena, 2021, Fatouh, Markose & Giansante, 2021) have shown that when QE is complemented with other credit facilities schemes, the effect to GDP is higher and eventually mitigate government debt.

Now, we explain the contribution of our paper to this literature. First, we study the interactions of structural reforms with fiscal and monetary policies. To the best of our knowledge, our paper is the first attempt to include, in the same model, those three policies. In doing so, our study contributes to the wide-ranging debate on institutional reform and deeper integration of European macroeconomic policies.

Second, we consider a scenario where the central bank implements unconventional monetary policy through QE in a context where conventional monetary policy is restricted by the zero lower bound. When analysing this unconventional policy in the way we do, interrelations arise of different economic policies which have not been considered so far in the literature. That is, we take into account that, although greater QE generates inflation, it also stabilises output. However, such policy has a further beneficial effect, since it reduces the rise in interest rates generated by government deficits. This debt market stabilisation effect, not studied in this literature, is a key element of our paper, since it generates strategic effects of decisions on structural reforms, fiscal deficits and monetary policies.

Third, even though our paper shares with other studies the fact that externalities arise when fiscal and monetary policies are implemented, in our model, the origin of those spillovers is different since we do not assume that a fiscal expansion in one country increases output in the rest of the union nor generates contagion in financial markets through higher interest rates [points (a) and (b) above]. In fact, those two external effects have not received significant support by data. For example, Cwik and Wieland (2011) have shown empirically that the first type of externalities from expansions in the EMU are not relevant because the direct increase of demand is offset with the impact of a euro appreciation. Besides, the empirical literature has also shown that the second type of externality is relatively small (Glover & Richards-Shubik, 2021; Pamies et al., 2022). We do not consider those types of spillovers. By contrast, structural reforms generate in our model two positive externalities since by increasing the resilience to shocks of the country



that implements them, reforms make it: (i) less dependent on QE to stabilise its output, which lowers common inflation (first positive externality); (ii) less dependent on public deficits, which will require less inflationary QE to limit interest rates (second positive externality). Therefore, because structural reforms are costly for the country that implements them and benefits the whole union, a free-rider problem arises. That is, each country lacks incentives to provide the public good (price stability) because the cost of supplying it through structural reforms is private. As a result, the level of those reforms will be suboptimally low, and inflation will be suboptimally high (inflation bias).

Fourth, in contrast with the literature reviewed above that points to the existence of an inflation bias, in our model, the origin of that bias is different. It does not arise because of a time inconsistency problem or the kind of fiscal externalities just referred. In our setup, the cause of the inflation bias is that structural reforms and budgets deficits are not optimal, which prompts the central bank to conduct a monetary policy that is too expansionary from the whole union's point of view.

Fifth, in the search for optimal institutional solutions that we also share with the previous literature, we prove that fiscal rules can make the economy reach the EMU's joint optimum. However, those constraints have been shown not to be feasible in practice: the enforcement of European fiscal rules has not gained credibility because member countries that had not fulfilled them have never been fined. On the other hand, we establish that collectively design rules on structural reforms as claimed, for example by Draghi (2015), fail to achieve the first best. Against this backdrop, we have proposed a monetary arrangement that is optimal for the whole union and involves a rule that dictates the maximum volumes of QE to be carried out by a hawkish and independent common central bank.

### 3 | THE MODEL

We follow the standard literature on policy games that specifies the interactions between policymakers in a linear-quadratic model: the functional form of the players' payoffs is quadratic whereas the variables that determine these payoffs are linear functions of the policy instruments. This kind of models make it possible to obtain tractable analytical results and study the interactions involved in a manageable way. Moreover, this approach allows us to compare different scenarios without making use of numerical simulations (Foresti, 2018).

We consider two countries ( $i = 1, 2$ ) which form a monetary union. The working of the economy is expressed by the following expressions:

$$y_i = \lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x \quad (1)$$

$$d_i = b_i + m_i \quad (2)$$

$$\pi = m_1 + m_2 \quad (3)$$

$$L_i^S = y_i^2 + \alpha b_i^2 + \beta \pi^2 + \delta \phi_i^2 \quad (4)$$

where  $i, j = 1, 2; i \neq j, \tilde{\phi}, \alpha, \beta, \delta, \lambda, \chi > 0$  and  $x$  is a stochastic disturbance with zero mean and finite variance  $E(x)^2$ . Expressions (1) and (3) are linear form equations, (2) is an accountancy relation and (4) is a payoff function. Equation (1) states that output in one country increases with

its government deficit ( $d_i$ ), the volume of the central bank's purchases of its bonds ( $m_i$ ), and decreases with a shock ( $x > 0$ ), whose impact on output will be smaller when the level of structural reforms ( $\phi_i$ ) is increased. These reforms cushion the effects of the disturbance on the economy by making it more resilient. That is, they lower the level of the economy's rigidity which, at the beginning of the period, is equal to  $\bar{\phi}$ . At this respect, for example, Duval et al. (2007) and Duval and Vogel (2008) find that structural reforms that imply product and labour market regulations make the economy more resilient to macroeconomic shocks. Similarly, Gnocchi et al. (2015) conclude that a lower business cycle volatility is associated with more flexible labour markets.

Our framework represents a scenario close to reality where, even though structural reforms reduce the negative impact of an output shock, they cannot completely eliminate it and, to tackle the ensuing economic slowdown, fiscal and monetary authorities stabilise the economy facing the trade-offs captured by our model.<sup>2</sup> This has been the case in the recent financial crisis or the COVID pandemic, where conventional monetary policy has been constrained by the zero lower bound. In this context, central banks have resorted to QE, which is the monetary tool considered in our paper. With that policy, central banks can affect long-term interest rates via buying long-term government bonds<sup>3</sup> (see Dell'Ariccia et al., 2018; Joyce et al., 2012) for a review and the empirical literature cited therein). Dell'Ariccia et al. (2018, p. 167) have pointed out that "existing studies suggest positive impacts of unconventional monetary policies on both GDP and inflation". Both effects are considered, respectively, in equation (1) where  $\chi$  is the positive monetary multiplier, and in equation (3). As for the effects of fiscal policies on output, our model considers a positive fiscal multiplier ( $\lambda > 0$ ). This is in accordance with the literature that studies those fiscal effects on GDP when the zero lower bound is present (see Bilbiie et al., 2019; Goode et al., 2021).

Governments are assumed to start off with no debt. Therefore, the volumes of sovereign debts issued in the period coincide with the levels of public deficits. Expression (2) is an accounting relation stating that country  $i$ 's total debt ( $d_i$ ) is divided into two parts: the one bought by the private sector ( $b_i$ ) and the one that the central bank has purchased in the secondary market ( $m_i$ ). Expression (3) shows that the common inflation risk ( $\pi$ ) increases with QE, as just stated when referring to the study of Dell'Ariccia et al. (2018, p. 167).

The loss function in (4) represents the social preferences, which are also shared by the governments. It shows that social welfare worsens when there are deviations, from target levels (normalised to zero), of output, public debt owned by the private sector, inflation and the volume of structural reforms. The inclusion in a social loss of the first and third term is standard in the literature (see Beetsma & Giuliodori, 2010; Foresti, 2018). However, our loss function incorporates two extensions with respect to previous literature. First, in contrast with the studies that encompass the effects of the fiscal deficit (or sovereign debt) in only one term of the loss function, in our model, those effects are broken down and considered separately in two terms: the part financed by debt that ends up in the hands of the private sector (third term) and the part of the debt purchased by the central bank (fourth term). This is an extension of the traditional model because we assume that what really determines the domestic interest rate is not just the total amount of debt but how it is distributed between those two categories. The point is that an increase in the public deficit raises interest rates lowering investment (see Beetsma &

<sup>2</sup>Notice that we have analysed the case of a common shock. However, the qualitative results of the paper do not change if the magnitude of the adverse effect of the shock is not the same in both countries.

<sup>3</sup>The central bank can purchase government bonds or assets issued by the private sector, but QE is mostly focused on the former because the latter expose the central bank to credit risk and potential losses.





Giuliodori, 2010; Pamies et al., 2022). However, and this is the novelty of our approach, we do not overlook the fact that, when the central bank buys government bonds, it lowers its yield because the private sector owns less of this debt. As Lagarde (2020) has recently said: “monetary policy has to minimize any “crowding-out” effects that might create negative spillovers for households and firms. Otherwise, increasing fiscal interventions could put upward pressure on market interest rates and crowd out private investors, with a detrimental effect on private demand”. By the same token, when sovereign debt is bought by the central bank, interest rates decrease but the inflation risk increases. The reader can easily verify that, in the particular case where QE is equal to zero, the second addend of the objective function is equal to the public deficit, giving rise to a loss function similar to that of the traditional literature (see, for example, Buti et al., 2001; Ferré, 2008, 2012; Foresti, 2015; Uhlig, 2003). On the other hand, Dell’Ariccia et al. (2018, p.137) states: “the literature finds significant effects on government bonds yields from unconventional monetary policy actions undertaken by the ECB”. Besides, Joyce et al. (2012) claim: “Although the precise estimates differ across studies, there is a broad consensus in the literature that central bank asset purchases had economically significant effects, at least on government bond yields.”

Our loss function adds the costs of implementing structural reforms [fourth term in (4)]. The existence of such costs has been put forward by some authors (see, for instance, Masuch et al., 2018). On the one hand, the process of implementation of reforms creates uncertainty which has a negative effect on efficiency. On the other hand, changes in tax laws give rise to “menu costs” because they have an effect in the way in which accountancy is carried out. Having said that, by adding structural reforms to our analysis, we are extending the traditional analysis of the interactions monetary and fiscal policy. To the best of our knowledge, our paper is the first attempt to include, in the same model, those three policies.

It is worth noting that our model follows the standard literature on policy games related to central bank’s design (see Svensson, 1997, p. 101 and Walsh, 2017, pp. 225–226) by making the following assumptions: (i) output is expressed as a linear function of the policy variables and the shock; (ii) the preferences of policymakers are represented by a quadratic loss function of the policy variables; and (iii) inflation is perfectly controlled by the central bank.<sup>4</sup>

We model the interactions between governments and the common central bank by considering a multistage game.

The timing of the game is:

1. Governments implement their structural reforms ( $\phi_i$ ).
2. The realisation of the shock is known ( $x$ ).
3. Budget deficits are determined by fiscal authorities ( $d_i$ ).
4. The central bank buys part of the sovereign debts in the secondary market ( $m_i$ ).

With respect to this sequence of events, it is worth making two observations. First, structural reforms are carried out before the shock. The reason is that the very aim of those reforms is to act preemptively to make economies more resilient to disturbances that will occur later on. Second, government deficits are determined before monetary policy. This order of moves is assumed in the literature that studies the interactions between monetary and fiscal policy (see, for example, Andersen, 2008; Beetsma & Bovenberg, 1998; Ferré, 2008, 2012; Uhlig, 2003). In fact, budget decisions are more difficult to change than monetary policy. The reason is that the central bank

<sup>4</sup>In section 6, we discuss the case where not only does inflation depend on monetary policy but also on fiscal policy, and show that this extension adds complexity to the model without changing the qualitative results.

holds meetings throughout the year and fiscal policy faces more lags: it is proposed, voted by parliament and then implemented (see Beetsma & Giuliodori, 2010).

The paper analyses the case in which, in the second stage, the realisation of shock  $x$  takes a value greater than zero ( $x > 0$ ), that is, it generates an economic slowdown in the union such as the recent financial crisis or the COVID pandemic. Therefore, once the adverse shock has hit the economy, and given the rigidity of the economy, governments run budget deficits in order to stabilise their economies, anticipating the response of the central bank. Finally, the common central bank will respond implementing QE, bearing in mind the effects that this policy will have on the stabilisation of output and debt markets, and on the risk of inflation.

## 4 | THE CENTRAL BANK'S RESPONSE

In this section, we obtain the monetary authorities' volumes of debt purchases in response to the structural reforms and governments deficits. This is a fundamental piece for the analysis to be carried out in sections 5–7. We assume that the common central bank is benevolent in the sense that it cares for the joint welfare of all the states in the union. As Rogoff (2022) has pointed out, the two traditional concerns for the central banks have been keeping inflation under control and smoothing out the business cycle. In this sense, article 105(1) of de Maastricht Treaty reads that “without prejudice to the objectives of price stability, the ECB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community”, including “a high level of employment”. Those two concerns are incorporated in the first and third term of the loss function (4). In addition to those two traditional concerns (Joyce et al., 2012), central banks are now more focused on financial stability because it is required to deal with inflation and the stabilisation of the economy (Buiter, 2022; Smets, 2014). At this respect, this third concern about financial stability was explicitly voiced by the former ECB president Draghi (2012) in his famous statement “The ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough”. In the same line, the current ECB President Lagarde's stated in March 2020 that there were no limits to the ECB's commitment to the Euro. This third concern about financial stability is incorporated in the second term of the loss function [expression (4)].

As for the fourth concern of the central bank, namely the cost of structural reforms, even though, as stated above, this assumption has been supported by this literature in the case of the government, it is less clear that the central bank would also care about those reforms. Having said that, including that fourth term in the monetary authorities' loss function does not alter the results. The reason being that, in our timing structural reforms are set before monetary policy. As a consequence, when the central bank makes its policy decisions, those reforms are taken as given and our conclusions would be exactly the same irrespective of whether or not this fourth term is added to the central bank's loss function.

Now, we will obtain, from (1) to (4), an expression that will be used very frequently throughout the paper, namely, the government's loss functions in terms of the players' strategic variables and the shock:

$$L_i^S = (\lambda d_1 + \chi m_1 - (\tilde{\phi} - \phi_i)x)^2 + \alpha (d_i - m_i)^2 + \beta (m_i + m_j)^2 + \delta \phi_i^2. \quad (5)$$

Given the sequence of events explained in the previous section, after observing the levels of reforms, the realisation of the shock and the budgets deficits, the monetary authorities choose the volumes of purchases of sovereign bonds to minimise the joint union's loss [from (5)]:





$$\min_{\{m_1, m_2\}} L_1^S + L_2^S = \sum_{i=1}^2 \left( (\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha (d_i - m_i)^2 + \beta (m_1 + m_2)^2 + \delta \phi_i^2 \right) \quad (6)$$

Solving simultaneously the first-order conditions  $\left( \frac{\partial(L_1^S + L_2^S)}{\partial m_1} = 0 \text{ and } \frac{\partial(L_1^S + L_2^S)}{\partial m_2} = 0 \right)$  one finds the central bank's reaction functions:

$$m_i = \frac{d_i(\alpha - \lambda\chi)(\alpha + 2\beta + \chi^2) - 2\beta d_j(\alpha - \lambda\chi) + \chi(\alpha + 2\beta + \chi^2)(\tilde{\phi} - \phi_i)x - 2\beta\chi(\tilde{\phi} - \phi_j)x}{(\alpha + \chi^2)(\alpha + 4\beta + \chi^2)}. \quad (7)$$

The following Remarks 1 and 2 are useful to pave the way to understand Proposition 1 in section 6. Both remarks describe the monetary authorities' response to the shock and the levels of structural reforms and deficits, obtained in (7). This response takes into account the following trade-off faced by the central bank when deciding the volume of purchases of debt. On the one hand, this policy has two benefits, namely, it stabilises output and reduces the risk of a rise in its interest rates. On the other hand, those purchases have a cost: they increase the risk of higher inflation.

*Remark 1.* When a shock reduces output in a monetary union, and for given levels of government deficits, the central banks purchases of countries' debt will increase if the level of structural reforms decrease.

*Proof.* Applying symmetry, we set  $\phi_i = \phi_j$  in (7). Taking derivatives: ■

$$\frac{\partial m_i}{\partial \phi_i} = - \frac{\chi x}{(\alpha + 4\beta + \chi^2)} < 0. \quad (8)$$

We obtain this result because when the levels of reforms are low, the economies' resilience to shocks will also be low and, to stabilise output, countries will need much support from the monetary authorities in the form of QE.

*Remark 2.* When a shock reduces output in a monetary union, and for given levels of structural reforms, the central bank purchases of countries' debt will increase:

- (i) when government deficits increase, if the risk associated to an increase in domestic interest rates is sufficiently high in relation to the stabilisation effects on output of deficits and monetary policy so that  $\alpha > \lambda\chi$ .
- (ii) when government deficits decrease, if the risk associated to an increase in domestic interest rates is sufficiently low in relation to the stabilisation effects on output of deficits and monetary policy so that  $\alpha < \lambda\chi$ .

*Proof.* Because countries are symmetric, we set  $d_j = d_i$  in (7). Taking derivatives:

$$\frac{\partial m_i}{\partial d_i} = \frac{\alpha - \lambda\chi}{(\alpha + 4\beta + \chi^2)}, \quad (9)$$

which is positive when  $\alpha > \lambda\chi$  and negative when  $\alpha < \lambda\chi$ . ■

The intuition behind this remark is as follows. (i) When countries' budget deficits increase, the risk that stems from a rise in domestic interest rates also does. If this risk is relatively high (in relation to the stabilising power of fiscal and monetary policy, that is,  $\alpha > \lambda\chi$ , to mitigate it, the central bank will buy more of the countries' debt. (ii) However, in the opposite scenario, where the stabilising power of fiscal and monetary policy is relatively high ( $\alpha < \lambda\chi$ ), a reduction in fiscal deficits will give rise to a strong drop in countries' outputs. As a result, the central bank will also implement a more expansionary monetary policy.

## 5 | THE MONETARY UNION'S OPTIMUM

In this section, we characterise the values of the structural reforms, fiscal deficits and QE which would maximise the union's joint welfare. As stated by Dixit and Lambertini (2001), this first-best regime is useful as a benchmark to compare other equilibria since it provides a scenario where all the agents' bliss points are achieved. Beginning with the central bank's optimal purchases of government bonds, we know that they are the ones obtained in the previous section because the monetary authorities are benevolent. As for the level of the budget deficits, given the central bank's behaviour (7), the problem to be solved is:

$$\begin{aligned} \underset{\{d_i, d_2\}}{\text{Min}} \quad & \sum_{i=1}^2 \left( (\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_1 + m_2)^2 + \delta\phi_i^2 \right) \\ \text{s. t.} \quad & m_i = \frac{d_i(\alpha - \lambda\chi)(\alpha + 2\beta + \chi^2) - 2\beta d_j(\alpha - \lambda\chi) + \chi(\alpha + 2\beta + \chi^2)(\tilde{\phi} - \phi_i)x - 2\beta\chi(\tilde{\phi} - \phi_j)x}{(\alpha + \chi^2)(\alpha + 4\beta + \chi^2)}, \end{aligned} \quad (10)$$

whose result is:

$$d_i = \frac{(2\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi + 2\beta\lambda\chi)(\tilde{\phi} - \phi_i)x - 2\beta(\alpha - \lambda\chi)(\tilde{\phi} - \phi_j)x}{(\lambda + \chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}. \quad (11)$$

Now, substituting (11) into (7) yields:

$$m_i = \frac{(\tilde{\phi} - \phi_i)x(2\alpha\beta + \alpha\lambda^2 + 2\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi) - 2\beta(\tilde{\phi} - \phi_j)x(\alpha + \lambda^2)}{(\lambda + \chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}. \quad (12)$$

Finally, the levels of the structural reforms that minimise the collective expected social loss are, taking into account (11) and (12):

$$\begin{aligned} \underset{\{\phi_1, \phi_2\}}{\text{Min}} \quad & E \left( \sum_{i=1}^2 \left( (\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_1 + m_2)^2 + \delta\phi_i^2 \right) \right) \\ \text{s. t.} \quad & \begin{cases} m_i = \frac{(\tilde{\phi} - \phi_i)x(2\alpha\beta + \alpha\lambda^2 + 2\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi) - 2\beta(\tilde{\phi} - \phi_j)x(\alpha + \lambda^2)}{(\lambda + \chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}, \\ d_i = \frac{(2\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi + 2\beta\lambda\chi)(\tilde{\phi} - \phi_i)x - 2\beta(\alpha - \lambda\chi)(\tilde{\phi} - \phi_j)x}{(\lambda + \chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}, \end{cases} \end{aligned} \quad (13)$$

yielding:

$$\phi_i^{FB} = \frac{4E(x^2)\alpha\beta\tilde{\phi}}{\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi}, \quad (14)$$



where the superscript *FB* stands for first best. Then, from (7), (12) and (14) one finds the values of the other the policy variables in the first best:

$$d_i^{FB} = \frac{\tilde{\phi}(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)(\alpha\lambda + 4\beta\lambda + \alpha\chi)x}{(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}, \quad (15)$$

$$m_i^{FB} = \frac{\tilde{\phi}(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)\alpha(\lambda + \chi)x}{(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}. \quad (16)$$

*Remark 3.* When a shock reduces output in a monetary union, the first best implies that (i) a positive level of structural reforms has to be carried out ( $\phi_i^{FB} > 0$ ) to make the economy more resilient to adverse shocks. However, (ii) it not optimal to completely eliminate the rigidity of the economy ( $\phi_i^{FB} < \tilde{\phi}$ ) and, as a result, (iii) a stabilisation policy mix of positive budget deficits ( $d_i^{FB} > 0$ ) and positive QE ( $m_i^{FB} > 0$ ) has to be implemented.

We get this remark because, given that structural reforms are costly, the problem cannot be solved exclusively by carrying them out and not retorting to fiscal and monetary policy. That is, the optimal combination of those three policies have to balance their positive and negative effects. As for the positive effects, reforms increase the economies' resilience to shocks, deficits and QE stabilise output, and debt purchases of the central bank also lowers the risk of an increase in interest rates. Regarding the negative effects, reforms are costly for society, deficits increase the risk of a rise in interest rates and the purchases of sovereign bonds by the monetary authorities increase the risk of inflation.

It should be emphasised that this result relates also to a major problem faced by currency unions. Namely, in the transition to the implementation of the optimal but costly level of structural reforms, limitations on budget deficits should not be too strong because a system of social protection will require temporary increases in public spending. Moreover, that can also help make reforms more politically feasible.

Finally, given the levels of structural reforms and deficits, we have obtained the best central bank's response in terms of purchases of debts without assuming any constraint or requirement from the countries in the union. However, as will be apparent in what follows, when reforms and public deficits are determined unilaterally by each country, the central bank will end up buying suboptimally high levels of sovereign debts. In this respect, we will show in section 7 that a rule which limits those debt purchases will achieve the first best because this commitment provides the right incentives for governments to implement structural reforms and fiscal policies in an optimal way from the union's point of view.

## 6 | THE NONCOOPERATIVE REGIME

In this section, we consider a regime in which structural reforms and fiscal deficits are determined at the national level. That is, those two policies will be implemented in a noncooperative way. That is a close-to-reality scenario, as far as the EMU is concerned, because, on the one hand, few measures have been taken to coordinate euro members' structural reforms,

whose design, in practice, has been made at the national level; and, on the other hand, even though some fiscal rules have been agreed such as the Stability and Growth Pact or the Six Pack, reality has shown that, after a shock, fiscal policy has also been left to the national level. In fact, fines have been never been imposed on members countries that have not fulfilled those deficit rules.

We assume throughout the paper that governments are not influenced by electoral interests but care about their respective country's welfare (and not about other countries') whose preferences are represented by the loss functions in (4). Against this backdrop, we will obtain the subgame perfect equilibrium of the game with the timing explained in section 3. Therefore, solve the game backward. Beginning, with the last stage, its result have been obtained in section 4. As for the preceding (third) stage, each government chooses unilaterally its public deficit with the aim of minimising its loss. It does so by taking as given the other country's deficit and bearing in mind the level of reforms implemented in the first stage and the central bank's response in the final stage. That is, country  $i$ 's fiscal deficit is determined by solving [from (5) and (7)]:

$$\begin{aligned} \underset{\{d_i\}}{\text{Min}} \quad & L_i^S = (\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_i + m_j)^2 + \delta\phi_i^2 \\ \text{s.t.} \quad & m_i = \frac{d_i(\alpha - \lambda\chi)(\alpha + 2\beta + \chi^2) - 2\beta d_j(\alpha - \lambda\chi) + \chi(\alpha + 2\beta + \chi^2)(\tilde{\phi} - \phi_i)x - 2\beta\chi(\tilde{\phi} - \phi_j)x}{(\alpha + \chi^2)(\alpha + 4\beta + \chi^2)}. \end{aligned} \quad (17)$$

From the first-order conditions one finds country  $i$ 's fiscal authorities' reaction functions:

$$d_i = \frac{K_1(\tilde{\phi} - \phi_i)x - \beta\chi(\alpha - \lambda\chi)(\tilde{\phi} - \phi_j)x - \beta d_j(\alpha - \lambda\chi)^2}{K_2}, \quad (18)$$

where  $K_1 = \alpha^2\lambda + \alpha^2\chi + \alpha\chi^3 + \alpha\lambda\chi^2 + \beta\lambda\chi^2 + 4\alpha\beta\lambda + 3\alpha\beta\chi$  and  $K_2 = \alpha^2\lambda^2 + \alpha^2\chi^2 + \alpha^2\beta + \alpha\chi^4 + 4\alpha\beta\lambda^2 + 4\alpha\beta\chi^2 + 2\alpha^2\lambda\chi + 2\alpha\lambda\chi^3 + \alpha\lambda^2\chi^2 + \beta\lambda^2\chi^2 + 6\alpha\beta\lambda\chi$ .

Solving simultaneously the system of equations that forms the first-order conditions in (18), one finds:

$$d_i = \frac{K_3(\tilde{\phi} - \phi_i)x - \beta(\alpha + \chi^2)(\alpha - \lambda\chi)(\tilde{\phi} - \phi_j)x}{(\lambda + \chi)K_4}, \quad (19)$$

where  $K_3 = \alpha^2\lambda^2 + \alpha^2\chi^2 + \alpha^2\beta + \alpha\chi^4 + 4\alpha\beta\lambda^2 + 3\alpha\beta\chi^2 + 2\alpha^2\lambda\chi + 2\alpha\lambda\chi^3 + \beta\lambda\chi^3 + \alpha\lambda^2\chi^2 + 2\beta\lambda^2\chi^2 + 5\alpha\beta\lambda\chi$  and  $K_4 = \alpha^2\lambda^2 + \alpha^2\chi^2 + 2\alpha^2\beta + \alpha\chi^4 + 4\alpha\beta\lambda^2 + 4\alpha\beta\chi^2 + 2\alpha^2\lambda\chi + 2\alpha\lambda\chi^3 + \alpha\lambda^2\chi^2 + 2\beta\lambda^2\chi^2 + 4\alpha\beta\lambda\chi$ .

Now, substituting (19) into (7) yields

$$m_i = \frac{K_5(\tilde{\phi} - \phi_i)x - \beta(\alpha^2 + \lambda^2\chi^2 + 2\alpha\lambda^2 + 2\alpha\chi^2 + 2\alpha\lambda\chi)(\tilde{\phi} - \phi_j)x}{(\lambda + \chi)K_4}, \quad (20)$$

where  $K_5 = \alpha^2\lambda^2 + \alpha^2\chi^2 + \alpha^2\beta + \alpha\chi^4 + 2\alpha\beta\lambda^2 + 2\alpha\beta\chi^2 + 2\alpha^2\lambda\chi + 2\alpha\lambda\chi^3 + \alpha\lambda^2\chi^2 + \beta\lambda^2\chi^2 + 2\alpha\beta\lambda\chi$ .

Finally, in the first stage, each government noncooperatively minimises its country's expected loss [from (5), (19) and (20)]:



$$\begin{aligned} \underset{\{\phi_i\}}{\text{Min}} \quad & E(L_i^S) = E\left((\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_i + m_j)^2 + \delta\phi_i^2\right) \\ \text{s. t.} \quad & \begin{cases} d_i = \frac{K_3(\tilde{\phi} - \phi_i)x - \beta(\alpha + \chi^2)(\alpha - \lambda\chi)(\tilde{\phi} - \phi_j)x}{(\lambda + \chi)K_4}, \\ m_i = \frac{K_5(\tilde{\phi} - \phi_i)x - \beta(\alpha^2 + \lambda^2\chi^2 + 2\alpha\lambda^2 + 2\alpha\chi^2 + 2\alpha\lambda\chi)(\tilde{\phi} - \phi_j)x}{(\lambda + \chi)K_4} \end{cases} \end{aligned} \quad (21)$$

The first-order conditions of that problem yield the reactions functions in the space of the levels of the structural reforms:

$$\phi_i = \frac{((4\tilde{\phi} - 2\phi_j)(\alpha + \chi^2)K_6)\alpha\beta E(x^2)}{2\delta + 2E(x^2)\alpha\beta(\alpha + \chi^2)K_6}. \quad (22)$$

where  $K_6 = \frac{\alpha^2\lambda^2 + \alpha^2\chi^2 + \alpha^2\beta + \alpha\chi^4 + 4\alpha\beta\lambda^2 + 4\alpha\beta\chi^2 + 2\alpha^2\lambda\chi + 2\alpha\lambda\chi^3 + \alpha\lambda^2\chi^2 + \beta\lambda^2\chi^2 + 6\alpha\beta\lambda\chi}{(\alpha^2\lambda^2 + \alpha^2\chi^2 + 2\alpha^2\beta + \alpha\chi^4 + 4\alpha\beta\lambda^2 + 4\alpha\beta\chi^2 + 2\alpha^2\lambda\chi + 2\alpha\lambda\chi^3 + \alpha\lambda^2\chi^2 + 2\beta\lambda^2\chi^2 + 4\alpha\beta\lambda\chi)^2}$

Now, solving the system of equations in (22), one obtains the values of the structural reforms (the superscript NC stands for No Cooperation):

$$\phi_i^{NC} = \frac{\tilde{\phi}((\alpha + \chi^2)K_6)4\alpha\beta E(x^2)}{2\delta + 4E(x^2)\alpha\beta(\alpha + \chi^2)K_6} \quad (23)$$

The following proposition states in what direction the values of the policy variables set in the noncooperative scenario differ from the ones in the first best.

**Proposition 1.** When public deficits and structural reforms policies are decided by each country unilaterally in a monetary union, the first best is not achieved because (i) the level of structural reforms are too low; (ii) budgets deficits are too high if  $\alpha > \lambda\chi$  and too low if  $\alpha < \lambda\chi$ ; and (iii) the central bank's purchases of sovereign debt are too high.

*Proof.* See the Appendix. ■

The intuition of this proposition is:

- (i) Reforms are costly for the country that implements them but generate benefits not only for that country but also for the other country. The failure to internalise those positive externalities is explained as follows. A country less affected by the shock, thanks to its reforms will need less recourse to output stabilisation through public deficit and QE. The lower deficit will imply less support by QE to cushion interest rate hikes, thus generating a first positive effect through the reduction of the common inflation risk that benefits two countries. Moreover, the reduced need for QE to stabilise output generates a second positive effect by lowering common inflation risk in both countries. Since these two effects also benefit the other country by lowering common inflation, they generate positive externalities. As a consequence, given that these spillovers are not taken into account by countries when they determine reforms noncooperatively, and because they are positive, this free-riding behaviour means that reforms are suboptimal low.

- (ii) Once the negative shock has occurred, and taking into account the structural reforms carried out, each country stabilises its production by making use of a fiscal deficit. This rises its domestic interest rates which, when being cushioned through QE, increases the risk of common inflation. Because that risk is also hurtful for the other country it generates a negative externality. On the other hand, since a fiscal deficit stabilises output, it implies less recourse to QE to carry out that task and lowers the common inflation risk, giving rise to a positive externality. Consequently, when the first (negative) externality dominates the second (positive) one, there is a negative (net) externality and the prisoner's dilemma situation implies that deficits will be suboptimally high. But in the opposite case, where the positive externality is the one that dominates, the free-rider scenario means that deficits will be suboptimally low.
- (iii) QE will be suboptimally high for two reasons. First, structural reforms are suboptimally low [see this Proposition 1 part (i)] which in combination with Remark 1 pushes the level of QE above its level in the first best. Second, this Proposition 1 part (ii) states that deficits are suboptimally high if  $\alpha > \lambda\chi$  and suboptimally low if  $\alpha < \lambda\chi$  which, adding the conclusion in Remark 2 implies the existence of an additional driving force that increases QE to a suboptimally high level.

Notice that Proposition 1 states that all the policy variables, in the noncooperative regime are suboptimal, namely, their values are different from ones in the first-best scenario. However, in contrast with parts (i) and (iii), part (ii) claims that the sign of that difference can be positive or negative. Now, which of the two scenarios takes place in a monetary union? The answer depends on the parameters of that economy. That is, when  $\alpha > \lambda\chi$ , the risk of a rise in interest rates (relative to the stabilisation effects of fiscal and monetary policy), is so important that the negative spillover [explained in the intuition of Proposition 1 part (ii)] is more relevant; and when that risk is relatively less important ( $\alpha < \lambda\chi$ ) the positive spillover [explained in the intuition of Proposition 1 part (ii)] is the one that dominates.

The question now is which of those two cases applies to the EMU. As explained in the review section, the answer is that there is a broad consensus that the relevant scenario is the one where the net fiscal externalities are not positive but negative and, therefore, limits on public deficits have to be imposed on member states. The convenience of adopting rules which discipline member countries' fiscal policies has always been proposed by academics and practitioners even at the time where the EMU architecture began to be designed. The Maastricht Treaty (1991), puts a ceiling on government deficits of 3% of GDP. This political process led to arrangements such as the Growth and Stability Pact (1997), Six Pack (2010), European Fiscal Compact (2012) and Euro Plus Pact (2014). All these institutions have also aimed to limit public deficits. Therefore, the concern has not been that deficits could too low but too high. The existence of such “negative spillovers” (not positive) has found support in the academic literature (see section 2).

Now, we will be more specific and discuss why the parameters of our model support the case where government deficits affect negatively other members in the euro area. The parameter  $\alpha$ , which represents the concern of the ECB with debt market stability, is relatively high because, as Buiter (2022) has claimed, “Financial stability is the de facto overriding mandate of any central bank, whatever the official mandate (price stability or the dual mandate of maximum employment and stable prices) may be”. On the other hand, Schnabel (2022), current member of the Executive Board of the ECB since 2020, has said that “the euro area as a currency union with sovereign states faces specific risk factors that may spur multiple equilibria and self-fulfilling market dynamics. One of these factors is redenomination risk. Markets at times assigned a positive





probability to the risk of exit of a euro area member country from the single currency.” In fact, this instability can give rise to fragmentation in debt markets, pointed out by Schnabel (2022): “fragmentation reflects a sudden break in the relationship between yields and fundamentals, giving rise to non-linear and destabilizing dynamics”. Finally, as Rogoff (2022, p. 34) said, “QE is really better thought of as quasi-fiscal instruments where, importantly, central banks are junior partners to Treasuries and finance ministries”.

In order for the model to be tractable, we have assumed that fiscal deficits do not affect inflation. However, extending the model to include the effects of deficits on inflation would not alter the qualitative results of our paper because of the following. In this new scenario, a new source of negative externality would have arisen. Public deficits would continue to have a positive effect on the stabilisation of production, so that the resort to QE to stabilise output would be reduced and common inflation would decrease (positive external effect already considered). On the other hand, these deficits would rise interest rates and, as a consequence, a greater volume of QE would be carried out to stabilise debt markets, generating an increase in common inflation (negative external effect already considered). Having said that, the only effect of this new assumption is that common inflation would increase (a new negative external effect), but that would not change the qualitative results of our analysis because in this more complex model, there would be another source of negative externality from budget deficits (direct effect on common inflation), and that would imply that the fiscal externality would be stronger.

In the following section, we study the design of rules that can tackle the inefficiencies studied in this section.

## 7 | RULES

The first best analysed in section 5 can be achieved, by definition, if Eurozone governments, instead of choosing their levels of structural reforms and budgets deficits at the national level, delegate those two policies to a supranational institution, and the European Central Bank implements its purchases of sovereign debts in a benevolent way. Having said that, in this section, we study whether it is possible to get that collective optimum if the noncooperative scenario analysed in the previous section is modified so that only one of those three policies commits to following a rule.

### 7.1 | Rules on structural reforms

We characterise a regime where a European supranational authority sets structural reforms to the levels obtained in the first-best scenario analysed in section 5 (14), but governments do not loose sovereignty over fiscal policy, and the central bank is benevolent. We consider such a scenario to analyse recent proposals to implement structural reforms in Europe at a supranational level in the Eurozone. For example, Draghi (2015) points out: “I believe there is a strong case for governance of structural reforms to be exercised jointly at the euro area level: to help each country to achieve the necessary level of resilience; and to ensure that they maintain that resilience permanently. Since structural reforms in any euro area country are a legitimate interest of the whole union, there needs to be stronger ownership of reforms not just at the national level, but at the European level as well [...]. The ECB has frequently called for stronger common governance of structural reforms that would make resilience part of our common DNA”.

Note that, in this scenario all stages are solved as in the noncooperative regime analysed in section 6, except for the first stage in which the volumes of structural reforms are the ones appearing in (14).

**Proposition 2.** In a monetary union where the volumes of structural reforms are those that would be set in the first-best regime, but fiscal deficits are unilaterally chosen by each country, the collective optimum is not achieved.

*Proof.* See the Appendix. ■

The explanation of Proposition 2 is as follows. When the levels of structural reforms correspond to the ones in the first-best regime, but budgets deficits are set in a noncooperative way, the rigidities of the economy are not completely eliminated (as stated by Remark 3). As a consequence, each government keeps on retorting to public deficits to stabilise the economy and, in doing so, following the reasoning in the intuition of Proposition 1(ii), they still fail to internalise the fiscal externalities, which implies that if  $\alpha > \lambda\chi / \alpha < \lambda\chi$  deficits will be suboptimally high/low and the central bank's purchases of both countries' debts be suboptimally high and, therefore, the collective optimum is not reached.

To sum up, when fiscal policies are decided at the national level, focusing efforts only on structural reforms will not be sufficient to reach the first best.

## 7.2 | Rules on budget deficits

In this regime, we consider the case in which the monetary union is also a fiscal union where after a shock that reduces output, member countries run public deficits following a rule dictated by a supranational entity. In such a scenario, we assume that the common central bank remains benevolent, and structural reform policies are subject to national decision making.

Notice that this scenario is solved as in the regime analysed in section 6 with the only exception that, in the third stage, the member countries now commit to run the budget deficits proposed by the supranational fiscal authority, which appear in (15) where the subscript RBD stands for Rule on Budget Deficits. Therefore, substituting (15) into (7), we have the following expression for the volumes of QE:

$$m_i^{RBD} = \frac{(\alpha + \chi^2)(\alpha - \lambda\chi)d_i^{RBD} + \chi(\alpha + 2\beta + \chi^2)(\tilde{\phi} - \phi_i)x - 2\beta\chi(\tilde{\phi} - \phi_j)x}{(\alpha + \chi^2)(\alpha + 4\beta + \chi^2)}. \quad (24)$$

Thus, governments set their national structural reforms solving the following problem [taking into account (5), (15) and (24)]:

$$\begin{aligned} \text{Min}_{\{\phi_i\}} \quad & E(L_i^S) = E\left((\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_i + m_j)^2 + \delta\phi_i^2\right) \\ \text{s. t.} \quad & \left\{ \begin{aligned} d_i &= \frac{\tilde{\phi}(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)(\alpha\lambda + 4\beta\lambda + \alpha\chi)x}{(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}, \\ m_i^{RBD} &= \frac{(\alpha + \chi^2)(\alpha - \lambda\chi)d_i^{RBD} + \chi(\alpha + 2\beta + \chi^2)(\tilde{\phi} - \phi_i)x - 2\beta\chi(\tilde{\phi} - \phi_j)x}{(\alpha + \chi^2)(\alpha + 4\beta + \chi^2)}. \end{aligned} \right. \quad (25) \end{aligned}$$



whose result is:

$$\phi_i^{RBD} = \frac{4E(x^2)\alpha\beta\tilde{\phi}}{\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi}, \quad (26)$$

where the subscript RBD stands for Rule on Budget Deficits.

**Proposition 3.** In a monetary union where the central bank is benevolent and structural reforms are unilaterally decided by each government, the first best is reached if budget deficits are determined by a supranational institution.

*Proof.* It is straightforward to check that the equilibrium values reached with this fiscal rule for budget deficits, purchases of public debts by the central bank and structural reforms are identical to the corresponding ones in the first-best scenario. ■

The intuition behind Proposition 3 is the following. If member countries form a fully fledged fiscal union where fiscal policy decisions are determined by a supranational institution and this entity decides to impose the levels of public deficits determined in the first-best regime, governments would no longer fail to internalise the fiscal externalities, which is the root of the problem. This will imply that the central bank, once it has observed that deficits are set at their optimal levels, will react by implementing the optimal levels of QE. Furthermore, this rule would also lead to the implementation of the first-best levels of structural reforms. Why? Because the temptation to free ride and implement suboptimally low reforms will no longer exist since they would not be compensated by suboptimal levels of public deficits and suboptimal levels of purchases of debts by the central bank.

Therefore, a true fiscal union would achieve the collective optimum. However, this theoretical possibility has been shown not to be feasible in practice in the case of the euro area, as member countries have made apparent its reluctance to give up their sovereignty with respect to decisions on fiscal instruments such as taxes and public expenditures. The recent experiences of the EMU have witnessed the creation of new institutions implying rule changes in fiscal matters in its short history, such as the Growth and Stability Pact (1997), Six Pack (2010), European Fiscal Compact (2012) and Euro Plus Pact (2014). Finally, in November 2022, the European Commission has put forward a proposal for new fiscal rules to be implemented in 2024. The continuous modifications in those rules convey the idea that, in reality, any fiscal rule can be broken. In fact, after any shock, there have always been exceptions for noncompliance with what was previously agreed.

### 7.3 | Rules on central bank's decisions

In this last scenario, we will assume that fiscal policies and structural reforms are under the responsibility of national governments and monetary policy is not carried out in a discretionary way by the benevolent central bank but follows a rule on the volumes of QE.

**Proposition 4.** In a monetary union where structural reforms and budget deficits are determined unilaterally by each national government, the first best is reached if the central bank commits to undertake the following purchases of government debt:

$$m_i^{RQE} = \frac{\tilde{\phi}(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)\alpha(\lambda + \chi)x}{(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}, \quad (27)$$

where the superscript *RQE* stands for Rule for Quantitative Easing. Notice that the previous expression coincides with that in the first-best regime appearing in (16).

*Proof.* Fiscal authorities choose their budget deficits noncooperatively taking into account the rule on central bank's purchases of debts.

$$\begin{aligned} \min_{\{d_i\}} \quad & L_i^S = (\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_i + m_j)^2 + \delta\phi_i^2 \\ \text{s. t.} \quad & m_i = \frac{\tilde{\phi}(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)\alpha(\lambda + \chi)x}{(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)}, \end{aligned} \quad (28)$$

giving rise to the following fiscal deficits:

$$d_i = \frac{(\alpha\delta\tilde{\phi}(\lambda + \chi)(\alpha - \lambda\chi) + \lambda(\tilde{\phi} - \phi_i)(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4E(x)^2\alpha\beta + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi))x}{(\alpha + \lambda^2)(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4E(x)^2\alpha\beta + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)} \quad (29)$$

Then, each government, anticipating the budget deficits in (29) and central bank's purchases of sovereign debts in (27), implements its country's structural reforms to minimise its expected social loss without cooperating with its counterpart:

$$\begin{aligned} \min_{\{\phi_i\}} \quad & E(L_i^S) = E\left((\lambda d_i + \chi m_i - (\tilde{\phi} - \phi_i)x)^2 + \alpha(d_i - m_i)^2 + \beta(m_i + m_j)^2 + \delta\phi_i^2\right) \\ \text{s. t.} \quad & \left\{ \begin{aligned} d_i &= \frac{(\alpha\delta\tilde{\phi}(\lambda + \chi)(\alpha - \lambda\chi) + \lambda(\tilde{\phi} - \phi_i)(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4E(x)^2\alpha\beta + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi))x}{(\alpha + \lambda^2)(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4E(x)^2\alpha\beta + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)}, \\ m_i &= \frac{\alpha\delta\tilde{\phi}x}{\alpha\delta + 4\beta\delta + 4\alpha\beta\delta + 4E(x^2)\alpha\beta}. \end{aligned} \right. \end{aligned} \quad (30)$$

whose result is:

$$\phi_i^{RQE} = \frac{4E(x^2)\alpha\beta\tilde{\phi}}{\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi}. \quad (31)$$

and finally substituting (31) into (29), we get the values of budget deficits in this regime:

$$d_i^{RQE} = \frac{\tilde{\phi}(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 2\alpha\lambda\delta\chi)(\alpha\lambda + 4\beta\lambda + \alpha\chi)x}{(\alpha\lambda^2\delta + 4\beta\lambda^2\delta + \alpha\delta\chi^2 + 4\alpha\beta\delta + 4E(x^2)\alpha\beta + 2\alpha\lambda\delta\chi)(4\alpha\beta + \alpha\lambda^2 + 4\beta\lambda^2 + \alpha\chi^2 + 2\alpha\lambda\chi)} \quad (32)$$

Notice that expressions  $d_i^{RQE}$ ,  $\phi_i^{RQE}$  and  $m_i^{RQE}$  are the same as the corresponding ones obtained in the first best. Therefore, this regime achieves the union's social optimum.

The reason why the first best will be achieved by a rule that only focuses on QE is that this mandate tackles the very root of the problem, namely, it eliminates the incentives that governments have on abusing the central bank's behaviour. In fact, this monetary commitment implies that: (a) each fiscal authority, in the third stage, now foresees that the volume of its bonds that will be bought by the monetary authorities will not change if the size of its budget deficit does, which does not



encourage anymore the issuance of a suboptimal volumes of bonds and to free ride on the common benefit (public good) of lowering the inflation risk. In other words, the rule eliminates the origin of the problem, namely, the externalities of the economy; and (b) in the first stage, anticipating that deficits and monetary policy will achieve the first-best levels because externalities are eliminated, structural reforms will also be set at the globally optimal level, since governments know that deficits are set at optimal levels and the central bank will no longer buy an amount of bond that depends on whether countries shirk collective responsibility and implements a suboptimally low level of reforms.

Thus, in this section, we have shown that the first best can be achieved by either (i) a full fiscal union where government deficits are decided by a supranational entity or (ii) by a rule on the amount of quantitative easing carried out by the common central bank (Propositions 3 and 4). Having said that, in reality, out of those two proposed mechanisms, setting common central bank rules is an easier and more credible mechanism in the Eurozone context. First, European countries have shown to be very reluctant to transfer their fiscal sovereignty to a supranational entity. The recent history of fiscal rules in the EMU has witnessed numerous but unsuccessful attempts to enforce fiscal discipline. Continuous modifications of such rules have attested the difficulties to get the member states of an ever-growing Eurozone to agree (20 countries in 2023, including Croatia). In fact, tensions between them have always been present when it has come to impose fines to countries that have not followed the rules. Second, it is more realistic to expect that a rule will be carried out by an institution such as the ECB, which is independent from the union's governments and whose primary mandate is to fight inflation. In fact, central banks as the ECB have been designed to resist political pressures so that they behave as an institution, using Rogoff's (1985) terminology, more "conservative" than the government or the society in their fight against inflation.

Our paper also supports an independent and hawkish central bank that, by following a QE rule in a monetary union, achieves the optimal inflation level, and acts as commitment to create the incentives for governments to implement the optimal levels of structural reforms and budget deficits when those two policies are decided at the national level. In this sense, we have modelled the optimal degree of conservatism by introducing a rule that limits government bond purchases, and this commitment to fight inflation has been shown in our paper to be optimal from the collective welfare point of view. In other words, joint welfare is maximised if the central bank is so conservative and independent that it can resist the pressures from governments to make it buy a volume of debt beyond a given limit. Thus, our study shows that, as long the EMU is not a fully fledged fiscal union, it is fundamental for the ECB to keep its independence and follow a conservative rule regarding debts purchases. This commitment will create the right incentives for governments to increase structural reforms in advance of future negative shocks and then become less dependent on stabilisation policies.

## 8 | CONCLUSIONS

Against the backdrop of the Great Recession and the COVID pandemic, the paper contributes to the wide-ranging debate on how institutions in the EMU should be reformed to improve its performance in the event of future crises. A major topic of the discussion has been how to incentivise member countries to undertake structural reforms that increase their resilience to shocks. That would make their economies less dependent on fiscal and monetary stabilisation policy,

which would put a lid on interest rates and inflation. We enter this debate by making use of a simple game-theoretic model that allows us to analyse, in a tractable way, the strategic interactions of structural reforms with fiscal and monetary policies in the euro area.

Our analysis considers that QE is implemented in a context where conventional monetary policy is constrained by the zero lower bound on interest rates, as in the recent financial crisis or the COVID pandemic. As Williamson (2017) stated, “QE is likely to be used again in a future recession or financial crisis”. In the face of these prospects, we have highlighted the need for the EMU countries to act preemptively by designing rules that can help policymakers to tackle new shocks in a better position.

We show that optimality is not guaranteed when each government in the EMU unilaterally decide their structural reforms and fiscal policy, and a common central bank conducts QE. In this scenario, close to the reality of the EMU, we study whether different economic institutions can overcome that unwelcome result. First, we prove that the collective optimum is not achieved when structural reforms are dictated by a supranational authority and fiscal deficits are determined unilaterally by each member government. The reason is that, in this regime, each national fiscal authority will try to take advantage of the loose QE policy of a benevolent ECB. But, this individualistic behaviour is self-defeating in aggregate. Then, we establish that the first best can, in theory, be achieved by a full fiscal union or an ECB's commitment over the volumes of QE. However, in the context of the EMU, the former proposal lacks feasibility because member countries have always been shown not to give up their fiscal sovereignty. By contrast, the ECB is a well-established independent institution which can provide more credibility. In fact, history has shown that attempts at policy cooperation among national policymakers in Europe have not been successful. For example, before the creation of the ECB, European countries had tried to reach coordination in monetary matters but, in the face of shocks, exchange rate crises were generated such as the collapse of the snake in the tunnel in 1973 or the Exchange Rate Mechanism in 1992–93. In view of these failures of a group of national players to achieve cooperation, countries decided to adopt a single currency, where a single and independent policymaker, as the ECB, dictates the monetary policy of the whole area.

Our proposed monetary arrangement advocates for the conservativeness and independence of the monetary authorities. More specifically, we have proved that, even if fiscal policies and structural reforms are conducted without cooperation, it is optimal for the union that the ECB commits to a rule that dictates the volumes of QE. This level is lower than the one that a central bank pursuing social demands would implement. In other words, it is optimal to have a central bank more hawkish than the society. The reason is that, if monetary authorities were benevolent, each government would try to exploit their generous behaviour in its own advantage, which would turn out to be counterproductive for the union as a whole. This caveat is avoided with our proposed monetary mandate because it changes expectations. That is, each government now foresees that an increase its budget deficit will no longer increase the volume of the ECB's purchases of its debt. Therefore, deficits will be set at optimal levels, and expecting that deficits and QE will achieve the first-best values, structural reforms will also be set at the collectively optimal levels.

Our proposed QE rule could be used in the euro area to avoid future sovereign bond market fragmentation because it would create the right incentives for governments to increase structural reforms and be less dependent on stabilisation policies. In this sense, the Governing Council of ECB has recently created (21 July 2022) a new tool to tackle this issue: the Transmission Protection Instrument (TPI). This mechanism is in line with the monetary rule proposed in our paper, given that the TPI makes ECB's purchases of sovereign debt conditional





on governments' fiscal discipline and structural reforms. However, one problem that stems from the "explicit conditionality" of the TPI, which is absent in the QE rule that we put forward, is that it can be interpreted as the ECB meddling with politics. That is, the TPI may put political pressure on monetary authorities if they are required to "publicly" assess whether a country has conducted "adequate" fiscal policies and structural reforms "to deserve" the ECB's debt support. This is not ideal for an institution as the ECB that aims to appear independent. Instead, a bond buying rule as the one we propose can be considered as more politically neutral: it implies that central bank's help is contingent on the magnitude of the "external" shock. And this magnitude can be measured more easily (e.g., in terms of percentage reduction in GDP), than "the level" of structural reforms. Finally, a general principle is that rules should be simple, and it is much more complex to apply them to the fiscal policies and structural reforms of 20 governments (as of 2023) than to set just a single rule on just a single institution as the ECB, which is independent from those governments.

## ACKNOWLEDGEMENT

We are grateful for valuable comments and suggestions from two anonymous referees. This paper has also benefited from comments by participants at the XXIII Conference on International Economics/Jornadas de Economía Internacional. The usual disclaimer applies.

## FUNDING INFORMATION

This research did not receive any specific grant from funding agencies in the public, commercial, or non-for-profit sectors.

## DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

## ORCID

Juan Carlos Negrete  <https://orcid.org/0000-0001-8566-5957>

## REFERENCES

- Aiyar, S., Bluedorn, J., Duval, R., Furceri, D., Daniel Garcia-Macia, D., Ji, Y., Malacrino, D., Qu, H., Siminitz, J., & Zdzienicka, A. (2019). *Strengthening the euro area: The role of national structural reforms in building resilience* (Staff Discussion Notes No. 2019/005) International Monetary Fund.
- Andersen, T. M. (2008). The macroeconomic policy mix in a monetary union with flexible inflation targeting. *Journal of International Money and Finance*, 27(3), 411–437.
- Beetsma, R., & Bovenberg, A. L. (1998). Monetary union without fiscal coordination may discipline policymakers. *Journal of International Economics*, 45(2), 239–258.
- Beetsma, R., & Giuliodori, M. (2010). The macroeconomic costs and benefits of the EMU and other monetary unions: An overview of recent research. *Journal of Economic Literature*, 48, 603–641.
- Bilbiie, F., Monacelli, T., & Perotti, R. (2019). Is government spending at the zero lower bound desirable? *American Economic Journal: Macroeconomics*, 11(3), 147–173.
- Buiter, W. (2022). *The widespread failure of central banks to control inflation*. Conference Paper 2, Institute of International Monetary Research.
- Buti, M., Roeger, W., & In't Veld, J. (2001). Stabilizing output and inflation: Policy conflicts and co-operation under a stability pact. *Journal of Common Market Studies*, 39(5), 801–828.
- Cœuré, B. (2015). *Lamfalussy was right: Independence and interdependence in a monetary union*, Lamfalussy Lecture conference. Magyar Nemzeti Bank.

- Cwik, T., & Wieland, V. (2011). Keynesian government spending multipliers and spillovers in the euro area. *Economic Policy*, 26, 493–549.
- De Grauwe, P. (2012). The governance of a fragile eurozone. *Australian Economic Review*, 45(3), 255–268.
- Dell'Ariccia, G., Rabanal, P., & Sandri, D. (2018). Unconventional monetary policies in the euro area, Japan, and the United Kingdom. *Journal of Economic Perspectives*, 32(4), 147–172.
- Dixit, A., & Lambertini, L. (2001). Monetary-fiscal policy interactions and commitment versus discretion in a monetary union. *European Economic Review*, 45, 977–987.
- Dixit, A., & Lambertini, L. (2003). Interactions of commitment and discretion in monetary and fiscal policies. *American Economic Review*, 93, 1522–1542.
- Draghi, M. (2012). *A central banker's perspective on European economic convergence*, Anchor conference, Magyar Nemzeti Bank.
- Draghi, M. (2015). *Structural reforms, inflation and monetary policy*. ECB Forum on Central Banking.
- Draghi, M. (2017). *Structural reforms in the euro area*. ECB conference, Frankfurt am Main.
- Duval, R., Elmeskov, J., & Vogel, L. (2007). *Structural policies and economic resilience to shocks*. OECD Economics Department Working Papers, OECD Publishing.
- Duval, R., & Vogel, L. (2008). Economic resilience to shocks: The role of structural policies. *OECD Journal: Economic Studies*, 1, 1–38.
- Faini, R. (2006). Fiscal policy and interest rates in Europe. *Economic Policy*, 47, 443–478.
- Fatouh, M., Giansante, S., & Ongena, S. (2021). Economic support during the COVID crisis. Quantitative easing and lending support schemes in the UK. *Economics Letters*, 209, 110138.
- Fatouh, M., Markose, S., & Giansante, S. (2021). The impact of quantitative easing on UK bank lending: Why banks do not lend to businesses? *Journal of Economic Behavior and Organization*, 183, 928–953.
- Ferré, M. (2008). Fiscal policy coordination in the EMU. *Journal of Policy Modelling*, 30, 221–235.
- Ferré, M. (2012). The effects of uncertainty about countries' compliance with the stability and growth pact. *Journal of Policy Modeling*, 34(5), 660–674.
- Foresti, P. (2015). Monetary and debt-concerned fiscal policies interaction in monetary unions. *International Economics and Economic Policy*, 12(4), 541–552.
- Foresti, P. (2018). Monetary and fiscal policies interaction in monetary unions. *Journal of Economic Surveys*, 32(1), 226–248.
- Fragetta, M., & Kirsanova, T. (2010). Strategic monetary and fiscal policy interactions: An empirical investigation. *European Economic Review*, 54(7), 855–879.
- Glover, B., & Richards-Shubik, S. (2021). *Contagion in the European Sovereign Debt Crisis*. NBER Working Paper No. w20567.
- Gnocchi, S., Lagerborg, S., & Pappa, A. (2015). Do labor market institutions matter for business cycles? *Journal of Economic Dynamics and Control*, 51, 299–317.
- Goode, E., Zheng Liu, Z., & Nguyen, T. (2021). Fiscal multiplier at the zero bound: Evidence from Japan. *FRBSF Economic Letter*, 14, 1–5.
- Joyce, M., Miles, D., Scott, A., & Vayanos, D. (2012). Quantitative easing and unconventional monetary policy. An introduction. *The Economic Journal*, 122(564), 271–288.
- Lagarde, C. (2020). *Monetary policy in a pandemic emergency*. Speech at the ECB Forum on Central Banking, Frankfurt am Main.
- Lambertini, L., Levine, P., & Pearlman, J. (2007). Fiscal policy in a monetary union: Can fiscal cooperation be counterproductive? School of Economics Discussion Papers 1707 School of Economics, University of Surrey.
- Lambertini, L., & Rovelli, R. (2004). Independent or coordinated? Monetary and fiscal policy in EMU. In R. Beetsma, C. Favero, A. Missale, A. Muscatelli, P. Natale, & P. Tirelli (Eds.), *Monetary policy, fiscal policies and labour markets: Macroeconomic policymaking in the EMU* (pp. 134–156). Cambridge University Press.
- Lastauskas, P., & Stakénas, J. (2020). Labor market reforms and the monetary policy environment. *European Economic Review*, 128, 103509.
- Martin, P. (1998). The exchange rate policy of the euro: A matter of size? *Journal of the Japanese and International Economies*, 12(4), 455–482.
- Masuch, K., Anderton, R., Setzer, R., & Benalal, N. (2018). Structural policies in the euro area, occasional paper series, n. 210, June, European Central Bank.



- OECD. (2021). *Going for growth 2021: Shaping a vibrant recovery*, OECD Report.
- Pamies, S., Carnot, N., & Patarau, A. (2022). Revisiting the link between government debt and sovereign interest rates in the euro area. *Quarterly Report on the Euro Area*, 20(4), 39–46.
- Papageorgiou, D., & Vourvachaki, E. (2017). Macroeconomic effects of structural reforms and fiscal consolidations: Trade-offs and complementarities. *European Journal of Political Economy*, 48, 54–73.
- Rieth, M., & Wittich, J. (2020). The impact of ECB policy on structural reforms. *European Economic Review*, 122, 1–20.
- Rogoff, K. (1985). The optimal commitment to an intermediate monetary target. *Quarterly Journal of Economics*, 100(4), 1169–1189.
- Rogoff, K. (2022). Risks to central Bank Independence. In E. Pastén & R. Reis (Eds.), *Independence, credibility and communication of central banking*. Central Bank of Chile.
- Sajedi, R. (2018). Fiscal consequences of structural reform under constrained monetary policy. *Journal of Economic Dynamics and Control*, 93, 22–38.
- Sajedi, R., & Steinbach, A. (2019). Fiscal rules and structural reforms. *International Review of Law and Economics*, 58, 34–42.
- Schnabel, I. (2022). *United in diversity. Challenges for monetary policy in a currency union*. ECB Speech, Panthéon-Sorbonne University.
- Smets, F. (2014). Financial stability and monetary policy: How closely interlinked. *International Journal of Central Banking*, 10(2), 263–300.
- Svensson, L. (1997). Optimal inflation targets, "conservative" central banks, and linear inflation contracts. *American Economic Review*, 87(1), 98–114.
- Uhlig, H. (2003). One money, but many fiscal policies in Europe: What are the consequences? In M. Buti (Ed.), *Monetary and fiscal policies in EMU: Interactions and coordination* (pp. 29–64). Cambridge University Press.
- Walsh, C. (1995). Optimal contracts for central bankers. *The American Economic Review*, 85(1), 150–167.
- Walsh, C. (2017). *Monetary theory and policy*. The MIT Press.
- Weidmann, J. (2012). *Ich muss nicht von allen geliebt werden*. Welt am Sonntag.
- Williamson, S. (2017). *Quantitative easing: How well does this tool work?* Federal Reserve Bank of St Louis.

**How to cite this article:** Campoy, J. C., & Negrete, J. C. (2023). Quantitative easing rules as a means to achieve optimal levels of structural reforms and government deficits in a monetary union. *The World Economy*, 46, 2755–2779. <https://doi.org/10.1111/twec.13460>

## APPENDIX 1

### Proof of Proposition 1.

Subtracting the values of country  $i$ 's level of structural reforms in the first-best scenario [expression (14)], from the corresponding one in the noncooperative regime (23), we obtain:

$$\phi_i^{NC} - \phi_i^{FB} = \frac{\delta}{2} \frac{A_1 + A_2 + A_3 + A_4}{A_5(A_6 + A_7 + A_8 + A_9 + A_{10} + A_{11})} < 0, \quad (33)$$

where:

$$A_1 = 4\alpha^4\beta^2 + \alpha^4\lambda^4 + \alpha^4\chi^4 + 2\alpha^3\chi^6 + \alpha^2\chi^8 + 3\alpha^4\beta\lambda^2 + 8\alpha^3\beta\lambda^4 + 3\alpha^4\beta\chi^2 + 11\alpha^3\beta\chi^4 + 4\alpha^4\lambda\chi^3 + 4\alpha^4\lambda^3\chi + 8\alpha^2\beta\chi^6,$$

$$A_2 = 8\alpha^3 \lambda \chi^5 + 4\alpha^2 \lambda \chi^7 + 12\alpha^3 \beta^2 \lambda^2 + 16\alpha^2 \beta^2 \lambda^4 + 12\alpha^3 \beta^2 \chi^2 + 16\alpha^2 \beta^2 \chi^4 + 6\alpha^4 \lambda^2 \chi^2 + 12\alpha^3 \lambda^2 \chi^4 + 8\alpha^3 \lambda^3 \chi^3 + 2\alpha^3 \lambda^4 \chi^2 + 6\alpha^2 \lambda^2 \chi^6 + 4\alpha^2 \lambda^3 \chi^5 + \alpha^2 \lambda^4 \chi^4,$$

$$A_3 = 4\beta^2 \lambda^4 \chi^4 + 40\alpha^2 \beta^2 \lambda \chi^3 + 40\alpha^2 \beta^2 \lambda^3 \chi + 39\alpha^3 \beta \lambda^2 \chi^2 + 12\alpha \beta^2 \lambda^2 \chi^4 + 8\alpha \beta^2 \lambda^3 \chi^3 + 12\alpha \beta^2 \lambda^4 \chi^2 + 39\alpha^2 \beta \lambda^2 \chi^4 + 32\alpha^2 \beta \lambda^3 \chi^3,$$

$$A_4 = 11\alpha^2 \beta \lambda^4 \chi^2 + 6\alpha^4 \beta \lambda \chi + 72\alpha^2 \beta^2 \lambda^2 \chi^2 + 8\alpha^3 \beta^2 \lambda \chi + 32\alpha^3 \beta \lambda \chi^3 + 26\alpha^3 \beta \lambda^3 \chi + 26\alpha^2 \beta \lambda \chi^5 + 3\alpha \beta \lambda^2 \chi^6 + 6\alpha \beta \lambda^3 \chi^5 + 3\alpha \beta \lambda^4 \chi^4,$$

$$A_5 = \alpha \lambda^2 \delta + 4\beta \lambda^2 \delta + \alpha \delta \chi^2 + 4\alpha \beta \delta + 4x^2 \alpha \beta + 2\alpha \lambda \delta \chi,$$

$$A_6 = 4\alpha^4 \beta^2 \delta + \alpha^4 \lambda^4 \delta + \alpha^4 \delta \chi^4 + 2\alpha^3 \delta \chi^6 + \alpha^2 \delta \chi^8 + 2E(x)^2 \alpha^4 \beta^2 + 16\alpha^3 \beta^2 \lambda^2 \delta + 16\alpha^2 \beta^2 \lambda^4 \delta + 16\alpha^3 \beta^2 \delta \chi^2 + 16\alpha^2 \beta^2 \delta \chi^4 + 6\alpha^4 \lambda^2 \delta \chi^2,$$

$$A_7 = 12\alpha^3 \lambda^2 \delta \chi^4 + 8\alpha^3 \lambda^3 \delta \chi^3 + 2\alpha^3 \lambda^4 \delta \chi^2 + 6\alpha^2 \lambda^2 \delta \chi^6 + 4\alpha^2 \lambda^3 \delta \chi^5 + \alpha^2 \lambda^4 \delta \chi^4 + 4\beta^2 \lambda^4 \delta \chi^4 + 8\sigma^2 \alpha^3 \beta^2 \lambda^2 + 10E(x)^2 \alpha^3 \beta^2 \chi^2 + 8x^2 \alpha^2 \beta^2 \chi^4,$$

$$A_8 = 4\alpha^4 \beta \lambda^2 \delta + 8\alpha^3 \beta \lambda^4 \delta + 4\alpha^4 \beta \delta \chi^2 + 12\alpha^3 \beta \delta \chi^4 + 4\alpha^4 \lambda \delta \chi^3 + 4\alpha^4 \lambda^3 \delta \chi + 8\alpha^2 \beta \delta \chi^6 + 8\alpha^3 \lambda \delta \chi^5 + 4\alpha^2 \lambda \delta \chi^7 + 2\alpha^4 \beta \sigma^2 \lambda^2 + 2\sigma^2 \alpha^4 \beta \chi^2 + 4\sigma^2 \alpha^3 \beta \chi^4,$$

$$A_9 = 2E(x)^2 \alpha^2 \beta \chi^6 + 10E(x)^2 \alpha^2 \beta^2 \lambda^2 \chi^2 + 12E(x)^2 \alpha^3 \beta^2 \lambda \chi + 8\alpha^3 E(x)^2 \beta \lambda \chi^3 + 4\alpha^2 \beta \lambda E(x)^2 \chi^5 + 32\alpha^2 \beta^2 \lambda \delta \chi^3 + 32\alpha^2 \beta^2 \lambda^3 \delta \chi + 36\alpha^3 \beta \lambda^2 \delta \chi^2 + 16\alpha \beta^2 \lambda^2 \delta \chi^4 + 16\alpha \beta^2 \lambda^3 \delta \chi^3,$$

$$A_{10} = 16\alpha \beta^2 \lambda^4 \delta \chi^2 + 36\alpha^2 \beta \lambda^2 \delta \chi^4 + 32\alpha^2 \beta \lambda^3 \delta \chi^3 + 12\alpha^2 \beta \lambda^4 \delta \chi^2 + 8\alpha^4 \beta \lambda \delta \chi + 12x^2 \alpha^2 \beta^2 \lambda \chi^3 + 4E(x)^2 \alpha \beta \lambda^2 \chi^2 + 2E(x)^2 \alpha \beta^2 \lambda^2 \chi^4 + 2\alpha^2 E(x)^2 \beta \lambda^2 \chi^4 + 4E(x)^2 \alpha^4 \beta \lambda \chi,$$

$$A_{11} = 56\alpha^2 \beta^2 \lambda^2 \delta \chi^2 + 16\alpha^3 \beta^2 \lambda \delta \chi + 32\alpha^3 \beta \lambda \delta \chi^3 + 24\alpha^3 \beta \lambda^3 \delta \chi + 24\alpha^2 \beta \lambda \delta \chi^5 + 4\alpha \beta \lambda^2 \delta \chi^6 + 8\alpha \beta \lambda^3 \delta \chi^5 + 4\alpha \beta \lambda^4 \delta \chi^4.$$

We find, for noncooperative regime, the partial derivative of the government deficit with respect to the level of reforms in (19), and find its absolute value. Then, we do the same operation, but for the first-best scenario using (11). Subtracting the latter calculation from the former one finds:

$$\frac{(\alpha + 4\beta + \chi^2)2x\alpha\beta(\lambda + \chi)(\alpha - \lambda\chi)}{A_{12}} \geq 0$$

where  $A_{12} = \alpha^2 \lambda^2 + \alpha^2 \chi^2 + 2\alpha^2 \beta + \alpha \chi^4 + 4\alpha \beta \lambda^2 + 4\alpha \beta \chi^2 + 2\alpha^2 \lambda \chi + 2\alpha \lambda \chi^3 + \alpha \lambda^2 \chi^2 + 2\beta \lambda^2 \chi^2 + 4\alpha \beta \lambda \chi + (4\alpha \beta + \alpha \lambda^2 + 4\beta \lambda^2 + \alpha \chi^2 + 2\alpha \lambda \chi)$ .

We obtain, for noncooperative regime, the partial derivative of QE with respect to the level of reforms in (20), and find its absolute value. Then, we do the same calculation but for the first-best scenario, from (12). Subtracting the latter calculation from the former one finds:

$$\frac{2x\alpha\beta(\lambda + \chi)(\alpha - \lambda\chi)^2}{A_{13}A_{14}} > 0$$

where  $A_{13} = 4\alpha \beta + \alpha \lambda^2 + 4\beta \lambda^2 + \alpha \chi^2 + 2\alpha \lambda \chi$ ,

$$A_{14} = \alpha^2 \lambda^2 + \alpha^2 \chi^2 + 2\alpha^2 \beta + \alpha \chi^4 + 4\alpha \beta \lambda^2 + 4\alpha \beta \chi^2 + 2\alpha^2 \lambda \chi + 2\alpha \lambda \chi^3 + \alpha \lambda^2 \chi^2 + 2\beta \lambda^2 \chi^2 + 4\alpha \beta \lambda \chi$$



### Proof of Proposition 2.

Substituting the value of structural reforms in the first best,  $\phi_i^{FB}$ , appearing in (14) into the equation that shows the values of fiscal deficits as functions of reforms when those deficits are determined in a noncooperative way (19), we get the resulting values for deficits in this regime, and subtracting the values of the deficits in the first best (15) from those values one gets:

$$\frac{(\alpha - \lambda\chi)2(\tilde{\phi} - \phi_i^{FB})(\lambda + \chi)(\alpha + 4\beta + \chi^2)x\alpha\beta}{A_{13}A_{14}} \geq 0$$

Bearing in mind that  $\tilde{\phi} - \phi_i^{FB} > 0$  (Remark 3), the last expression is not equal to zero, which implies that if the volumes of structural reforms are those that would be set in the first-best regime but fiscal deficits are decided at the national level, those deficits are not optimal. More specifically, when  $\alpha > \lambda\chi / \alpha < \lambda\chi$  deficits will be suboptimally high/low.

Similarly, substituting the value of structural reforms in the first best,  $\phi_i^{FB}$ , appearing in (14) into the equation that shows the values of QE as functions of reforms when deficits are determined in a noncooperative way (20), we get the resulting values for QE in this regime, and subtracting the values of QE in the first best (16) from those values one gets:

$$\frac{(\alpha - \lambda\chi)^2 x \alpha \beta (\lambda + \chi) 2(\tilde{\phi} - \phi_i^{FB})}{A_{13}A_{14}} > 0$$

Bearing in mind that  $\tilde{\phi} - \phi_i^{FB} > 0$  (Remark 3), the last expression is not equal to zero, which implies that if the volumes of structural reforms are those that would be set in the first-best regime but fiscal deficits are decided at the national level, the volumes of QE are not optimal. More specifically, those volumes will be suboptimally high.

Therefore, given that we have shown that fiscal deficits and QE are not optimal, the first best is not achieved.