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Time inconsistency and the incentives for free-riding in a monetary union

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Abstract

We show that a time inconsistency problem in monetary policy leads to a free rider problem in the setting of non-monetary policies, like fiscal policy, bank regulation or unemployment policy. This free rider problem leads the member countries to pursue lax non-monetary policies and, in equilibrium, leads to high inflation. This free-rider problem can be mitigated by imposing constraints on the non-monetary policies, like debt constraints on fiscal policy, union-wide regulation of banks and union-wide rules on unemployment compensation, severance pay and the like. When there is no time consistency problem there is no free rider problem and constraints on non-monetary policies are unnecessary and possibly harmful.

In the last decade there has been growing interest in the design of monetary unions. Monetary unions combine member countries or states which have a great deal of independence in setting fiscal and other non-monetary policies with a central monetary authority which sets a single monetary policy for all the members. In practice, some monetary unions have worked well while others have not. Argentina is an example of a less successful one, the United States is an example of a successful monetary union, and the jury is still out on the European Union. Why are some monetary unions successful and others not? Here we develop a theory that can answer this question.

Time inconsistency problems in monetary policy are at the heart of our theory. We argue that a time inconsistency problem in monetary policy leads to a free rider problem in the setting of non-monetary policies, like fiscal policy, bank regulation or unemployment policy. This free rider problem leads the member countries to pursue lax non-monetary policies and, in equilibrium, leads to high inflation. This free-rider problem can be mitigated by imposing constraints on the non-monetary policies, like debt constraints on fiscal policy, union-wide regulation of banks and union-wide rules on unemployment compensation, severance pay and the like. When there is no time consistency problem there is no free rider problem and constraints on non-monetary policies are unnecessary and possibly harmful.

While time inconsistency problems lead to free rider problems we also show that free rider problems exacerbate time inconsistency problems. Constraints on non-monetary policies reduce the free rider problems and lower the monetary authority's benefits from ex-post inflation. Hence, with such constraints the monetary authority ends up choosing lower inflation.

We illustrate these points in an abstract setup and then consider three applications. We first apply our theory to fiscal policy. We consider a simple dynamic model with two countries. Each fiscal authority issues nominal debt to outside risk neutral lenders. After that the monetary authority decides the common inflation rate. The monetary authority balances the benefits of devaluing nominal debt against the costs of lowering output from higher inflation. The larger the debt the monetary authority inherits, the higher it sets the inflation rate.

The fiscal authorities balance the consumption-smoothing gains from issuing debt against the induced costs of higher inflation on their own output. Each fiscal authority ignores the induced costs of inflation on output in the other country. Thus, relative to a benchmark in which debt levels are set cooperatively, each authority issues too much debt, inflation is too high and output is too low. With appropriately chosen constraints on debt, this free rider problem can be solved and the cooperative benchmark achieved. Indeed, in this simple example the ¯scal constraints eliminate the time inconsistency problem completely.

When there is no time consistency problem the outcomes are the same as in a cooperative benchmark. We show this result by supposing that the monetary authority can commit to its policies ex-ante. With commitment, the in°ation rate is set before the debt levels are chosen, so that higher debt levels in one country have no e®ect on in°ation and hence no e®ect on the other country's output. Thus, with commitment the outcomes coincide with the cooperative benchmark.

We next apply our theory to bank regulation. We develop a simple dynamic model with many countries. Each country's government regulates the riskiness of banks' portfolios. In the event that banks cannot fully pay o® depositors, the monetary authority prints money to pay the residual amount. Each government balances the costs of bank regulation against the induced costs of in°ation resulting from bank bailouts. In doing so the governments ignore the induced costs of in°ation on other members of the union. These forces generate a free rider problem in which supervision of banks is lax, bank bailouts that are too frequent, and the rate of in°ation is excessive. With mutually agreed upon constraints on bank regulatory policy the free rider problem can be mitigated. Mitigating the free-rider problem also helps solve the time inconsistency problem. Of course, if there is no time consistency problem to begin with then there is no free rider problem.

Finally, in the Appendix, we consider the classic model of time inconsistency in monetary policy due to Kydland and Prescott (1977) and Barro and Gordon (1983) in which ex-post in°ation reduces unemployment. We modify this example to allow governments to set labor market policies which determine the natural rate of unemployment. We show that the free rider problem leads government to adopt policies that result in excessively high unemployment and in°ation.

Our theory suggests that monetary unions are likely to fail when there is a time inconsistency problem in monetary policy and constraints on non-monetary policies are either not present or not e®ective. We think Argentina is a good example of a country which has a serious time inconsistency problem with its monetary policy and, regardless of its good intentions, it is unable to set e®ective constraints on its provincial governments. These provincial governments routinely run budget de¯cits that end up being ¯nanced by the central bank. Nicolini et. al. (2000) demonstrate that the monetary authority routinely bailed out the provincial governments when these governments ran into fiscal difficulties. Expectations of these bailouts increased the provinces' incentives to behave in a financially profligate manner. Indeed, one rationalization of the convertibility law which linked the peso to the dollar was the hope of restraining the financial profligacy of provincial governments. Jones et al, (1998) show some evidence that fiscal deficits fell after the imposition of convertibility, though the recent collapse of the currency board suggests that the time inconsistency problems in monetary policy were always present. For a related discussion of the Argentina see Cooper and Kempf (2001a and 2001b) and Tommasi et al. (2001).

The United States is an example of a successful monetary union. In our view the United States appears to have solved the time inconsistency problem in monetary policy so that there is no free rider problem among the states. An alternative view is the United States has not solved the time inconsistency problem in monetary policy but that the balanced budget provisions in the state constitutions prevent free-rider problems in fiscal policy and thereby help solve time inconsistency problems in monetary policy. One problem with the alternative view is that the states choose to keep the balanced budget provisions while the theory predicts that an individual state can gain by eliminating its own provisions unilaterally.

Our theory provides one rationale for the fiscal policy restrictions in the Maastricht Treaty and the Stability and Growth Pact among members of the European Union. One reading of the Maastricht Treaty notwithstanding the solemn expressions of intent of the primacy of price stability in the treaty, as a practical matter monetary policy is set sequentially by majority rule. As such, the time consistency problem in monetary policy is potentially severe. In such a scenario, our analysis shows that debt constraints are desirable. Our analysis is consistent with the view that the framers of the treaty thought that it is extremely difficult to commit to monetary policy and therefore wisely included debt constraints as an integral part of the Treaty and the Pact.

An alternative reading of the Treaty is that the primacy of the goal of price stability and the independence of the Central Bank effective ensure commitment to future monetary policy and thereby solve the time consistency problem. On this reading, debt constraints can only be harmful. (See Buiter et al. 1993 for a forceful argument that debt constraints are harmful.) Our analysis with commitment supports this view.

So far we have discussed 3 countries. Von Hagen and Eichengreen (1996) assemble data on fiscal policy restrictions on 49 countries. Interestingly, they find that 37 of these countries impose restrictions on fiscal policies of subcentral governments. This finding suggests that, in practice, policymakers are concerned with fiscal profligacy of these subcentral governments and have adopted measures to constrain such behavior.

This paper is related to a literature on fiscal policy in monetary unions including Uhlig and Beetsma (1997), Dixit and Lambertini (2001), Cooper and Kempf (2002) and Uhlig (2002). The last two are the most closely related. Cooper and Kempf focus mostly on the gains to monetary union with commitment by the monetary authority and show that when there is no commitment the monetary union may be undesirable. Uhlig develops a reduced form model as in Clarida, Gali, and Gertler (1999). In his model, there is a free rider problem in fiscal policy. This free rider problem ends up reducing welfare but does not raise the inflation rate.

An extensive literature has discussed the gains from international cooperation in setting fiscal policy. This literature shows that cooperation is desirable if a country's fiscal policy affects world prices and real interest rates. (See Chari and Kehoe 1990, Canzoneri and Diba 1991 for details.) The kind of desirable cooperation that this literature points to applies equally as well to Germany and Canada as it does to Germany and Italy in that it is not especially related to countries being in a monetary union. Because the issues raised in this literature are well understood, we abstract from them here. We do so by considering models in which the fiscal policies of the cooperating countries taken as a group do not affect world prices and real interest rates. In such models there can be no gains to cooperation of this sort.

1 General setup

We begin with a general setup which is intended to make explicit the logic whereby time inconsistency leads to free rider problems in monetary unions. Consider an world economy with N countries indexed $i = 1, \ldots, N$. In each country there is a continuum of private agents indexed $j \in [0, 1]$ each of whom chooses an action y_{ij}. Let $y_i = \int y_{ij} dj$ denote the aggregate choice by private agents in country i. The government of country i chooses a policy x_i and the monetary authority of the union chooses a common inflation rate for the union denoted π. The payoffs of private agents are

$$V(x_i, y_{ij}, y_i, \pi)$$

The payoff of government of country i is the integral of the payoffs of the private agents in that country

$$\int V(x_i, y_{ij}, y_i, \pi)dj$$

while the payoff of monetary authority is the sum of the payoffs of the governments

$$\sum_{i=1}^{N} \int V(x_i, y_{ij}, y_i, \pi)dj.$$

Notice that have assumed that the policies of individual governments do not directly affect the payoffs of other governments and thus the only way governments interact is through the effect of their actions on the common inflation rate. We make this assumption to abstract from standard nonmonetary policy linkages across countries, like tariffs and taxes. These have been analyzed extensively in the literature and have no obvious bearing on issues concerning monetary union. (See, for example, Chari and Kehoe 199?).

Typically time inconsistency problems in monetary policy arise when there is no commitment by the monetary authority. We will say that there is a free rider problem in a monetary union when noncooperative behavior by governments leads to outcomes that differ from a benchmark with cooperation. We show that time inconsistency problems lead to free rider problems by considering a situation in which the monetary authority cannot commit to its policies and showing that noncooperative outcomes are different from cooperative outcomes.

We formalize the lack of commitment that drives the time inconsistency problem with a no commitment game with the following timing. The governments first choose x_i; then private agents choose y_{ij}, and finally the monetary authority chooses π. An noncooperative equilibrium of this game is given by policies for the governments $\vec{x} = (x_1, \ldots, x_N)$, private agent decision rules $y_{ij}(\vec{x})$ that depend on government policies, and a monetary authority policy function $\pi(\vec{x}, \vec{y})$ that depends on government policies and the private agents decisions $\vec{y} = \{y_{ij} | \text{ all } i, j\}$ such that i) for all $\vec{x}, \vec{y}$, the policy $\pi(\vec{x}, \vec{y})$ maximizes the monetary authority's payoff, ii) for each private agent ij, for all $\vec{x}$, given the choices of the other private agents $y_{i'j'}(\vec{x})$ all $i'j'$ and given the monetary authority policy function π; the private agent's decision rule $y_{ij}(\mathbf{x})$ maximizes his payoff, iii) for each government i; given the policies of the other governments i'; the private agents' decision rules y_{ij} and the monetary authority's policy rule π; the policy x_i maximizes the payoff of government i: A cooperative equilibrium of this game is defined similarly with iii) replaced by iii$'$) given the private agents' decision rules y_{ij} and the monetary authority's policy rule π; the vector $\mathbf{x}$ maximizes the sum of the payoffs of the governments:

Throughout we focus on symmetric equilibria where all governments choose the same policy and all private agents choose the same decision. Consider the symmetric equilibria of the subgames after governments have chosen $\mathbf{x}$: Clearly the equilibrium outcomes in these subgames only depend on $\mathbf{x}$: We summarize these outcomes by outcome functions $y(\mathbf{x})$; $\pi(\mathbf{x})$: For simplicity we assume these outcome functions are differentiable.

Acting noncooperatively, government i chooses x_i to maximize

$$V(x_i; y_i(\mathbf{x}); y_i(\mathbf{x}); \pi(\mathbf{x}))$$

The first order condition for this government is

$$(1) \quad V_1 + (V_2 + V_3)\frac{\partial y_i}{\partial x_i} + V_4\frac{\partial \pi}{\partial x_i} = 0$$

Acting cooperatively the governments choose x to maximize

$$\sum_{i=1}^{N} V(x_i; y_i(\mathbf{x}); y_i(\mathbf{x}); \pi(\mathbf{x}))$$

Taking the first order conditions and then imposing symmetry gives

$$(2) \quad V_1 + (V_2 + V_3)\frac{\partial y_i}{\partial x_i} + NV_4\frac{\partial \pi}{\partial x_i} = 0$$

Comparing (1) to (2) we see that the noncooperative policies of governments will typically not be the same as the cooperative policies. In this sense there is a free rider problem. Notice that as the number of member states in the monetary union N increases the free rider problem gets worse in the sense that these policies get further apart.

The intuition for the free problem is that inflation confers a common cost on the members of the union while an individual government's policies confer affect only its payoff. Since the monetary authority cannot commit it optimally responds to the policies of the governments. Acting noncooperatively, each government ignores the inflation costs its policies induce on other governments. Cooperative governments take these induced inflation costs into account and hence the outcomes with and without cooperation are different.

We now show that if there are no time inconsistency problems then there are no free rider problems. There are no time inconsistency problems we the monetary authority can commit to its policies. The timing in the commitment game is as follows. First, the monetary authority chooses π; then governments choose x_i; and finally private agents choose y_{ij}: A noncooperative equilibrium of this game is given by a monetary policy π;government policy functions $x_i(\pi)$ and private agent decision rules $y_{ij}(\pi; \bar{x})$ such that i) for each private agent ij, for all $\bar{x}$ and π; given the choices of the other private agents $y_{i'j'}(\pi; \bar{x})$ all $i'j'$; the private agent's decision rule $y_{ij}(\pi; \bar{x})$ maximizes his payoff ii) for each government i;for all π; given the policies of the other governments $x_{i'}(\pi)$; the private agents' decision rules $y_{ij}(\pi; \bar{x})$; the policy $x_i(\pi)$ maximizes the payoff of government i; iii) given the government policy functions x_i and the private agent decision rules y_{ij}; the policy π maximizes the monetary authority's payoff. A cooperative equilibrium is defined similarly with ii) replaced by ii$'$) for all π; given the private agents' decision rules $y_{ij}(\pi; \bar{x})$; the policy $x_i(\pi)$ maximizes the sum of the payoffs of the governments:

Acting noncooperatively the governments choose x_i to maximize

$$V(x_i; y_i(\pi; \bar{x}); y_i(\pi; \bar{x}); \pi):$$

The first order condition in a noncooperative equilibrium is

$$(3) \quad V_1 + (V_2 + V_3)\frac{\partial y_i}{\partial x_i} = 0$$

Acting cooperatively the governments choose x_i to maximize

$$\sum_{i=1}^{N} V(x_i; y_i(\pi; \bar{x}); y_i(\pi; \bar{x}); \pi))$$

Taking the first order conditions and then imposing symmetry gives (3): It is clear that the noncooperative and the cooperative solutions coincide. Thus with commitment there is no free rider problem.

The intuition is that since inflation does not respond to government policy, each government's policy confers no cost on other governments and hence there is no free rider problem.

2 Nominal Debt and Fiscal Policy

In our second example, the time inconsistency problem arises because governments cannot commit to not defaulting on their debts. The most natural way to model default is to suppose that governments issue nominal debt and use inflation to reduce the real value of their debts and thus effectively default. example that is useful for building intuition. Consider a two period model with two identical countries that are small in the world economy. In period 0 the countries start with an identical price level p_0 which is given. Each country issues nominal debt in period 0 to lenders who live outside of these two countries. These lenders are risk neutral and have discount factors β. In period 1 the countries form a monetary union in which a common monetary authority determines monetary policy. We model monetary policy as the choice of the price level in period 1, p_1. In both countries in period 0 output is a constant given by ω, while in period 1 output y is a decreasing and convex function of the common inflation rate from period 0 to period 1, denoted by $\pi = p_1/p_0$.

We begin by setting up the budget constraints and objective functions. We denote country 1 allocations without an asterisk and country 2 allocations with an asterisk. The budget constraints of the government in country 1 are

$$p_0 c_0 = \omega + qb$$

add

$$p_1 c_1 = p_1 y - b$$

where b is nominal debt sold to foreign lenders at price q and c_0 and c_1 denote consumption of the citizens of country 1 in the two periods. The objective function of the country 1 government is

$$U(c_0) + \beta U(c_1).$$

The model starts with p_0 given, so it is convenient to set $p_0 = 1$. It is also convenient to let the repayment rate $r = 1/\pi$ denote the inverse of the inflation rate. Output is then an increasing and concave function of r, denoted $y(r)$. The period 1 budget constraint is then

$$c_1 = y(r) - rb.$$

Notice that r is the fraction of nominal debt that is repaid. We will assume that ω is sufficiently smaller than $y(1)$, so that the governments have an incentive to borrow. The government of country 2 has similar budget constraints and objective function. The monetary authority's objective function is the sum of the objective functions of the two governments.

The timing of the model in period 0 is that first, the two governments choose their debt levels $(b; b^*)$; then the price of debt q is determined. In period 1 the monetary authority chooses the common repayment rate r. We consider two regimes: a noncooperative regime in which the governments simultaneously choose their debt levels to maximize their own objective functions and a cooperative regime in which the debt levels are chosen to maximize the sum the objective functions. This timing reflects the idea that two countries recognize that they will form the monetary union but that they cannot commit to the policies that the union will follow. Specifically, the monetary authority takes $(b; b^*)$ as given and then chooses the repayment rate optimally. When choosing their debt levels, the two governments recognize their effect on future inflation by influencing the actions of the monetary authority.

In both regimes we solve the model by starting at the end. In both regimes the problems of the monetary authority and the lenders are the same. Taking b and b^* as given the monetary authority chooses r to solve

(4) $$\max_r U(y(r) - rb) + U(y(r) - rb^*).$$

Let $r(b; b^*)$ denote the resulting repayment function. Consider next the foreign lenders. Since they are risk neutral and have discount factors β, the debt price function is given by

(5) $$q(b; b^*) = \beta r(b; b^*).$$

In the noncooperative regime, the government of country 1, taking b^* as given, solves

(6) $$\max_b U(\omega + q(b; b^*)b) + \beta U(y(r(b; b^*)) - r(b; b^*)b).$$

The government of country 2 solves an analogous problem. In the cooperative regime b and b^* are chosen to solve

(7) $$\max_{b;b^*} [U(\omega + q(b; b^*)b) + \beta U(y(r(b; b^*)) - r(b; b^*)b)] +$$

(8) $$[U(\omega + q(b; b^*)b^*) + \beta U(y(r(b; b^*)) - r(b; b^*)b^*)]$$

A noncooperative equilibrium is a repayment function r that solves (4), a debt price function q that solves (5), and a pair of debt levels $(b_N; b_N^*)$ that solve (6) and its analogue.

A cooperative equilibrium is a repayment function r that solves (4), a debt price function q that solves (5), and a pair of debt levels $(b_C; b_C^*)$ that solve (7).

In comparing the two regimes it is convenient to assume

$$(9) \quad y = \bar{y} - r^{-\sigma}/\sigma \text{ with } \sigma > 0$$

We restrict consideration to symmetric equilibrium in the debt levels are the same in the two countries. We then have

Proposition 1. Under assumption (9), the symmetric noncooperative debt level b_N is greater than the symmetric cooperative debt level b_C. Moreover, inflation is higher and welfare is lower in the noncooperative regime than in the cooperative regime.

Proof: The first order condition for the monetary authority is

$$U'(c_1)(y_r - b) + U'(y^* - rb^*)(y_r - b^*) = 0$$

Differentiating this first order condition with respect to b gives

$$(10) \quad (\partial r/\partial b) = \frac{U'(c_1) + rU''(c_1)(y_r - b)}{U'(c_1)y_{rr} + U''(c_1)(y_r - b)^2 + U'(c_1^*)y_{rr} + U''(c_1^*)(y_r - b^*)^2}$$

In a symmetric equilibrium the monetary authority's first order condition implies that

$$(11) \quad y_r = b$$

and hence in a symmetric equilibrium (10) reduces to

$$(12) \quad (\partial r/\partial b) = \frac{1}{2y_{rr}}$$

Differentiating the equilibrium condition for the lenders, $q = \beta r$ gives

$$(13) \quad \frac{\partial q}{\partial b} = \beta \frac{\partial r}{\partial b}$$

The first order condition for debt in the noncooperative equilibrium is

$$(14) \quad [U'(c_0)q - \beta r U'(c_1)] + U'(c_0)b\frac{\partial q}{\partial b} + \beta U'(c_2)(y_r - b)\frac{\partial r}{\partial b} = 0$$

Substituting $q = \beta r$ together with (11) $-$ (13) and using symmetry, (14) reduces to

$$r(U'(c_0) - U'(c_1)) + U'(c_0)\frac{y_r}{2y_{rr}} = 0$$

which, using (9), can be rewritten as

$$(15) \quad \left(1 - \frac{1}{2}\frac{1}{1+\sigma}\right) = \frac{U'(y - ry_r)}{U'(\omega + \beta r y_r)}$$

The first order condition for debt in the cooperative equilibrium is

$$(16) \quad [U'(c_0)q - \beta U'(c_1)] + [U'(c_0)b + U'(c_0^*)b^*]\frac{\partial q}{\partial b} + \beta[U'(c_2)(y_r - b) + U'(c_2^*)(y_r - b^*)]\frac{\partial r}{\partial b} = 0$$

Substituting $q = \beta r$ together with (11) $-$ (13) and using symmetry, (16) reduces to

$$r(U'(c_0) - U'(c_1)) + U'(c_0)\frac{y_r}{y_{rr}} = 0$$

which can be rewritten as

$$(17) \quad \left(1 - \frac{1}{1+\sigma}\right) = \frac{U'(y - ry_r)}{U'(\omega + \beta r y_r)}$$

From (9) it follows $(y - ry_r)$ is increasing in r and $(\omega + \beta r y_r)$ is decreasing in r so that the right hand side of both (15) and (17) are decreasing in r. Since the left hand side of (15) is greater than the left hand side of (17), it follows that $r_N < r_C$. Since $y_r = b$ and y is concave it follows that $b_N > b_C$. QED.

The following corollary is immediate.

Corollary: If the two countries in the noncooperative regime face the constraints $b \le b_C$ and $b^* \le b_C$, then they will achieve the cooperative outcome.

Thus far we have assumed that it is not possible to commit in period 0 to the common inflation rate between period 0 and period 1. This lack of commitment is crucial for our result that debt constraints improve welfare. To see this, consider a change in the timing of our model in which the repayment rate is chosen first, then the two governments choose debt levels and finally the price of debt is determined. Clearly, in this scenario the repayment rate does not depend on the debt levels. Optimal behavior by lenders implies that

$$q = \beta r;$$

and thus implies that the price of debt also does not depend on the debt levels. In the noncooperative regime, the government of country 1 solves

$$(18)\quad \max_{b} U(\omega + qb) + \beta U(y(r) - rb).$$

The government of country 2 solves an analogous problem. In the cooperative regime b and b^* are chosen to solve

$$(19)\quad \max\, [U(\omega + qb) + \beta U(y(r) - rb)] + [U(\omega + qb^*) + \beta U(y(r) - rb^*)]$$

Since b^* does not affect the utility level of country 1 and b does not affect the utility level of country 2 we have

Proposition 2. With commitment by the monetary authority, the noncooperative and the cooperative equilibria coincide.

Propositions 1 and 2 taken together imply that question of whether debt constraints are desirable is intimately connected to the extent to which it is possible to commit to future monetary policy. Proposition 2 says that once a monetary policy has been committed to, binding constraints on future debt issues can only reduce welfare. Proposition 1implies that as long as such commitment is not possible, appropriately chosen debt constraints improve welfare.

The economy with commitment is broadly similar to the economies studied in an extensive literature that has discussed the gains from international cooperation in setting fiscal policy. (See Chari and Kehoe 1990, Canzoneri and Diba 1991.) As we noted in the introduction, this literature shows that cooperation is desirable if a country's fiscal policy affects world prices and real interest rates. In our model there are no gains to cooperation under commitment because we have assumed that the monetary union is small in the world in the sense that the world interest factor β is independent of the fiscal policy decisions of the union. Suppose instead we had considered a general equilibrium model with no outside lenders, so that countries 1 and 2 constitute the entire world. Specifically, suppose that each country chooses it's spending level on a public good that benefits its own residents and finances the spending with debt and distorting taxes. In such a formulation, even with commitment by the monetary authority the noncooperative and cooperative equilibria do not coincide. This is because any country's spending decision affects the world interest rate and hence the other country's welfare. Since these types of gains to cooperation are not related to the formation of a monetary union we have chosen a formulation where these effects don't appear.

3 Bank supervision and bailouts

In our third example the time inconsistency problem arises because the monetary authority cannot commit to not bailing out insolvent banks. In it government policy consists of determining the level of supervision of banks. The free rider problem leads to lax supervision of banks, bank bailouts that are too frequent, and an excessive rate of inflation.

In our second example we assume that depositors in banks are fully insured, banks have limited liability and the monetary authority bails out the depositors in insolvent banks. Deposit insurance together with limited liability creates an incentive for banks to take on excessive risk. We assume that governments supervise banks to limit risk-taking. In this example the free rider problem leads to governments to do too little supervision and banks to take on too much risk.

The environment is as follows. The aggregate state of the world economy is $s \in \{H, L\}$, where H denotes a boom and L denotes a recession. The probability of H and L is μ_H and μ_L respectively Output is produced as follows. There are a large number of projects indexed by $z \in [0, 1/2]$. A project of type z yields a return R per unit of investment when it succeeds and 0 otherwise. The probability of success in a boom is $p_H(z) = 1/2 + z$ and the probability of success in a recession is $p_L(z) = 1/2 - z$. We will show that only one type of project will be chosen. Total output in state s, $p_s(z)R$. Notice that when projects with a higher value of z are chosen the distribution of output is a mean preserving spreads of output when projects with a lower value of z is chosen.

There are a large number of banks. Each bank can finance up to one unit of investment. The bank obtains funds from depositors who must be paid an interest rate r_i. Banks have limited liability in the sense that they must pay depositors only if their receipts exceed their obligations. If their receipts fall short of their obligations their payoff is zero and the monetary authority pays off the depositors by liquidating the banks assets and by printing money to cover any shortfall. The government of country $i = 1, \ldots, N$ can do some costly monitoring of level x_i and prohibit banks from financing projects with $z > x_i$.

We first describe a competitive equilibrium for some given policies for inflation π and monitoring levels $\vec{x} = (x_1, \ldots, x_N)$ and then describe the game among governments and the monetary authority that determines these policies.

Assuming all banks within country i choose the same project type z_i, total output in each country is given by $y_s(z_i; x_i) = p_s(z_i)R - e(x_i)$ where $e(x_i)$, which is increasing in x_i, represents the costs of monitoring at level x_i. We assume that consumers cannot share risk across countries, so that each consumer simply consumes the endowment. The utility of private agents and the government of each country is given by

$$\sum_s \mu_s U(y_s(z_i; x_i); \pi_s)$$

where π_s denotes the common inflation rate across countries in state s. We assume the utility function is decreasing in the inflation rate.

A bank's maximization problem is to choose which type of project to fund. It chooses z to maximize profits

$$(20) \quad q_{Hi} \max\{p_H(z)R - r_i, 0\} + q_{Li} \max\{p_L(z)R - r_i, 0\}$$

subject to

$$(21) \quad z \leq x_i$$

where q_{Hi} and q_{Li} are the prices in country i for one unit of consumption in state H and L respectively. Let $z_i(x_i)$ denote the portfolio rule for the bank.

For some given policies π, x a competitive equilibrium consists of portfolio rules $z_i(x_i)$, deposit rates r_i, and state prices q_{si}, for $i = 1, \ldots, N$, $s = H, L$ such that i) $z_i(x_i)$ solves (20), ii) profits in (20) are zero and iii) the state prices $q_i(s)$ are proportional to the marginal utility of consumption $U_c(y_s(z_i; x_i))$.

Lemma. In equilibrium $z_i(x_i) = x_i$ and $r_i = p_H(z_i(x_i))R$.

Proof. Since profits are zero in equilibrium, each term in (20) is zero. We drop the i subscript for simplicity. Since $p_H(z) \geq p_L(z)$ it follows that $r = p_H(z)R$ and $p_L(z)R - r \leq 0$. To see that $z = x$, suppose, by way of contradiction, that in equilibrium $z < x$. Then increasing z increases $p_H(z)R - r$ and thus increases the first term in (20). The second term is unchanged since $p_L(z)R - r$ falls from a value at most zero. Thus, increasing z increases profits which contradicts profit maximization. Q.E.D.

Consider now the determination of the policies. We begin with the monetary authority. This authority is required to print money to bail out the banks when they cannot pay off depositors. An inflation rate of π raises revenues of πM where M is the initial money stock that we normalize to 1. Thus the monetary authority must set π so that

$$\pi_s(\tilde{x}) = \sum_i (r_i - p_s(x_i)) \tag{22}$$

where $\tilde{x} = (x_1, \ldots, x_N)$. and we have used the result that in equilibrium $z_i(x_i) = x_i$.

The noncooperative government chooses x_i to maximize

$$\max \sum_i \mu_s U(y_s(x_i), \pi_s(\tilde{x}))$$

where we have let $y_s(x_i) = y_s(x_i; x_i)$ be the output in country i in a competitive equilibrium.

The first order condition for the noncooperative government is

$$\sum_i \mu_s U_c(y_s(x_i), \pi_s(\tilde{x}))$$

$$\sum_s \mu_s [U_c(s; i) \frac{\partial y_s(x_i)}{\partial x_i} + U_\pi(s; i) \frac{\partial \pi_s(\tilde{x})}{\partial x_i}] = 0. \tag{23}$$

where $U_c(s; i)$ and $U_\pi(s; i)$ denote the derivatives of the utility function of country i consumers in state s with respect to consumption and inflation respectively. Let x^N denote the symmetric noncooperative equilibrium level of supervision and $\pi^N = \pi(\tilde{x}^N)$ denote the corresponding level of inflation.

In a cooperative equilibrium these first order conditions are

$$\sum_s \mu_s [U_c(s; i) \frac{\partial y_s(x_i)}{\partial x_i} + U_\pi(s; i) \frac{\partial \pi_s(\tilde{x})}{\partial x_i}] + \sum_{j \neq i} \sum_s \mu_s [U_\pi(s; j) \frac{\partial \pi_s(\tilde{x})}{\partial x_i}] = 0. \tag{24}$$

We assume that the solution to (24) is unique and therefore symmetric. This assumption holds with appropriate concavity conditions. With symmetry, (24) reduces to

$$\sum_s \mu_s [U_c(s) \frac{\partial y_s(x)}{\partial x} + U_\pi(s) \frac{\partial \pi_s(\tilde{x})}{\partial x}] + (N - 1) \sum_s \mu_s [U_\pi(s) \frac{\partial \pi_s(\tilde{x})}{\partial x}] = 0. \tag{25}$$

Let x^C denote the cooperative level of supervision and $\pi^C = \pi(\tilde{x}^C)$ denote the corresponding level of inflation. equilibrium

Proposition ?. The noncooperative supervision level x^N is smaller than the cooperative supervision level x^C while the noncooperative in°ation rate π^N is larger than the cooperative in°ation rate π^C:

Proof. Let $F^N(x)$ and $F^C(x)$ denote the left-sides of (23) and (25) evaluated at $x_1 = x_2 = ::: = x_N = x$: Since $U_\pi < 0$ by assumption and $\partial\pi = \partial x > 0$; from (22) it follows that $F^C(x) < F^N(x)$: Thus the solution to $F^C(x) = 0$; namely x^C; is smaller than the solution to $F^N(x) = 0$, namely x^N: Hence, in the nocooperative equilibrium bank supervision is less strict, in°ation rates are higher and bank bailouts are more frequent. Q.E.D.

The mechanism the leads to the free rider problem is as follows. When supervision by a government becomes slacker, its banks take on riskier portfolios and in a recession the monetary authority must make larger bailouts. These larger bailouts lead to higher in°ation and lower welfare. In a noncooperative equilibrium a government trades o® the gains from slacker supervision against the cost it bears from higher in°ation. In particular, it ignores the costs on others of the higher in°ation that it induced by its actions. In a cooperative equilibrium, the gains from slacker supervision are traded o® against the costs that all bear from higher in°ation. These tradeo®s lead to higher in°ation and lower welfare in the noncooperative equilibrium.

One way to mitigate the free rider problem is to have countries set a mutually agreed upon level of bank supervision. Here that level is x^C which given the symmetry is the same for all countries. Of course, with commitment by the monetary authority there is no free rider problem.

4 Conclusion

In this paper we have argued that the desirability of debt constraints in monetary unions depends critically to the extent of commitment of the monetary authority. If the monetary authority can commit to it's policies debt constraints can only impose costs. If the monetary authority cannot commit then there is a free-rider problem in ¯scal policy and debt constraints may be desirable.

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Appendix on Unemployment and Labor Market Policies

Here we discuss a third application using the classic model of time inconsistency in monetary policy due to Kydland and Prescott (1977) and Barro and Gordon (1983) in which ex-post inflation reduces unemployment. We modify this model to allow governments to set labor market policies which determine the natural rate of unemployment. We show that the free rider problem leads government to adopt policies that result in excessively high unemployment and inflation.

Consider the following modified version of Kydland and Prescott and Barro and Gordon. In this example the natural rate of unemployment in country i; $\bar{u}(x_i)$; is affected by labor market policies in that country denoted by x_i: For simplicity let $\bar{u}(x_i) = \bar{u} - x_i$: The realized unemployment rate u_i is determined by the natural rate and the log of the real wage $w_i - \pi$; which is the difference between the log of the nominal wage and the log price level. Since initial prices are given π is both the price level and the inflation rate. Specifically,

$$(26) \quad u_i = w_i - \pi + \bar{u}(x_i):$$

Each private agent chooses a wage w_{ij} and wage in country i is given by $w_i = \int w_{ij} dj$: The objective function of the each private agent ij is

$$(27) \quad -\frac{1}{2}(w_{ij} - \pi)^2 - \frac{a}{2}u_i{}^2 - \frac{b}{2}\pi^2 - \frac{c}{2}x_i^2:$$

The first term in the objective function provides a target real wage for the private agents, the second and the third terms reflect concerns over aggregate unemployment and inflation, and the last term captures the cost of altering labor market policies which affect the natural rate. Substituting for u_i from (26) and $\bar{u}(x_i) = \bar{u} - x_i$ gives private agents payoffs

$$(28) \quad V(x_i; w_{ij}; w_i; \pi) = -\frac{1}{2}(w_{ij} - \pi)^2 - \frac{a}{2}(w_i - \pi + \bar{u} - x_i)^2 - \frac{b}{2}\pi^2 - \frac{c}{2}x_i^2:$$

The payoff of government i is $\int V(x_i; w_{ij}; w_i; \pi) di$ and the payoff of the monetary authority is the sum of the government's payoffs. These payoff functions ensure that private agents choose their wages to be the expected value of inflation and that the monetary authority cares about the average rate of unemployment (see Chari, Kehoe, Prescott 1989 for why this assumption is important.) In much of the literature the payoffs of the private agents are given (implicitly) by the first term in (28) and the payoffs of the monetary authority are given by the second and third terms. We choose to combine these terms so that the governments and the monetary authority are benevolent.

Equilibria in the no commitment and the commitment games are defined exactly as in the general setup. Consider first the no commitment game. The monetary authority's first order condition is

$$(29)\quad \sum_{i=1}^{N} \int [(w_{ij} - \pi) + a(w_i - \pi + \theta - x_i) - b\pi] = 0$$

Let $w_{ij}(\tilde{x})$ and $\pi(\tilde{x})$ denote the outcome functions in any subgame following the choice of government policies $\tilde{x}$. The first order condition for private agents implies that in any equilibrium of the subgame $w_{ij}(\tilde{x}) = w_i(\tilde{x}) = \pi(\tilde{x})$. Substituting $w_i(\tilde{x}) = \pi(\tilde{x})$ into (29) gives the equilibrium outcome functions for π and w

$$(30)\quad \pi(\tilde{x}) = w_i(\tilde{x}) = \frac{a}{bN} \sum_i (\theta - x_i).$$

Substituting these outcome functions into the objective for government i gives

$$-\frac{a}{2}(\theta - x_i)^2 - \frac{b}{2}\Big[\frac{a}{bN} \sum_i (\theta - x_i)\Big]^2 - \frac{c}{2}x_i^2.$$

In the noncooperative environment the first order condition for government i is

$$a(\theta - x_i) + \frac{a^2}{bN^2}\Big[\sum_i (\theta - x_i)\Big] - cx_i = 0.$$

In a symmetric equilibrium, we have $x_i = x^n = (a + a^2/bN)\theta/(a + a^2/bN + c)$ so that the equilibrium level of unemployment under noncooperation is

$$u^n = \frac{c\theta}{a + a^2/bN + c}$$

and the equilibrium inflation rate under noncooperation is $\pi^n = au^n/b$. In the cooperative equilibrium the first order condition for x_i is

$$a(\theta - x_i) + \frac{a^2}{bN}\Big[\sum_i (\theta - x_i)\Big] - cx_i = 0;$$

so that in a symmetric equilibrium $x^c = (a + a^2/b)\bar{u}/(a + a^2/b + c)$ so that the cooperative level of unemployment is

$$u^c = \frac{c\bar{u}}{a + a^2/b + c}$$

and the equilibrium inflation rate is $\pi^c = au^c/b$. Clearly the noncooperative level of unemployment and inflation u^n and π^n are greater than the corresponding cooperative levels u^c and π^c. Moreover, the free rider problem gets worse as N gets larger in the sense that unemployment and inflation rates rise monotonically with N under noncooperation.

One interpretation is that labor markets more rigid under noncooperation. Notice that (mention should not stick $N = 1$ in monetary authority's problem and say there are at most losses from a monetary union.) ???

Consider next the commitment game. In this game the governments choose their policies given the inflation rate π and the decision rules of private agents $w_{ij}(\pi; \bar{x})$. Since in any subgame following π and $\bar{x}$, $w_{ij}(\pi; \bar{x}) = \pi$, the payoff of government i reduces to

$$\text{(31)} \quad V(x_i; w_{ij}; w_i; \pi) = -\frac{a}{2}(\bar{u} - x_i)^2 - \frac{b}{2}\pi^2 - \frac{c}{2}x_i^2.$$

Clearly the optimal choices of x_i with and without cooperation are the same.