Does monetary unification lead to excessive debt accumulation

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Does Monetary Unification Lead to Excessive Debt Accumulation?

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ABSTRACT:
If discretionary monetary policy implies an inflation bias, monetary unification boosts the accumulation of public debt. The additional debt accumulation is welfare reducing only if governments are sufficiently myopic. In the presence of myopic governments, debt ceilings play a useful role in avoiding excessive debt accumulation in a monetary union and allow a conservative, independent central bank to focus on price stability.

Keywords: Common central bank, monetary union, credibility effect, government myopia, price stability weight, (optimal) debt target.
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1. Introduction

Many central bankers fear that establishing a European Monetary Union (EMU) will result in excessive accumulation of public debt. In response to this fear, which was voiced in the Report of the so-called Delors Committee (1989), the Maastricht treaty incorporates fiscal entrance criteria for EMU, including ceilings on public debt and fiscal deficits. Moreover, to discipline fiscal policymakers, it proposes strict surveillance of national fiscal policies within the EMU. These restrictions aimed at disciplining fiscal policy have been criticized for being both unnecessary and undesirable (see, e.g., Buiter and Kletzer, 1991, and Bean, 1992).

This paper explores whether monetary unification results in the excessive accumulation of public debt. To that end, we formulate a dynamic two-period model of discretionary monetary and fiscal policymaking in a monetary union. Alesina and Tabellini (1987), Debelle (1993) and Debelle and Fischer (1994) explore the interaction between discretionary monetary and fiscal policy in a static setting of a closed economy. Obstfeld (1991a,b) and Jensen (1994) study the dynamics of public debt under monetary discretion. Employing a model in the tradition of Barro and Gordon (1983) to incorporate commitment problems, we extend these dynamic models of discretionary policymaking to a monetary union with several fiscal policymakers. Within such a framework, decentralized, national fiscal policies impact the other fiscal players by affecting the inflation rate set by the common central bank (CCB), which is unable to commit.

Our paper differs in a number of ways from other papers that study the dynamic interactions between fiscal and monetary policies in a monetary union (see, e.g., Levine and Pearlman, 1992; Levine, 1993; Levine and Brociner, 1994; Krichel, Levine and Pearlman, 1994). First, our model allows for analytical solutions, which provide additional intuition about the effects of the policy interactions on public debt accumulation and welfare. Second, we analyze how political distortions affect public debt policy. Third, we explore optimal institutions (such as debt ceilings and an independent, conservative CCB) designed to address commitment problems and political distortions.

The rest of the paper is structured as follows. Section 2 presents the model. Section 3 explores how monetary unification affects debt accumulation. If discretionary policymaking gives rise to an inflation bias, we confirm the prediction of central bankers that monetary unification relaxes fiscal discipline by boosting the accumulation of public debt. Turning to normative issues, Section 4 investigates whether the additional debt accumulation can be termed excessive in the sense that it harms welfare. Contrary to the fear of the central bankers, the additional accumulation of public debt turns out to be welfare enhancing if governments represent the preferences of their societies. However, if fiscal policymakers are myopic in the sense that they are more impatient than society, the additional debt accumulation may harm welfare by excacerbating the political distortions associated with myopia. Section 5 explores the optimal design of monetary and fiscal institutions in the presence of discretionary policymaking. In line with Rogoff (1985), the central bank should be made more conservative (in the sense that it attaches a higher priority to price stability) than society to offset the monetary distortions due to the lack of commitment. In the absence of political distortions, an optimally designed conservative, independent central bank can reach the second best (i.e. the Pareto optimum in the absence of lump-sum taxes). In the presence of myopic governments, however, a conservative central bank needs to be supplemented by debt ceilings to estabish the second best. Section 6 concludes the paper.

2. The model

2.1. Output and social objectives

The monetary union consists of n participating countries. Whereas the common central bank (CCB) sets monetary policy for the entire union, fiscal policy is determined at a decentralized, national level by the n governments. All economies are identical and each economy produces a single perfectly substitutable good. Without barriers to commodity trade, the inflation rate is uniform across the union. Labor is immobile internationally.[1]

Consider some economy i (i=1,..,n). Following, among others, Alesina and Tabellini (1987), Debelle (1993) and Debelle and Fischer (1994), workers are represented by trade unions whose sole objective is to achieve a target real wage rate, the logarithm of which we normalize to zero. Therefore, the (log) of the nominal wage rate in period t is set equal to the (rationally) expected (log) price level in period t, p_t^e, where the superscript "e" denotes an expectation. Nominal wage contracts are signed before discretionary policies are selected. Accordingly, unions act as Stackelberg leaders vis-à-vis the authorities.

Output of a representative firm in country i amounts to $Y_{it} = L_{it}^{\eta}$ $(0<\eta<1)$, where L_{it} is labor. The firm's output is taxed at a rate τ_{it}. The firm maximizes profits, $P_t L_{it}^{\eta}(1-\tau_{it})-W_t L_{it}$, where P_t and W_t denote, respectively, the price level and the wage rate, which are uniform across the union. Hence, (log) output is given by $y_{it} = (\eta/(1-\eta))(\pi_t-\pi_t^e-\tau_{it}+\log\eta)$, where π_t stands for the inflation rate, which is defined as $\log(P_t/P_{t-1})$. For convenience, we normalize output by subtracting the constant $(\eta/(1-\eta))\log\eta$ from y_{it}. Hence, normalized output, x_{it}, amounts to

[1] For the case of Europe it is well known that labor is relatively immobile (for example, due to linguistic, cultural, social and institutional barriers).

$$x_{it} = \nu(\pi_t - \pi_t^e - \tau_{it}),\ \nu \equiv \eta/(1-\eta). \tag{2.1}$$

Without tax distortions (i.e. $\tau_{it}=0$), $x_{it}=0$ in a rational expectations equilibrium (where inflation is anticipated, i.e. $\pi_t=\pi_t^e$, see (2.1)). In addition to distortionary output taxes, we allow for other, non-tax, distortions due to, for example, union power in the labor market or monopoly power in commodity markets. The first-best output level, i.e. output with neither tax nor non-tax distortions, is denoted by $\tilde{x}_t$. Thus, $\tilde{x}_t>0$ measures the non-tax distortions and can be interpreted as an *implicit* tax on output. In fact, by offsetting the implicit output tax, an output subsidy ($\tau_{it}=-\tilde{x}_t/\nu$) can raise output towards its first-best level $\tilde{x}_t$.

Each society features a social welfare function. By accounting for the preferences of both workers and non-workers, social objectives differ from the objectives of the unions. In particular, the loss function of society i is defined over inflation, output and public spending:

$$V_{S,i} = \tfrac{1}{2} \sum_{t=1}^{2} \beta_S^{t-1} [\alpha_{\pi S}\, \pi_t^2 + (x_{it}-\tilde{x}_t)^2 + \alpha_{gS}\, (g_{it}-\tilde{g}_t)^2],\ 0<\beta_S\leq 1,\ \alpha_{\pi S},\alpha_{gS}>0. \tag{2.2}$$

Welfare losses increase in the deviations of inflation, (log) output and government spending (g_{it} is government spending as a share of non-distortionary output) from their targets (or first-best levels or 'bliss points').[2] Social objectives are the same in each country. The target level of inflation corresponds to price stability. The non-distortionary output level, $\tilde{x}_t$, represents the bliss point for output. The first-best level of government spending, $\tilde{g}_t$, can be interpreted as the optimal share of non-distortionary output to be spent on public goods if (non-distortionary) lump-sum taxes are available (see Debelle and Fischer, 1994). Parameters $\alpha_{\pi S}$ and α_{gS} correspond to the weights of the price stability and government spending objectives, respectively, relative to the weight of the output objective. The limiting case of $\alpha_{gS}\rightarrow\infty$ corresponds to the situation where government spending is exogenously fixed at $\tilde{g}_t$. Finally, β_S denotes society's subjective discount factor.

2.2. The fiscal authorities

Country i's government features the following loss function:

$$V_{F,i} = \tfrac{1}{2} \sum_{t=1}^{2} \beta_F^{t-1} [\alpha_{\pi S}\, \pi_t^2 + (x_{it}-\tilde{x}_t)^2 + \alpha_{gS}\, (g_{it}-\tilde{g}_t)^2],\ 0<\beta_F\leq 1. \tag{2.3}$$

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[2] Employment is directly related to output through the production function. Hence, instead of output, employment could have been included as an argument in the loss functions, with the target employment level corresponding to the output level in absence of any distortions.

The subjective discount factor of the fiscal authorities, β_F, may differ from societies', β_S. A government whose subjective rate of time preference exceeds that of society (i.e. $\beta_F<\beta_S$) will be called *myopic*. Such myopia may originate in a high probability of being voted out of office at the end of period one.[3]

The government of country i faces the following government budget constraint (see, e.g., Beetsma and Bovenberg, 1995):

$$g_{it} + (1+\rho)d_{i,t-1} = \tau_{it} + \kappa\pi_t + d_{it},\ t=1,2, \tag{2.4}$$

where ρ respresents the (constant) real rate of return required by a risk-neutral investor who faces an outside investment opportunity with the same real rate of return. τ_{it} and $\kappa\geq 0$ (a constant) stand for, respectively, distortionary tax revenue and real holdings of base money as shares of non-distortionary output. Modern economies feature low holdings of base money due to the presence of efficient financial systems. Accordingly, we assume that $\kappa<1$.[4] All countries share equally in the seigniorage revenues of the CCB. Accordingly, the seigniorage revenues accruing to country i are given by $\kappa\pi_t$. Furthermore, $d_{i,t-1}$ is the amount of public debt carried over from the previous period, while d_{it} is the amount of newly issued public debt. All public debt is real and matures after one period.

Countries feature the same initial stock of public debt, d_0. With all debt being paid off at the end of the second period ($d_{i2}=0$, i=1,..,n), the government budget constraints in the two periods can be consolidated into a single intertemporal government budget constraint,

$$(1+\rho)d_0 + g_{i1} + g_{i2}/(1+\rho) = \tau_{i1}+\kappa\pi_1 + (\tau_{i2}+\kappa\pi_2)/(1+\rho). \tag{2.5}$$

For later convenience, we derive the *government financing requirement* by rewriting (2.4) as,

$$GFR_{it} \equiv \tilde{K}_t + (1+\rho)d_{i,t-1} - d_{it} = [\tau_{it}+\tilde{x}_t/\nu] + \kappa\pi_t + [\tilde{g}_t-g_{it}],\text{ where } \tilde{K}_t\equiv\tilde{g}_t+\tilde{x}_t/\nu. \tag{2.6}$$

[3] Accordingly, short election cycles and political instability may make governments rather myopic, which raises the effective rate at which they discount future events. For theoretical and empirical work on the interactions between short election cycles or political instability and public debt accumulation, see for example Roubini and Sachs (1989), Alesina and Tabellini (1990) and Tabellini and Alesina (1990).

[4] Tabellini (1986), Alesina and Tabellini (1987), Debelle (1993) and Debelle and Fischer (1994), in contrast, assume that $\kappa=1$. However, as will become clear below, the fact that κ is smaller than unity plays an important role for our results.

The government financing requirement (GFR_{it}) amounts to the government spending target $\tilde{g}_t$, a labor subsidy aimed at offsetting the implicit output tax due to non-tax distortions, $\tilde{x}_t/\nu$, and net debt servicing costs, $(1+\rho)d_{i,t-1}-d_{it}$. The last right-hand side of (2.6) represents the sources of finance: explicit and implicit tax revenues, $\tau_{it}+\tilde{x}_t/\nu$, seigniorage revenues, $\kappa\pi_t$ and the shortfall of government spending from its target, $\tilde{g}_t-g_{it}$.

If we take the discounted (to period 1) sums of the left and right hand sides of ((2.6), t=1,2), we obtain the *intertemporal government financing requirement*,

$$\tilde{F} \equiv (1+\rho)d_0 + \tilde{K}_1 + \tilde{K}_2/(1+\rho) = \sum_{t=1}^{2} (1+\rho)^{-(t-1)} [(\tau_{it}+\tilde{x}_t/\nu)+\kappa\pi_t+(\tilde{g}_t-g_{it})]. \tag{2.7}$$

2.3. The common central bank

Monetary policy is selected by the common central bank (CCB). Its objective function amounts to

$$V_M = \tfrac{1}{2} \sum_{t=1}^{2} \beta_S^{t-1} \{\alpha_{\pi M}\, \pi_t^2 + \sum_{i=1}^{n} [(x_{it}-\tilde{x}_t)^2 + \alpha_{gM}\, (g_{it}-\tilde{g}_t)^2]/n\},\ \alpha_{\pi M},\ \alpha_{gM}>0. \tag{2.8}$$

We allow the CCB's price stability weight, $\alpha_{\pi M}$, to diverge from societies', $\alpha_{\pi S}$. If $\alpha_{\pi M}=\alpha_{\pi S}$ and $\alpha_{gM}=\alpha_{gS}$,[5] the objective function of the CCB corresponds to an equally weighted average of the individual societies' objective functions.

In each period, the CCB and the government are involved in a Nash game. Each government selects taxes, public spending and (in period one) public debt, taking as given the inflation rate and expectations about the inflation rate in the current period.[6] At the same time, the common monetary policy is set by the CCB, which is unable to commit and takes as given the governments' policy choices as well as the current period inflation expectations.

The period t reaction function of the CCB is,[7]

$$\pi_t = \left(\frac{\nu^2}{\alpha_{\pi M}+\nu^2}\right)\left(\pi_t^e+\frac{1}{n}\sum_{i=1}^{n}\left(\tau_{it}+\tilde{x}_t/\nu\right)\right). \tag{2.9}$$

[5] As will become clear below, the CCB's spending weight does not affect the equilibrium.

[6] Whereas the first-period fiscal authorities take inflation expectations in the first period as given, they can affect second-period inflation expectations by using public debt. In this way, the first-period fiscal authorities act as Stackelberg leaders vis-à-vis the various players in the second period.

[7] A complete derivation of the equilibrium is contained in Appendix A.

Higher expected inflation and more severe tax and non-tax distortions in any of the participating countries reduce output below its target level, thereby inducing the CCB to use unanticipated inflation as an instrument to expand output. The weight the CCB attaches to output in country i is only 1/n-th of the weight that a national central bank would attach to output if monetary policy would be set at the national rather than the union level. Therefore, the inflation-reducing effect of a unilateral cut in the tax rate τ_i is only 1/n-th of the corresponding effect under national monetary policymaking. Intuitively, in a monetary union with many fiscal players, the strategic position of each individual fiscal player vis-à-vis the (common) monetary authority is relatively weak.

3. Does monetary unification boost debt accumulation?

Central bankers often express the fear that European monetary unification will result in excessive accumulation of public debt. Before the next section considers the welfare implications of debt accumulation, this section explores the positive question whether the establishment of a monetary union can be expected to boost the accumulation of debt.

In determining debt policy (see Appendix A.1), the first-period fiscal authorities equate the marginal benefit from issuing more debt (i.e. smaller distortionary losses in the first period) to the marginal cost (i.e. larger distortionary losses in the second period on account of higher debt service):[8]

$$N_D^{-1}[\tilde{K}_1+(1+\rho)d_0-d_1] = \beta_F(1+\rho)(N_{DU}^*/N_D^2)[\tilde{K}_2+(1+\rho)d_1], \tag{3.1}$$

where $N_D \equiv \kappa/\alpha_{\pi M}+1/\nu^2+1/\alpha_{gS}>0$ and $N_{DU}^* \equiv (1/n)(\alpha_{\pi S}/\alpha_{\pi M}^2)+((n-1)/n)(\kappa/\alpha_{\pi M})+1/\nu^2+1/\alpha_{gS}>0$. We can solve explicitly for first-period debt from the first-order condition (3.1):

$$[\beta_{FU}^*(1+\rho)+1]\ d_1 = [\tilde{K}_1+(1+\rho)d_0-\tilde{K}_2] + (1-\beta_{FU}^*)\tilde{K}_2, \tag{3.2}$$

where $\beta_{FU}^* \equiv \beta_F(1+\rho)(N_{DU}^*/N_D)=\beta_F(1+\rho)[1+(1/n)\alpha_{\pi M}^{-1}(\alpha_{\pi S}/\alpha_{\pi M}-\kappa)/N_D]$. This section assumes that the monetary authorities share society's price stability weight (i.e. $\alpha_{\pi M}=\alpha_{\pi S}$), so that $\beta_{FU}^*=\beta_F(1+\rho)[1+(1/n)\alpha_{\pi S}^{-1}(1-\kappa)/N_D]$. Without commitment problems, $\beta_{FU}^*=\beta_F(1+\rho)$. The term $(1/n)\alpha_{\pi S}^{-1}(1-\kappa)/N_D>0$, which thus originates in the inability to commit, raises the effective discount factor β_{FU}^*, thereby raising the marginal costs of debt accumulation (see the right-hand side of (3.1)) and thus reducing first-period debt (i.e. $\partial d_1/\partial\beta_{FU}^*<0$, see (3.2)). This term will be called the

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[8] We omit the country index because the identical economies set the same fiscal policy.

credibility effect because it stems from the attempts of the first-period fiscal player to enhance the credibility of anti-inflation policies in the second period. In particular, whereas they perceive inflation expectations in the first period to be given, first-period fiscal policymakers can use debt policy to affect inflation expectations in the second period. From the ex-ante perspective of these policymakers, second-period inflation expectations are too high due to the inability of the CCB to commit.[9] Accordingly, first-period fiscal policymakers reduce debt accumulation in order to reduce the "stock of credibility problems" in the second period, as measured by the government financing requirement $\tilde{K}_2+(1+\rho)d_1$. In this way, the lower stock of debt alleviates the inflationary bias because the lower second-period financing requirement allows for lower second-period tax rates, thereby decreasing the incentive facing the CCB to employ unanticipated inflation as an instrument to alleviate tax distortions (see the reaction function of the CCB (2.9)).[10]

If the monetary union becomes larger (i.e. n grows), the credibility effect becomes less effective in raising the effective discount rate β_{FU}^*, thereby boosting debt accumulation. In fact, if $n\to\infty$, the credibility effect vanishes completely. Intuitively, from the perspective of each individual government, the credibility of the CCB is a public good. In a larger union, each individual fiscal authority faces less of an incentive to contribute to this public good by building up assets, because the (perceived) beneficial effects of more assets (and thus lower second-period taxes) in terms of lower second-period inflation are smaller (see (2.9)). Hence, public debt and thus long-term inflation are higher in a monetary union (i.e. $n>1$) than with national monetary policymaking (i.e. $n=1$).

4. Does monetary unification yield excessive debt accumulation?

Section 3 confirms that monetary unification results in additional accumulation of public debt if discretionary policymaking implies an inflation bias. To scrutinize the presumption of central bankers that the EMU would result in *excessive* debt accumulation, this section turns to the welfare implications of the additional debt accumulation in a monetary union.

To that end, we write society's equilibrium welfare loss V_S^U in a monetary union as follows (see Appendix A.2):

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[9] Discretionary monetary policymaking suffers from an inflation bias because the price stability weight of the CCB coincides with that of society. If the CCB's price stability weight would exceed society's weight, inflation is no longer necessarily excessive. In particular, if $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$, inflation is optimal and the credibility effect vanishes (as $\beta_{FU}^*=\beta_F(1+\rho)$; see Section 5).

[10] In Obstfeld (1991a,b), the government accumulates assets in order to alleviate the time-inconsistency problems associated with nominal money demand.

$$V_S^U = L_A L_E \tilde{F}^2, \text{ where } L_A \equiv \left(\frac{\frac{\alpha_{\pi S}}{\alpha_{\pi M}^2} + \frac{1}{\nu^2} + \frac{1}{\alpha_{gS}}}{2N_D^2} \right), \; L_E \equiv \left(\frac{(1+\rho)^2\left((\beta_{FU}^*)^2 + \beta_S\right)}{\left(\beta_{FU}^*(1+\rho)+1\right)^2} \right). \quad (4.1)$$

The factor L_A is termed the *intratemporal welfare loss* because it corresponds to the intratemporal distribution of distortions across the available instruments. The factor L_E stems from the intertemporal distribution of distortionary losses across the two periods and, therefore, will be called the *intertemporal welfare loss*.

The intertemporal welfare loss indicates whether debt accumulation is excessive. In particular, this component L_E is strictly decreasing in β_{FU}^* if $\beta_{FU}^* < \beta_S^* \equiv \beta_S(1+\rho)$, strictly increasing in β_{FU}^* if $\beta_{FU}^* > \beta_S^*$, and thus attains its global minimum at $\beta_{FU}^* = \beta_S^*$. Accordingly, debt policy implies the optimal intertemporal allocation of distortionary losses if and only if $\beta_{FU}^* = \beta_S^*$ while debt accumulation is excessive if and only if $\beta_{FU}^* < \beta_S^*$. This latter inequality can be rewritten as:

$$(1/n)\alpha_{\pi M}^{-1}(\alpha_{\pi S}/\alpha_{\pi M} - \kappa)/N_D < \beta_S/\beta_F - 1. \quad (4.2)$$

4.1. Authorities share the social objectives

Compared to the second best (i.e. the Pareto optimum in the absence of lump-sum taxes, which is attained if a benevolent, centralized policymaker can commit; see Appendix B), both the intra- and intertemporal welfare loss components are too high. The additional intratemporal losses originate in excessive inflation due to the self-defeating incentive facing discretionary monetary policymakers to boost employment through inflation surprises.[11]

Intertemporal losses are excessive because the effective discount factor is too high from a social point of view (i.e. $\beta_{FU}^* = \beta_S(1+\rho)[1+(1/n)\alpha_{\pi S}^{-1}(1-\kappa)/N_D] > \beta_S^*$). Intuitively, from the perspective of the discretionary fiscal policymakers who set debt policy in the first period, only second-period inflation expectations are endogenous. This induces these policymaker to rely heavily on first-period financing, among other things in the form of unanticipated inflation. In equilibrium, however, inflation expectations are endogenous also in the first period as the private

[11] The independent central bank does not internalize government budget constraint (formally, it does not optimize under the restriction imposed by the government budget constraint) and thus ignores the benefits of inflation in terms of seigniorage revenue. However, with small holdings of base money (i.e. $\kappa<1$), this distortion is dominated by the inflation bias associated with the lack of commitment.

sector correctly anticipates the incentives of the first-period fiscal player to build up assets through unanticipated inflation in the first period. Consequently, the discretionary equilibrium relies excessively on first-period sources of financing and thus suffers from an asset bias (see also (4.2) with $\alpha_{\pi M}=\alpha_{\pi S}$ and $\beta_F=\beta_S$).

Monetary unification (i.e. an increase in the number of participating countries n) reduces the asset bias by pushing debt accumulation in the direction of its second-best level.[12] Accordingly, a larger union raises welfare (n does not affect L_A but reduces L_E).[13]

4.2. Myopic governments ($\beta_F<\beta_S$)

With myopic governments, debt rather than asset accumulation may be excessive.[14] Inequality (4.2) reveals that both the size of the union, n, and the political distortion (as measured by β_S/β_F) determine whether the stock of public debt is too large from a social point of view. In particular, for a large enough union or a small enough discount factor β_F, inequality (4.2) holds so that debt accumulation is excessive. In that case, a larger union implies more debt accumulation, thereby exacerbating the debt bias in the initial equilibrium. Accordingly, the additional debt accumulation in a larger monetary union can be termed ’excessive’. [15,16]

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[12] In fact, the second-best level of L_E is approached as the number of countries goes to infinity (i.e. $n\to\infty$).

[13] Hence, if the authorities share the social objectives, the optimal size of the union is infinite.

[14] Roubini and Sachs (1989) provide empirical evidence for the OECD countries that debt accumulation is larger if the expected government tenure is shorter, so that the government effectively becomes more myopic. In particular, if the expected tenure of the government is short, coalition governments find it hard to cooperate in implementing budget cuts. Budget adjustments are therefore more likely to be postponed, which results in more debt accumulation.

[15] Hence, in the presence of myopic governments, the optimal size of the union is finite.

[16] Fiscal cooperation induces governments to internalize the benefits that other governments perceive from restraining debt accumulation in terms of building up the credibility of the CCB. Accordingly, fiscal cooperation in a monetary union produces the same equilibrium as with national monetary policymaking (i.e. n=1). In the absence of myopic governments, fiscal cooperation is counterproductive by exacerbating the asset bias of the discretionary equilibrium. Whereas cooperation among benevolent fiscal players is thus counterproductive, cooperation among myopic governments may raise welfare. The paradoxical nature of this result is due to the interaction of various distortions in a third-best world.

5. Optimal institutions

5.1. Optimal monetary arrangements in absence of political distortions

Rogoff (1985) has shown that, in the absence of commitment, society can make itself better off by delegating discretionary monetary policy to an independent central bank who is more conservative (i.e. attaches a higher weight to price stability) than society. Intuitively, by adjusting monetary preferences, society offsets the distortions due to the lack of commitment. Indeed, in an already distorted world, introducing another distortion may raise welfare.

If the preferences of the fiscal policymakers coincide with societies', the price stability weight of the CCB that minimizes the intratemporal welfare loss component in our model is given by:[17]

$$\alpha_{\pi M} = \alpha_{\pi M}^{opt} = \alpha_{\pi S}/\kappa > \alpha_{\pi S}. \tag{5.1}$$

This confirms Rogoff's (1985) finding that a conservative, independent central bank can help to deal with commitment problems. An optimally designed independent central bank featuring the price stability weight given by (5.1) minimizes not only intratemporal losses L_A but also intertemporal losses L_E.[18] Accordingly, in the absence of fiscal imperfections, optimal monetary arrangements produce the second best by alleviating both intra- intertemporal distortions.[19] Intuitively, the incentive facing the fiscal authorities in the first period to accumulate assets in order to enhance the credibility of second-period monetary policy originates in the inflation bias in the second period. Endowing the CCB with the price stability weight in (5.1) eliminates this inflation bias so that the fiscal authorities no longer perceive any need to employ debt policy to alleviate the inflation bias.

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[17] This can be checked by differentiating L_A with respect to $\alpha_{\pi M}$ and noting that the derivative is negative for $\alpha_{\pi M}<\alpha_{\pi S}/\kappa$ and positive for $\alpha_{\pi M}>\alpha_{\pi S}/\kappa$.

[18] By inserting (5.1) into the definition of the effective discount factor in order to eliminate $\alpha_{\pi M}$, we find that the effective discount factor β_{FU}^* equals β_S^*. This is the value of β_{FU}^* that minimizes intertemporal losses (see Section 4).

[19] This statement holds irrespective of the size of a monetary union. Hence, monetary unification affects neither the policy outcomes nor welfare in the presence of benevolent fiscal authorities and optimal monetary institutions.

5.2. Optimal monetary arrangements in the presence of political distortions

Optimal institutional design is complicated in the presence of myopic governments. In this case, the second best can no longer be established by endowing an independent central bank with the proper price stability weight. Furthermore, monetary institutions can no longer be targetted only at the optimal intratemporal inflation rate but also must bear the burden of dealing with the political distortions due to myopic governments. In particular, in the presence of myopic governments (i.e. $\beta_F<\beta_S$), the central bank should be made *less* conservative than in the absence of fiscal imperfections (see Appendix C). The resulting inflation bias induces the fiscal authorities to enhance the credibility of second period monetary policy by restraining debt accumulation, thereby alleviating the excessive debt accumulation associated with myopia. The optimal price stability weight of the CCB balances, on the one hand, the intratemporal distortion due to excessive inflation originating in the lack of commitment (the 'monetary' distortion) and, on the other hand, the intertemporal distortion due to excessive debt accumulation originating in myopic governments (the 'fiscal' distortion). Raising the price stability weight from its optimal value towards the optimal value in the absence of fiscal distortions (given by (5.1)), while reducing monetary distortions, would worsen fiscal distortions due to myopic fiscal policymakers. This is a typical second-best result: Removing a single distortion (the monetary distortion in this case) in a world with multiple distortions may reduce overall welfare by exacerbating other distortions (the fiscal distortion in this case).

5.3. Optimal monetary and fiscal arrangements in the presence political distortions

The previous sub-section showed that granting an independent central bank the proper degree of conservatism is no longer sufficient for attaining the second best if governments are myopic. Intuitively, monetary institutions are not the most appropriate instruments to address fiscal imperfections. Indeed, in the presence of political distortions involving the preferences of the fiscal authorities in addition to distortions due to the inability to commit monetary policy, the second best can be established only by adopting two instruments, each targetted at a single distortion. In this sub-section we explore debt targets as an instrument to address government myopia.

In the presence of a union-wide target $\hat{d}_1$ on first-period public debt d_1, each fiscal authority solves two single period optimisation problems with exogenous government financing requirements $\tilde{K}_1+(1+\rho)d_0-\hat{d}_1$ and $\tilde{K}_2+(1+\rho)\hat{d}_1$ in the first and second period, respectively. Optimal intratemporal choices of inflation, taxes and public spending yield the following expression for society's welfare loss (see Appendix D):

$$L_A\left(\left(\tilde{K}_1+(1+\rho)d_0-\hat{d}_1\right)^2+\beta_S\left(\tilde{K}_2+(1+\rho)\hat{d}_1\right)^2\right). \tag{5.2}$$

The optimal debt target minimizes the term between brackets and is thus given by,

$$\hat{d}_1^{\,opt} = \frac{\tilde{K}_1+(1+\rho)d_0-\tilde{K}_2+(1-\beta_S^*)\tilde{K}_2}{\beta_S^*(1+\rho)+1}, \text{ where } \beta_S^* \equiv \beta_S(1+\rho). \tag{5.3}$$

The optimal debt target $\hat{d}_1^{opt}$, which coincides with debt accumulation in the second best, depends on neither the size of the union nor the severity of political distortions. In fact, irrespective of the degree of government myopia and the size of union, the second best is established by supplementing an optimally designed conservative, independent CCB featuring a price stability weight given by (5.1) with the optimal debt target given by (5.3). Indeed, the need to address not only monetary distortions due to the lack of commitment but also fiscal distortions due to government myopia explains why, following the Report of the Delors Committee (1989), the Maastricht Treaty on the EMU incorporates ceilings on public debt as complements to a conservative, independent European central bank. In this way, institutional arrangements are targetted directly at the origins of the distortions so that monetary institutions can be designed exclusively with an eye on price stability.

Debt targets are particularly useful in a monetary union with many myopic fiscal players because unrestrained debt accumulation is likely to be most excessive in large monetary unions. In particular, if β_F is sufficiently low, the gap between unrestrained debt accumulation and $\hat{d}_1^{opt}$ increases in the size of the union, n (see also (4.2)). The model thus explains not only why European central bankers are such strong advocates of debt ceilings, but also why they are more concerned about excessive debt accumulation in an EMU than with national monetary policymaking.

6. Conclusions

This paper explored how monetary unification impacts the accumulation of public debt. From a positive perspective, we showed that monetary unification boosts debt accumulation and long-run inflation if discretionary monetary policy suffers from an inflation bias. Debt accumulation is stimulated because a larger union reduces the benefits of lower public debt that each individual government perceives to have on the public good of the credibility of the common monetary policy. From a normative perspective, the additional debt accumulation implied by monetary unification is excessive only in the presence of fiscal imperfections in the form of myopic governments. In the absence of fiscal imperfections, debt accumulation is too low if monetary policy suffers from an inflation bias. Removing this inflation bias by delegating monetary policy to a sufficiently conservative central bank establishes the second best.

Monetary unification thus produces additional excessive debt accumulation only in the presence of both monetary distortions (originating in the inability to commit and resulting in excessive inflation) and fiscal distortions (originating in myopic governments and resulting in excessive debt accumulation). The monetary distortions cause monetary unification to boost debt accumulation while the fiscal distortions imply that this additional debt accumulation is excessive. In these circumstances, the second best can be achieved by supplementing a conservative, independent central bank by debt ceilings. In this way, institutional arrangements are targetted directly at the origins of the monetary and fiscal distortions.

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A: Derivation of debt accumulation and welfare loss under a monetary union.

The CCB and the fiscal authorities play a Nash game in the first and second period. The central bank chooses the inflation rate taking as given the fiscal authorities' policy choices and taking as given the expected inflation rate. The fiscal authority of country i selects the τ_{i2} and g_{i2} in period 2, taking as given π_2, π_2^e and the other fiscal authorities' policies, and τ_{i1}, g_{i1} and d_{i1} in period 1, taking as given π_1, π_1^e and the other fiscal authorities' policies.

A.1. Derivation of debt accumulation

The CCB's second period problem is to minimize over π_2,

$$½ \{\alpha_{\pi M}\, \pi_2^2 + \textstyle\sum_{i=1}^{n} [(x_{i2}-\tilde{x}_2)^2 + \alpha_{gS}\, (g_{i2}-\tilde{g}_2)^2]/n\}. \tag{A.1}$$

The second period reaction function of the CCB is,

$$\pi_2 = \left(\frac{\nu^2}{\alpha_{\pi M}+\nu^2}\right)\left(\pi_2^e+\frac{1}{n}\sum_{i=1}^{n}\left(\tau_{i2}+\tilde{x}_2/\nu\right)\right). \tag{A.2}$$

The second period Lagrangian of the fiscal authority of country i is,

$$£_{i2} = ½[\alpha_{\pi S}\pi_2^2 + (\nu(\pi_2-\pi_2^e-\tau_{i2})-\tilde{x}_2)^2 + \alpha_{gS}(g_{i2}-\tilde{g}_2)^2] + \lambda_{i2}[g_{i2}+(1+\rho)d_{i1}-\tau_{i2}-\kappa\pi_2], \tag{A.3}$$

where λ_{i2} is the Lagrange multiplier associated with the second-period budget constraint of government i. The first order conditions for τ_{i2} and g_{i2} are given by, respectively,

$$-\nu(\nu(\pi_2-\pi_2^e-\tau_{i2})-\tilde{x}_2) = \lambda_{i2}, \tag{A.4}$$

$$\alpha_{gS}(\tilde{g}_2-g_{i2}) = \lambda_{i2}. \tag{A.5}$$

Impose rationality of expectations ($\pi_2^e=\pi_2$) upon (A.4) and combine the resulting expression and (A.5) with country i's government financing requirement (2.6) for period 2, to yield

$$\nu(\nu\tau_{i2}+\tilde{x}_2) = (1/\nu^2+1/\alpha_{gS})^{-1}[\tilde{K}_2+(1+\rho)d_{i1}-\kappa\pi_2], \tag{A.6}$$

$$\tilde{g}_2-g_{i2} = (1/\alpha_{gS})(1/\nu^2+1/\alpha_{gS})^{-1}[\tilde{K}_2+(1+\rho)d_{i1}-\kappa\pi_2]. \tag{A.7}$$

Impose rational expectations ($\pi_2^e=\pi_2$) on (A.2) and substitute (A.6) (i=1,..,n) into the resulting expression.

After some algebra we then find,

$$\kappa\pi_2 = \left(\frac{\kappa/\alpha_{\pi M}}{N_D}\right)\left(\frac{1}{n}\sum_{j=1}^{n}\left(\tilde{K}_2+(1+\rho)d_{j1}\right)\right), \tag{A.8}$$

where $N_D \equiv 1/\alpha_{\pi M}+1/\nu^2+1/\alpha_{gS}$, as defined in the main text.

Government i's second period equilibrium welfare loss is,

$$L_{i2}^F \equiv ½[\alpha_{\pi S}\pi_2^{\,2} + (\nu\tau_{i2}+\tilde{x}_2)^2 + \alpha_{gS}(g_{i2}-\tilde{g}_2)^2], \tag{A.9}$$

where π_2, τ_{i2} and g_{i2} are the equilibrium policy outcomes. Substitute (A.8) into (A.9). Furthermore, substitute (A.8) into (A.6) and (A.7), and substitute the resulting expressions into (A.9). This yields,

$$L_{i2}^F = \frac{1}{2}\left(\frac{\alpha_{\pi S}/\alpha_{\pi M}^2}{N_D^2}\right)\left(\frac{1}{n}\sum_{j=1}^{n}\left(\tilde{K}_2+(1+\rho)d_{j1}\right)\right)^2 +$$

$$\frac{1}{2}\left(\frac{1}{1/\nu^2+1/\alpha_{gS}}\right)\left[\left(\tilde{K}_2+(1+\rho)d_{i1}\right) - \left(\frac{\kappa/\alpha_{\pi M}}{N_D}\right)\left(\frac{1}{n}\sum_{j=1}^{n}\left(\tilde{K}_2+(1+\rho)d_{j1}\right)\right)\right]^2. \tag{A.10}$$

In the first period, the central bank selects π_1 to minimize,

$$½\ \{\alpha_{\pi M}\ \pi_1^{\,2} + \textstyle\sum_{i=1}^{n} [(x_{i1}-\tilde{x}_1)^2 + \alpha_{gS}\ (g_{i1}-\tilde{g}_1)^2]/n\}. \tag{A.11}$$

This yields the first period reaction function of the CCB,

$$\pi_1 = \left(\frac{\nu^2}{\alpha_{\pi M}+\nu^2}\right)\left(\pi_1^e+\frac{1}{n}\sum_{i=1}^{n}\left(\tau_{i1}+\tilde{x}_1/\nu\right)\right). \tag{A.12}$$

The first-period Lagrangian of the fiscal authority of country i is,

$$£_{i1} = ½[\alpha_{\pi S}\pi_1^{\,2} + (\nu(\pi_1-\pi_1^{\,e}-\tau_{i1})-\tilde{x}_1)^2 + \alpha_{gS}(g_{i1}-\tilde{g}_1)^2] + \beta_F L_{i2}^F + \lambda_{i1}[g_{i1}+(1+\rho)d_0-\tau_{i1}-\kappa\pi_1-d_{i1}], \tag{A.13}$$

where λ_{i1} is the Lagrange multiplier associated with the first period budget constraint of government i. The first order conditions for τ_{i1}, g_{i1} and d_{i1} are given by, respectively,

$$-\nu(\nu(\pi_1-\pi_1^{\,e}-\tau_{i1})-\tilde{x}_{i1}) = \lambda_{i1}, \tag{A.14}$$

$$\alpha_{gS}(\tilde{g}_1\text{-}g_{i1}) = \lambda_{i1}, \tag{A.15}$$

$$\beta_F \partial L_{i2}^F/\partial d_{i1} = \lambda_{i1}. \tag{A.16}$$

Impose rationality of expectations $\pi_1^e=\pi_1$ upon (A.14) and combine the resulting expression with (A.15) and country i's government financing requirement (2.6) for period one, to yield

$$\nu(\nu\tau_{i1}+\tilde{x}_1) = N_D^{-1}[\tilde{K}_1+(1+\rho)d_0\text{-}d_{i1}], \tag{A.17}$$

Combine (A.14) (after having imposed $\pi_1^e=\pi_1$), (A.16) and (A.17) to yield,

$$\beta_F\ \partial L_{i2}^F/\partial d_{i1} = N_D^{-1}[\tilde{K}_1+(1+\rho)d_0\text{-}d_{i1}]. \tag{A.18}$$

We have that

$$\frac{\partial L_{i2}^F}{\partial d_{i1}} = \frac{1}{n}\left(\frac{\alpha_{\pi S}/\alpha_{\pi M}^2}{N_D^2}\right)\left(\frac{1}{n}\sum_{j=1}^{n}\left(\tilde{K}_2+(1+\rho)d_{j1}\right)\right)(1+\rho)\ +$$

$$\left(\frac{1}{1/\nu^2+1/\alpha_{gS}}\right)\left(\left(\tilde{K}_2+(1+\rho)d_{i1}\right) - \left(\frac{\kappa/\alpha_{\pi M}}{N_D}\right)\left(\frac{1}{n}\sum_{j=1}^{n}\left(\tilde{K}_2+(1+\rho)d_{j1}\right)\right)\right)\left(1-\frac{1}{n}\left(\frac{\kappa/\alpha_{\pi M}}{N_D}\right)\right)(1+\rho). \tag{A.19}$$

Because the necessary (and sufficient) conditions for an equilibrium are linear, there is a unique equilibrium solution in general. Moreover, because the economies are all identical, in equilibrium all governments choose the same values for their policy instruments. Hence, we can impose $d_{j1}=d_1$ (j=1,..,n) on (A.19), to yield (after some algebra),

$$\frac{\partial L_{i2}^F}{\partial d_{i1}} = \left(\frac{N_{DU}^*}{N_D^2}\right)\left(\tilde{K}_2+(1+\rho)d_1\right)(1+\rho), \tag{A.20}$$

where $N_{DU}^*=(1/n)(\alpha_{\pi S}/\alpha_{\pi M}^2)+((n\text{-}1)/n)(\kappa/\alpha_{\pi M})+1/\nu^2+1/\alpha_{gS}$, as defined in the main text. Substitute (A.20) into (A.18) to yield,

$$N_D^{-1}[\tilde{K}_1+(1+\rho)d_0\text{-}d_1] = \beta_F(1+\rho)(N_{DU}^*/N_D^2)[\tilde{K}_2+(1+\rho)d_1], \tag{A.21}$$

which is (3.1) in the main text. (A.21) can be rewritten as,

$$d_1 = [\beta_{FU}{}^*(1+\rho)+1]^{-1} \{[\tilde{K}_1+(1+\rho)d_0-\tilde{K}_2] + (1-\beta_{FU}{}^*)\tilde{K}_2\}, \qquad (A.22)$$

where $\beta_{FU}{}^*=\beta_F{}^*(N_{DU}{}^*/N_D)$ and where $\beta_F{}^*=\beta_F(1+\rho)$, as defined in the main text. Substitute (A.22) for d_{i1} into (A.17) and rewrite to give the equilibrium tax rate in period one,

$$\tau_1+\tilde{x}_1/\nu = \left(\frac{1/\nu^2}{N_D}\right)\left(\frac{\beta^*_{FU}(1+\rho)\left(\tilde{K}_1+(1+\rho)d_0\right)+\beta^*_{FU}\tilde{K}_2}{\beta^*_{FU}(1+\rho)+1}\right) = \left(\frac{1/\nu^2}{N_D}\right)\left(\frac{\beta^*_{FU}(1+\rho)}{\beta^*_{FU}(1+\rho)+1}\right)\tilde{F}, \qquad (A.23)$$

where $\tilde{F}=(1+\rho)d_0+\tilde{K}_1+\tilde{K}_2/(1+\rho)$, as defined in the main text. Similarly, substitute (A.22) for d_{i1} into (A.6) and rewrite to give,

$$\tau_2+\tilde{x}_2/\nu = \left(\frac{1/\nu^2}{N_D}\right)\left(\frac{(1+\rho)\left(\tilde{K}_1+(1+\rho)d_0\right)+\tilde{K}_2}{\beta^*_{FU}(1+\rho)+1}\right) = \left(\frac{1/\nu^2}{N_D}\right)\left(\frac{1+\rho}{\beta^*_{FU}(1+\rho)+1}\right)\tilde{F}, \qquad (A.24)$$

The country index i has been suppressed because of the equivalence of the equilibrium policy choices across countries.

A.2. Derivation of society's equilibrium welfare loss

Using the, respectively, first- and second-period first-order conditions of the government's optimization problem, we find

$$\tilde{g}_1-g_1 = \left(\frac{1/\alpha_{gS}}{N_D}\right)\left(\frac{\beta^*_{FU}(1+\rho)\left(\tilde{K}_1+(1+\rho)d_0\right)+\beta^*_{FU}\tilde{K}_2}{\beta^*_{FU}(1+\rho)+1}\right) = \left(\frac{1/\alpha_{gS}}{N_D}\right)\left(\frac{\beta^*_{FU}(1+\rho)}{\beta^*_{FU}(1+\rho)+1}\right)\tilde{F}, \qquad (A.25)$$

$$\tilde{g}_2-g_2 = \left(\frac{1/\alpha_{gS}}{N_D}\right)\left(\frac{(1+\rho)\left(\tilde{K}_1+(1+\rho)d_0\right)+\tilde{K}_2}{\beta^*_{FU}(1+\rho)+1}\right) = \left(\frac{1/\alpha_{gS}}{N_D}\right)\left(\frac{1+\rho}{\beta^*_{FU}(1+\rho)+1}\right)\tilde{F}. \qquad (A.26)$$

Imposing rationality of expectations on the CCB's reaction functions, using (A.23) and (A.24) and the equivalence of equilibrium fiscal policies across all countries, we have

$$\pi_1 = \left(\frac{1/\alpha_{\pi M}}{N_D}\right)\left(\frac{\beta^*_{FU}(1+\rho)\left(\tilde{K}_1+(1+\rho)d_0\right)+\beta^*_{FU}\tilde{K}_2}{\beta^*_{FU}(1+\rho)+1}\right) = \left(\frac{1/\alpha_{\pi M}}{N_D}\right)\left(\frac{\beta^*_{FU}(1+\rho)}{\beta^*_{FU}(1+\rho)+1}\right)\tilde{F}. \qquad (A.27)$$

$$\pi_2 = \left(\frac{1/\alpha_{\pi M}}{N_D}\right)\left(\frac{(1+\rho)\left(\tilde{K}_1+(1+\rho)d_0\right)+\tilde{K}_2}{\beta^{*}_{FU}(1+\rho)+1}\right) = \left(\frac{1/\alpha_{\pi M}}{N_D}\right)\left(\frac{1+\rho}{\beta^{*}_{FU}(1+\rho)+1}\right)\tilde{F}. \tag{A.28}$$

Substitute (2.1, t=1,2) into (2.2), impose rationality of expectations and the equivalence of fiscal policies across countries, to obtain

$$V_{S,i} = ½ \sum_{t=1}^{2} \beta_S^{t-1} [\alpha_{\pi S}\, \pi_t^2 + (\nu\tau_t+\tilde{x}_t)^2 + \alpha_{gS}\, (g_t-\tilde{g}_t)^2],\ 0<\beta_S\leq 1,\ \alpha_{\pi S},\alpha_{gS}>0. \tag{A.29}$$

It is straightforward to obtain (4.1) through the substitution of (A.23)-(A.28) into (A.29).

B: Derivation of the second best equilibrium.

The second best equilibrium is the Pareto optimum in the absence of lump-sum taxes. This equilibrium is attained if both the fiscal and monetary policy instruments for an individual country are selected by a benevolent policymaker (i.e. the policymaker who shares the preferences of his own society) who is able to commit. The solution is again found by working back in time and solving for the optimal policies given the current value of the state variable (public debt) and given that future policies are optimally selected.

We omit the country index because now the inflation rate is selected at the national level, while each country's policymaker faces the same optimization problem. Substitute (2.1) into (2.2) (for t=2) and impose $\pi_2^e=\pi_2$, so that the second-period Lagrangian of the policymaker can be written as,

$$£_2 = ½[\alpha_{\pi S}\pi_2^2 + (\nu\tau_2+\tilde{x}_2)^2 + \alpha_{gS}(g_2-\tilde{g}_2)^2] + \lambda_2[g_2+(1+\rho)d_1-\tau_2-\kappa\pi_2], \tag{B.1}$$

where λ_2 is the Lagrange multiplier associated with the government budget constraint in the second period. The first order conditions (given the linear-quadratic specification of the problem, the first order conditions are necessary and sufficient for the optimum) for π_2, τ_2 and g_2 are given by, respectively,

$$\alpha_{\pi S}\pi_2 = \lambda_2\kappa, \tag{B.2}$$

$$\nu(\nu\tau_2+\tilde{x}_2) = \lambda_2, \tag{B.3}$$

$$\alpha_{gS}(\tilde{g}_2-g_2) = \lambda_2, \tag{B.4}$$

Eliminate λ_2 from the system (B.2)-(B.4) to obtain:

$$\pi_2 = (\kappa^2\nu^2/\alpha_{\pi S})(\tau_2+\tilde{x}_2/\nu), \tag{B.5}$$

$$\tilde{g}_2-g_2 = (\nu^2/\alpha_{gS})(\tau_2+\tilde{x}_2/\nu), \tag{B.6}$$

Combine (B.5) and (B.6) with the government financing requirement (2.6) for period 2, to obtain the second-period policy outcomes for a given value of d_1:

$$\pi_2 = \left(\frac{\kappa/\alpha_{\pi S}}{P}\right)\left(\tilde{K}_2+(1+\rho)d_1\right), \tag{B.7}$$

$$\tau_2+\tilde{x}_2/\nu = \left(\frac{1/\nu^2}{P}\right)\left(\tilde{K}_2+(1+\rho)d_1\right), \tag{B.8}$$

$$\tilde{g}_2-g_2 = \left(\frac{1/\alpha_{gS}}{P}\right)\left(\tilde{K}_2+(1+\rho)d_1\right), \tag{B.9}$$

where $P\equiv\kappa^2/\alpha_{\pi S}+1/\nu^2+1/\alpha_{gS}$. Substitution of (B.7)-(B.9) into the fiscal authority's welfare loss function (and imposing $\pi_2^e=\pi_2$), yields a second period welfare loss of $\frac{1}{2}P^{-1}[\tilde{K}_2+(1+\rho)d_1]^2$.

If we substitute (2.1) into (2.2) (for t=1) and impose $\pi_1^e=\pi_1$, the first-period Lagrangian of the benevolent policymaker can be written as,

$$£_1 = \tfrac{1}{2}[\alpha_{\pi S}\pi_1^2 + (\nu\tau_1+\tilde{x}_1)^2 + \alpha_{gS}(g_1-\tilde{g}_1)^2] + \tfrac{1}{2}\beta_S P^{-1}[\tilde{K}_2+(1+\rho)d_1]^2 + \lambda_1[g_1+(1+\rho)d_0-\tau_1-\kappa\pi_1-d_1], \tag{B.10}$$

where λ_1 is the Lagrange multiplier associated with the government budget constraint in the first period. The first order conditions for π_1, τ_1, g_1 and d_1 are given by, respectively,

$$\alpha_{\pi S}\pi_1 = \lambda_1\kappa, \tag{B.11}$$

$$\nu(\nu\tau_1+\tilde{x}_1) = \lambda_1, \tag{B.12}$$

$$\alpha_{gS}(\tilde{g}_1-g_1) = \lambda_1, \tag{B.13}$$

$$\beta_S P^{-1}[\tilde{K}_2+(1+\rho)d_1](1+\rho) = \lambda_1. \tag{B.14}$$

Combine (B.11)-(B.13) with the government financing requirement (2.6) for period 1, to yield

$$\nu(\nu\tau_1+\tilde{x}_1) = P^{-1}[\tilde{K}_1+(1+\rho)d_0-d_1]. \tag{B.15}$$

Combine (B.12), (B.14) and (B.15) to give

$$[\tilde{K}_1+(1+\rho)d_0-d_1] = \beta_S(1+\rho)[\tilde{K}_2+(1+\rho)d_1]. \tag{B.16}$$

Equation (B.16) can be rewritten as,

$$d_1 = [\beta_S^*(1+\rho)+1]^{-1}\ \{[\tilde{K}_1+(1+\rho)d_0-\tilde{K}_2]+(1-\beta_S^*)\tilde{K}_2\},\ \text{where}\ \beta_S^*\equiv\beta_S(1+\rho). \tag{B.17}$$

Substitute (B.17) into (B.15) and rewrite to give the equilibrium tax rate in period one,

$$\tau_1+\tilde{x}_1/\nu = \left(\frac{1/\nu^2}{P}\right)\left(\frac{\beta_S^*(1+\rho)\big(\tilde{K}_1+(1+\rho)d_0\big)+\beta_S^*\tilde{K}_2}{\beta_S^*(1+\rho)+1}\right) = \left(\frac{1/\nu^2}{P}\right)\left(\frac{\beta_S^*(1+\rho)}{\beta_S^*(1+\rho)+1}\right)\tilde{F}. \tag{B.18}$$

Similarly, substitute (B.17) into (B.8) and rewrite to give the equilibrium tax rate in period two,

$$\tau_2+\tilde{x}_2/\nu = \left(\frac{1/\nu^2}{P}\right)\left(\frac{(1+\rho)\big(\tilde{K}_1+(1+\rho)d_0\big)+\tilde{K}_2}{\beta_S^*(1+\rho)+1}\right) = \left(\frac{1/\nu^2}{P}\right)\left(\frac{1+\rho}{\beta_S^*(1+\rho)+1}\right)\tilde{F}. \tag{B.19}$$

From the first- and second-period first order conditions we can also derive the other policy outcomes:

$$\pi_1 = \left(\frac{\kappa/\alpha_{\pi S}}{P}\right)\left(\frac{\beta_S^*(1+\rho)\big(\tilde{K}_1+(1+\rho)d_0\big)+\beta_S^*\tilde{K}_2}{\beta_S^*(1+\rho)+1}\right) = \left(\frac{\kappa/\alpha_{\pi S}}{P}\right)\left(\frac{\beta_S^*(1+\rho)}{\beta_S^*(1+\rho)+1}\right)\tilde{F}. \tag{B.20}$$

$$\pi_2 = \left(\frac{\kappa/\alpha_{\pi S}}{P}\right)\left(\frac{(1+\rho)\big(\tilde{K}_1+(1+\rho)d_0\big)+\tilde{K}_2}{\beta_S^*(1+\rho)+1}\right) = \left(\frac{\kappa/\alpha_{\pi S}}{P}\right)\left(\frac{1+\rho}{\beta_S^*(1+\rho)+1}\right)\tilde{F}. \tag{B.21}$$

$$\tilde{g}_1-g_1 = \left(\frac{1/\alpha_{gS}}{P}\right)\left(\frac{\beta_S^*(1+\rho)\big(\tilde{K}_1+(1+\rho)d_0\big)+\beta_S^*\tilde{K}_2}{\beta_S^*(1+\rho)+1}\right) = \left(\frac{1/\alpha_{gS}}{P}\right)\left(\frac{\beta_S^*(1+\rho)}{\beta_s^*(1+\rho)+1}\right)\tilde{F}. \tag{B.22}$$

$$\tilde{g}_2-g_2 = \left(\frac{1/\alpha_{gS}}{P}\right)\left(\frac{(1+\rho)\big(\tilde{K}_1+(1+\rho)d_0\big)+\tilde{K}_2}{\beta_S^*(1+\rho)+1}\right) = \left(\frac{1/\alpha_{gS}}{P}\right)\left(\frac{1+\rho}{\beta_S^*(1+\rho)+1}\right)\tilde{F}. \tag{B.23}$$

Combination of (2.1, t=1,2), the assumption of rational expectations, (2.2) and (B.18)-(B.23) yields the following expression for society’s welfare loss in the second-best equilibrium:

$$\left(\frac{1}{2P}\right)\left(\frac{(1+\rho)^2\left((\beta_S^*)^2+\beta_S\right)}{\left(\beta_S^*(1+\rho)+1\right)^2}\right)\tilde{F}^2. \tag{B.24}$$

C: Proof that $\alpha_{\pi M}{}^{E}<\alpha_{\pi M}{}^{opt}<\alpha_{\pi S}/\kappa$ if $\beta_F<\beta_S$.

(where $\alpha_{\pi M}{}^{E}>0$ is defined as the value of $\alpha_{\pi M}$ which minimizes L_A).

Society's welfare loss is

$$V_S{}^U = L_A L_E \tilde{F}^2, \tag{C.1}$$

where

$$L_A \equiv \left(\frac{\dfrac{\alpha_{\pi S}}{\alpha_{\pi M}^2}+\dfrac{1}{\nu^2}+\dfrac{1}{\alpha_{gS}}}{2N_D^2}\right) > 0, \tag{C.2}$$

$$L_E \equiv \left(\frac{(1+\rho)^2\left((\beta_{FU}^*)^2+\beta_S\right)}{\left(\beta_{FU}^*(1+\rho)+1\right)^2}\right) > 0. \tag{C.3}$$

Let us first establish some properties of L_A, the intratemporal welfare loss, and L_E, the intertemporal the welfare loss.

Differentiate L_A with respect to $\alpha_{\pi M}$, to yield,

$$\frac{\partial L_A}{\partial \alpha_{\pi M}} = \left(\frac{\dfrac{1}{\alpha_{\pi M}^2}\left(\kappa-\dfrac{\alpha_{\pi S}}{\alpha_{\pi M}}\right)\left(\dfrac{1}{\nu^2}+\dfrac{1}{\alpha_{gS}}\right)}{N_D^3}\right). \tag{C.4}$$

Hence, L_A is strictly decreasing (increasing) for $\alpha_{\pi M}$ < (>) $\alpha_{\pi S}/\kappa$ so that it reaches its global minimum at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$.

Differentiate L_E with respect to $\alpha_{\pi M}$, to yield,

$$\frac{\partial L_E}{\partial \alpha_{\pi M}} = 2(1+\rho)^2\left(\frac{\beta_{FU}^*-\beta_S^*}{\left(\beta_{FU}^*(1+\rho)+1\right)^3}\right)\left(\frac{\partial \beta_{FU}^*}{\partial \alpha_{\pi M}}\right). \tag{C.5}$$

The first factor between square brackets on the right hand side of (C.5) is negative (positive) if $\beta_{FU}^* < (>)$ β_S^*. Furthermore,

$$\frac{\partial \beta_{FU}^*}{\partial \alpha_{\pi M}} = \frac{1}{n}\left(\frac{-\frac{\kappa \alpha_{\pi S}}{\alpha_{\pi M}^4} + \frac{1}{\alpha_{\pi M}^2}\left(\kappa - 2\left(\frac{\alpha_{\pi S}}{\alpha_{\pi M}}\right)\right)\left(\frac{1}{\nu^2} + \frac{1}{\alpha_{gS}}\right)}{N_D^2}\right)\beta_F^*, \tag{C.6}$$

which is negative if $\alpha_{\pi M} \leq 2\alpha_{\pi S}/\kappa$.

The proof consists of the following steps, in which we show that: (i) L_E reaches its global minimum at $\alpha_{\pi M}=\alpha_{\pi M}^E$, where $0<\alpha_{\pi M}^E<\alpha_{\pi S}/\kappa$; (ii) L_A is strictly decreasing for $\alpha_{\pi M}\leq\alpha_{\pi M}^E$ and L_E is strictly decreasing for $\alpha_{\pi M}<\alpha_{\pi M}^E$, hence there exists a value of $\alpha_{\pi M}>\alpha_{\pi M}^E$, such that society's welfare loss is lower than for any $0<\alpha_{\pi M}\leq\alpha_{\pi M}^E$; (iii) L_E, when evaluated at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$, is strictly increasing and is lower than when evaluated at any other $\alpha_{\pi M}>\alpha_{\pi S}/\kappa$. Given that L_A reaches a global minimum for $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$ (the minimum is interior, hence the slope of L_A is flat at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$ and, hence, there are no first-order effects on L_A of a change in $\alpha_{\pi M}$ when evaluated at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$), it then follows that $\alpha_{\pi M}^{opt}<\alpha_{\pi S}/\kappa$.

Step (i): Remember that for $\alpha_{\pi M}\leq\alpha_{\pi S}/\kappa$, β_{FU}^* is strictly decreasing in $\alpha_{\pi M}$. At $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$, $\beta_{FU}^*=\beta_F^*<\beta_S^*$. Moreover, β_{FU}^* goes to infinity as $\alpha_{\pi M}$ approaches zero from above. Hence, by continuity, there should be a (unique) value of $\alpha_{\pi M}$, denoted by $\alpha_{\pi M}^E$, between 0 and $\alpha_{\pi S}/\kappa$ at which $\beta_{FU}^*=\beta_S^*$. L_E reaches its global minimum at $\beta_{FU}^*=\beta_S^*$, hence at $\alpha_{\pi M}=\alpha_{\pi M}^E$.

Step (ii): Because $\alpha_{\pi M}^E<\alpha_{\pi S}/\kappa$, it follows immediately that L_A is strictly decreasing for $\alpha_{\pi M}\leq\alpha_{\pi M}^E$. Moreover, we have seen that β_{FU}^* is strictly decreasing for $\alpha_{\pi M}<\alpha_{\pi S}/\kappa$, hence, by the definition of $\alpha_{\pi M}^E$, $\beta_{FU}^*>\beta_S^*$ for $\alpha_{\pi M}<\alpha_{\pi M}^E$. Hence, for $\alpha_{\pi M}<\alpha_{\pi M}^E$, $\partial L_E/\partial\beta_{FU}^*>0$ and $\partial\beta_{FU}^*/\partial\alpha_{\pi M}<0$, and, hence, $\partial L_E/\partial\alpha_{\pi M}<0$.

Step (iii): Remember that at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$, $\beta_{FU}^*=\beta_F^*<\beta_S^*$, and, hence, $\partial L_E/\partial\beta_{FU}^*<0$ at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$. Remember also that β_{FU}^* is strictly decreasing at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$. Therefore, $\partial L_E/\partial\alpha_{\pi M}>0$ at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$. Furthermore, $N_{DU}^*/N_D=1$ at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$, while $N_{DU}^*/N_D<1$ for $\alpha_{\pi M}>\alpha_{\pi S}/\kappa$, as is easy to check. Hence, for $\alpha_{\pi M}>\alpha_{\pi S}/\kappa$, $\beta_{FU}^*<\beta_F^*<\beta_S^*$. Because L_E is strictly decreasing in β_{FU}^* for $\beta_{FU}^*<\beta_S^*$, L_E when evaluated at $\alpha_{\pi M}=\alpha_{\pi S}/\kappa$ (hence at $\beta_{FU}^*=\beta_F^*$) must be lower than L_E, when evaluated at some $\alpha_{\pi M}>\alpha_{\pi S}/\kappa$.

D: Derivation of (5.2), societies' welfare loss under a union-wide debt target $\hat{d}_1$.

To obtain society's second-period welfare loss we can follow Appendix A.1. replacing d_{j1} (j=1,..,n) with $\hat{d}_1$ (remember that Appendix A.1. derives the second-period welfare loss for *given* first-period debt policies). Hence, an expression for the second-period welfare loss under a debt target $\hat{d}_1$ is obtained by replacing d_{j1} (j=1,..,n) with $\hat{d}_1$ in (A.10), which then reduces to

$$L_A\left(\tilde{K}_2+(1+\rho)\hat{d}_1\right)^2. \tag{D.1}$$

In the first period the CCB selects π_1 to minimize (A.11), which yields the reaction function (A.12). The first-period Lagrangian of the fiscal authority is now given by (the fiscal authority can no longer affect its second-period financing requirement because it is constrained to set $d_1=\hat{d}_1$),

$$£_{i1} = ½[\alpha_{\pi S}\pi_1^2 + (\nu(\pi_1-\pi_1^e-\tau_{i1})-\tilde{x}_1)^2 + \alpha_{gS}(g_{i1}-\tilde{g}_1)^2] + \lambda_{i1}[g_{i1}+(1+\rho)d_0-\tau_{i1}-\kappa\pi_1-\hat{d}_1], \tag{D.2}$$

Combining the first-order conditions for τ_{i1} and g_{i1} with the government financing requirement (2.6, t=1) (where d_{i1} is replaced by $\hat{d}_1$) and the CCB's first-period reaction function, and using rationality of expectations and the equivalence of the policies across countries in equilibrium, we obtain the following policy outcomes for period one (where we drop again the country index, because of the equivalence of equilibrium fiscal policies across countries):

$$\tau_1+\tilde{x}_1/\nu = \left(\frac{1/\nu^2}{N_D}\right)\left(\tilde{K}_1+(1+\rho)d_0-\hat{d}_1\right), \tag{D.3}$$

$$\pi_1 = \left(\frac{1/\alpha_{\pi M}}{N_D}\right)\left(\tilde{K}_1+(1+\rho)d_0-\hat{d}_1\right), \tag{D.4}$$

$$\tilde{g}_1-g_1 = \left(\frac{1/\alpha_{gS}}{N_D}\right)\left(\tilde{K}_1+(1+\rho)d_0-\hat{d}_1\right), \tag{D.5}$$

Combining (D.3)-(D.5) and (2.2) (after having substituted (2.1, t=1) and imposed $\pi_1^e=\pi_1$) it is straightforward to derive society's first-period welfare loss:

$$L_A\left(\tilde{K}_1+(1+\rho)d_0-\hat{d}_1\right)^2. \tag{D.6}$$

Society's intertemporal welfare loss (5.2) is the sum of (D.1) (discounted to the first period against discount factor β_S) and (D.6).