Credibility and Seignorage in a Common Currency Area

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Abstract

In the paper we show that Common Currency Areas tend to amplify the inefficiencies associated with lack of credibility of monetary policy.

Lack of commitment in *redistribution of seignorage* leads to excessive inflation and suboptimal taxation in the Monetary Union. Lack of commitment to *inflation* creates multiple inefficient equilibria which do not exist in a regime of national monetary independence.

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1. Introduction

In this paper we study the implications of establishing a Common Currency Area (CCA) for the conduct of monetary policy. We argue that a CCA may aggravate the inefficiencies associated with the *lack of commitment*.

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A CCA is defined as an institutional allocation of taxing rights where national governments provide a local public good and retain the exclusive rights of raising revenue from a domestic source, labor income in the model. However, one tax base, real money balances, becomes entrusted to a supra-national authority, the Common Central Bank (CCB). The CCB sets a uniform rate (the rate of inflation) across countries.

Our main finding is that the CCB's lack of commitment to a lump-sum *redistribution of seignorage* produces excessive inflation and sub-optimal labor income taxation. The effect is akin to fiscal competition. The intuition is as follows. A Currency Area introduces a new externality between national fiscal policies: the common currency is a *common pool* of potential tax revenue that member countries may try to appropriate. *Ex-post,* in the absence of commitment, the CCB optimally redistributes seignorage in favor of the country with less tax revenue. National governments, anticipating this behavior, try to appropriate seignorage by lowering their income tax rates to "attract" the monetary transfer. As a consequence, the burden of financing the public good is distorted towards inflationary finance.

This result can explain those rules in the ECB Statute that dictate that seignorage must be redistributed on the basis of fixed parameters that are "truly" exogenous and not manipulable by national governments. To our knowledge, the issue of commitment and seignorage redistribution has been completely overlooked in the vast literature on optimal currency areas.

The ability to commit to such a simple rule, however, is not a panacea if commitment to *price stability* cannot be taken for granted. In fact, we show that in such circumstances the Common Currency opens the way to self-fulfilling multiple equilibria. These equilibria are inefficient and asymmetric (despite countries being identical). The fiscal authorities may end up choosing different labor tax rates and providing different level of public goods, so that tax distortions are not equalized, neither across tax bases nor across countries. Again, the reason is simple: a reduction in labor taxation by one country is partially accommodate by the Central Bank with a higher, and therefore more distortionary, inflation tax. In order to keep inflation in check and to try to equate distortions across tax bases, the other country may respond by raising its own income tax rate.

These results differ somewhat from the conclusions found in the literature. For example, Chari and Kehoe (1998) present a two-country cash-in advance model where a CCA aggravates the problem of debt monetization, because some of the cost of inflation spills over to the other country. Conversely, Sibert (1992), within a simple two-country overlapping generations model with lump-sum taxes, finds the opposite result: the lack of commitment by the CCB leads to sub-optimal inflation and excessive taxation. The CCB reacts to one country higher taxation by lowering seignorage, thus harming the other country. This negative externality generates excessive taxation (and sub-optimal inflation).

Section 2 presents the model, Sections 3 and 4 look at the cases of lack of commitment to seignorage redistribution and to inflation, respectively Section 5 summarizes and draws the implications for policy and institutional design.

2. The Model

The world consists of two countries, domestic and foreign, the latter denoted by an asterisk. There are three types of agent in each country: a representative consumer/worker, a government, who is in charge of fiscal policy, and a central bank, who chooses the rate of money growth. We consider two distinct monetary regimes. In the first, that we call "Monetary Independence" (MI), each country has its own money and central bank. Seignorage is redistributed to the national government who raises labor taxes and finance the provision of the local public good. In the second regime, the "Common Currency Area" (CCA), there is a single currency and central bank, the CCB. This chooses a common rate of inflation for the two union members. Seignorage is redistributed to national governments according to the shares σ and $\sigma^* = 1 - \sigma$.

Output is produced by a single factor, labor, L, which is immobile across countries. We assume a linear technology so that one unit of labor can be transformed into one unit of either private, c, or public, g, consumption. Thus the marginal product of labor, the real wage, is equal to one. Domestic and foreign consumption goods are perfect substitutes, they are sold at the same price, so that the real exchange rate is one and there is no trade in the model.[1] There is one single asset in each country, money. We focus on the domestic economy.

2.1. Households

Households have an infinite horizon. In each period, they are endowed with one unit of time and real balances from the previous period. Given the sequence of prices, tax rates and public spending, $\{p_t, \tau_t, g_t\}_0^\infty$, they decide how many hours of labor to supply, L_t, how much to consume, c_t, and to save out of their disposable income. They save by carrying nominal money balances, M_{t+1} into next period. Preferences are additive both with respect to time and with respect to the arguments. Consumers choose the sequence $\{c_t, M_{t+1}, L_t\}_0^\infty$ so as to maximize the present discounted value of the utility stream[2]:

$$U = \sum_{t=0}^{\infty} \beta^t \mathcal{U}(c_t, \frac{M_{t+1}}{p_t}, L_t, g_t) = \sum_{t=0}^{\infty} \beta^t \left(u(c_t) + w(\frac{M_{t+1}}{p_t}) + v(1 - L_t) + H(g_t) \right) \tag{2.1}$$

where $0 < \beta < 1$ is the rate of time preference, $\frac{M_{t+1}}{p_t}$ is the stock of domestic money balances at the beginning of period $t+1$, expressed in units of time t goods, and u, w, v and H are quasi-concave functions. The consumer's budget constraints is

$$c_t + \frac{M_{t+1}}{p_t} = (1 - \tau_t)L_t + \frac{M_t}{p_t} \tag{2.2}$$

where τ_t denotes the income tax rate. Consumers spend their disposable income, $(1 - \tau_t)L_t$, in consumption goods, and save by adding to their money holdings.

2.2. Government budget constraint

The government in each country chooses the sequence of labor tax rates, $\{\tau_t\}_0^\infty$ and provides a(local) public good, g_t. The Central Bank chooses the sequence of nominal balances, $\{M_t\}_1^\infty$given an initial value M_0. Both policy-makers are benevolent, and face the following constraints: the market-clearing condition , $c_t + g_t = L_t$, the first-order conditions of the private sector problem, and the government budget constraint . This constraint differs between monetary regimes. Under MI the government budget constraint reads

$$g_t = \tau_t L_t + \frac{M_{t+1} - M_t}{p_t} \tag{2.3}$$

In a CCA, the constraint is:

$$g_t = \tau_t L_t + \sigma \left(\frac{\widetilde{M}_{t+1} - \widetilde{M}_t}{p_t} \right) \tag{2.4}$$

where $\widetilde{M_t} = M_t + M_t^*$ represents the common currency, which is now held by both domestic and foreign households[3].

2.3. Solution

The private sector maximizes (2.1) subject to the constraint (2.2). By assuming that the sub-utility function $u(.)$ is linear in consumption, we simplify matters in two respects: we get rid of the income effect in labor supply, and we simplify the dynamics in money demand: The first order conditions can be written as follows:

$$v'(1 - L_t) = 1 - \tau_t \tag{2.5a}$$

$$1 = w'(\frac{M_{t+1}}{p_t}) + \beta \frac{p_t}{p_{t+1}} \tag{2.5b}$$

The first condition equates the marginal rate of substitution between consumption and leisure to the marginal rate of transformation, in every period; the second assures that no gains can be made by re-allocating consumption over time.

We place the following restrictions on the policy-makers' policies: we assume that the government selects a constant tax rate τ, and that the Central Bank chooses the rate of money growth in order to achieve a constant inflation rate , $\widetilde{\pi}_t = \frac{p_{t+1}-p_t}{p_t}$. It is easy to see that the last restriction requires that the rate of money growth, $\mu_t = \frac{M_{t+1}-M_t}{M_t}$ is constant and equal to $\widetilde{\pi}$ [4].Thus we can write households' supply for labor and demand for money as follows:

$$L = l(\tau), \quad l_\tau < 0 \tag{2.6a}$$

$$\frac{M_{t+1}}{p_t} = m(\pi), \;\; all\ t, \;\; m_\pi < 0 \tag{2.6b}$$

$$c = (1-\tau)l(\tau) - \pi m(\pi) \tag{2.6c}$$

where it is convenient to define $\pi = \frac{p_{t+1}-p_t}{p_{t+1}} = \frac{\widetilde{\pi}}{1+\widetilde{\pi}}$. These expressions immediately yield the indirect utility function W :

$$\begin{aligned} (1-\beta)\, W(\pi,\tau) &= (1-\tau)l(\tau) - \pi m(\pi) + \\ &+ v(1-l(\tau)) + w(m(\pi)) + H\left(\tau l(\tau) + \pi m(\pi)\right) \end{aligned} \tag{2.7}$$

The optimal (constant) rates of inflation π [5] and income tax, τ, are found by maximizing the consumers' welfare.

2.4. No Commitment to Seignorage Redistribution

In this section we show that, in the absence of a credible commitment to a lump-sum redistribution of seignorage, a Common Currency Area results in excessive inflation and sub-optimal taxation. Ex-post the CCB redistributes seignorage in favor of the country with lower fiscal revenue. Anticipating this behavior, countries compete for attracting seignorage by lowering their tax rates.

2.5. Monetary Independence

Consider a single country in isolation. The national central bank chooses π and seignorage is appropriated by the government, who chooses g. The timing is given below:

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CB: π Gov: $\tau(\tau^*)$ Households: $c, \frac{M'}{p}, l$

t = 0 t=1 t=2

Figure 1: Monetary Independence

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At t=1 the domestic government chooses τ, for a given rate of inflation. This yields, from (2.5a), applying the envelope theorem

$$H_g(\tau l(\tau) + \pi m(\pi)) = \frac{1}{1 - \eta(\tau)} \tag{2.8}$$

where $\eta(\tau) = -\tau l_\tau / l$ represents the elasticity of the labor supply to the income tax rate. This condition simply equates the marginal rate of substitution between private and public consumption (the l.h.s.) to the marginal rate of transformation (the r.h.s). Clearly, for a given π, the more elastic is the labor supply, the more distortionary is the income tax and the lower is the optimal τ.

At t=0, the domestic central bank chooses π, given the reaction function (2.8). The first order condition, from the envelope theorem, can be written as

$$H_g(\tau l(\tau) + \pi m(\pi)) = \frac{1}{1 - \varepsilon(\pi)} \tag{2.9}$$

where $\varepsilon(\pi) \equiv - m_\pi(\pi)\pi/m$ is the elasticity of money demand [6]. This condition has the same interpretation of the previous one. The Monetary Independence (MI) equilibrium tax and inflation rates, (π^m, τ^m) are the solution of the last two equations. These imply that π^m, τ^m should be set so as to equalize distortions across tax bases, $\varepsilon(\pi^m) = \eta(\tau^m)$. Note that since the two countries are identical and there are no externalities between them, the same tax and inflation rates prevail in the foreign country, i.e. $\tau = \tau^* = \tau^m$, $\pi = \pi^* = \pi^m$.

Under MI, the strategic relationships (who moves first) between policy authorities within a country is irrelevant, since the policy-makers share the same objectives and the envelope theorem applies: the optimal monetary and fiscal policies will always satisfy (2.9)-(2.8). These conditions define the second best. As a result, the lack of pre-commitment of the central bank vis à vis the government has no consequences under MI. Next we show that, on the contrary, lack of pre-commitment to seignorage redistribution has major implications in a CCA.

2.6. Common Currency Area

As before, suppose that the Common Central Banks can credibly commit to inflation. But assume that the monetary authority does employ the other instrument at her disposal, the seignorage share σ, at her discretion. The sequence of the game looks like this:

CCB: π	Govs: τ (and τ^*)	CCBs: σ	Households: c, m, l	
t = 0	t=1		t=2	t=3

Figure 1: Lack of commitment with respect to σ

It is easy to show that the lack of commitment with respect to σ leads to excessive inflation and suboptimal taxation. The reason is simply that, at $t = 0$, the domestic and foreign governments correctly anticipate that the CCB's optimal policy at $t = 1$ is to redistribute seignorage in favor of the country with less tax revenue. Hence, they tend to lower their tax rates in order to substitute seignorage for labor taxation. Clearly these attempts cancel out in equilibrium and lead to excessive inflation and inefficiently low income taxes[7] .

>From the government budget constraint in a CCA, (2.4), the amount of public goods that each country can afford depends on its share of seignorage. Proceeding as before, the indirect utility function (2.7), $W(.)$, can now be written as an (increasing) function of σ , given π, τ : $(1-\beta)\, W(\pi, \tau, \sigma) = (1-\tau)l(\tau) - \pi m(\pi) + v(1-l(\tau)) + w(m(\pi)) + H\, (\tau l(\tau) + \sigma 2m(\pi)\pi)$ [8]

At $t = 1$, the CCB chooses σ so as to maximize the joint welfare $W(\pi, \tau, \sigma) + W(\pi, \tau^*, 1-\sigma)$, given the tax rates and the mandatory inflation rate. The f.o.c for this problem is

$$H_g\, (\tau l(\tau) + \sigma 2m(\pi)\pi) = H_{g*}\, (\tau^* l(\tau^*) + (1-\sigma)2m(\pi)\pi) \tag{2.10}$$

The CCB allocates seignorage to equalize the marginal utility of public goods across countries. This requires that domestic and foreign total revenues to be equalized, which can be achieved by setting

$$\sigma = \frac{1}{2} + \frac{1}{2}\frac{\tau^* l(\tau^*) - \tau l(\tau)}{2m(\pi)\pi} = S(\overset{-}{\tau}, \overset{+}{\tau}{}^*) \tag{2.11}$$

If both countries choose the same tax rate, the optimal division of seignorage is one half each. The CCB rewards the country with lower revenue (and tax rate) by compensating him with a higher share of seignorage. When the CCB cannot commit to a fix share of redistribution, both governments anticipate that the rule (2.11) will be followed, ex-post. Therefore, they will try to reduce their tax rate below the one of their opponent, in order to appropriate more seignorage.

An equilibrium in a CCA is defined as a set of values for $(\tau, \tau^*, \pi, \sigma)^c$ such that tax rates are chosen in order to maximize national welfare in individual countries subject to the seignorage rule (2.11), and the inflation rate is chosen in order to maximize total welfare $W + W^*$. It is easy to show that

Lemma 2.1. *The unique CCA equilibrium when the CCB cannot pre-commit with respect to the distribution of seignorage is symmetric , and such that a) tax rates are lower than under MI,* $\tau^c < \tau^m$*; b) seignorage is equally redistributed,* $\sigma^c = 1/2$*; and c) inflation in CCA exceeds inflation under Monetary Independence,* $\pi^c > \pi^m$

Proof. See Appendix

In summary, a change in regime, from Monetary Independence to a Common Currency Area, has strong implications when monetary authorities cannot precommit. When promises to adhere to a lump-sump redistribution of seignorage are not credible, the equilibrium rate of inflation is excessive and labor taxation is too low. The reason is that in a CCA seignorage becomes a *common pool* of revenue that each country tries to appropriate.

3. No Commitment to Inflation

In this section we briefly discuss a second inefficiency of Common Currency Areas: in the absence of a credible commitment to an inflation rate, a CCA may result in a multiplicity of inefficient equilibria, where, despite being identical, national authorities choose different tax rates. Intuitively, a reduction in labor taxation by one country is partially accommodated by the Central Bank with a higher, and therefore more distortionary, inflation tax. In order to keep inflation in check and to equate distortions across tax bases, the other country may optimally respond by raising its own income tax rate. This results in equilibria where tax distortions are neither equalized across tax bases nor across countries.

3.1. Commitment to both σ and π

When the CCB can commit to the ex-ante optimal shares of seignorage, $\sigma = \sigma^* = 1/2$, as well as to the inflation rate π, the resulting equilibrium tax and inflation rates exactly replicates the second best. Intuitively, when both monetary instruments are taken as given by fiscal authorities, there is no externality at work between countries, and the Nash equilibrium in tax rates is efficient.

3.2. No Commitment to π

Assume instead that the CCB cannot commit to π . The timing of the game looks like in Figure 2:

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t =0 t=1 t=2

($\sigma = 1/2$) Govs: τ (and τ^*) CCB: $=\pi$ Households: c, m, l

Figure.2: Lack of commitment with respect to π

In the second stage the Central Bank chooses the common rate of inflation in order to maximize the level of joint welfare, $W(\pi,\tau)+W(\pi,\tau^*)$, given $\sigma = 1/2$, τ and τ^*. This yields a condition similar to (2.9), except that the domestic marginal willingness to pay for the public goods, H_g, is replaced by the *average* willingness to pay $\frac{1}{2}(H_g + H_{g^*}) = \frac{1}{1-\varepsilon(\pi)}$. From this, one derives the CCB's optimal inflation policy, $\pi = \Pi(\overline{\tau}, \bar{\tau}^*)$. Inflation depends negatively on income tax rates: the benevolent CCB substitutes seignorage for tax revenues.

Currency union members choose the tax rates while taking into account that their choice will affect the inflation rate via $\Pi(.)$.[9,10] The foreign tax rate affects domestic welfare through inflation, so that each government plays the optimal response to foreign policy, $\tau = T(\tau^*)$.

It is easy to show that if a symmetric equilibrium ($\tau = \tau^*$) exist , it must coincide with the second best- MI equilibrium [11]. Interestingly, asymmetric multiple equilibria may also exist.

Consider the consequences of a foreign tax cut. As the CCB reacts by raising inflation, there are two opposite effects on domestic welfare. On the one hand, revenue from seignorage rises, and the supply of the domestic public good is boosted. Since its marginal utility falls, the optimal domestic tax rate falls. This income effect leads to *strategic complementarity* among tax rates. On the other hand, a cut in τ^*, by raising inflation, lowers the tax base for the inflation tax: the demand for money shrinks and becomes more elastic (recall that $\varepsilon_\pi > 0$,from footnote (6)). To equate distortions across tax bases, and to keep inflation in check, the domestic government raises its labor tax rate. This substitution effect leads to *strategic substitutability.* If the latter effect prevails, so that the reaction curves $T(.)$ are downward-sloping at intersection points, multiple asymmetric equilibria may occur [12]. Hence, identical governments choose different tax rates and distortions are not equalized, neither across tax bases nor across countries. This inefficiency arises because CCA members are striving to achieve two "objectives" (equating the marginal rate of substitution of private/public consumption to the rate of transformation, and equating tax distortions across tax bases) with only one independent instrument (τ). In the Appendix we compute a simple numerical example where we find multiple asymmetric equilibria of this sort. In a CCA one country (which can clearly be either one) taxes labor very heavily and ends up on the "wrong" side of the Laffer curve: labor supply decisions are strongly distorted, and the economy suffers a heavy output and consumption loss.

4. Discussion and Conclusions

We have shown that a CCA aggravates the inefficiencies associated with lack of credibility in monetary policy. The lack of commitment to the *redistribution of seignorage* leads to excessive inflation and suboptimal taxation. The CCB is tempted to redistribute in favor of the country with less revenue, so that governments try to appropriate seignorage by lowering the income tax rates. The outcome is similar to the standard tax competition effect, whereby governments drive tax rates down in the attempt to attract firms and capitals. In our setup, however, this occurs because the CCA regime creates a common pool of resources (seignorage) that can be appropriated by national tax policies.

This result suggests that Common Currency Areas should design their institutions so as to provide for fixed *rules* for the redistribution of seignorage. Interestingly, the Protocol of the "Statute of the European System of Central Banks and the ECB" of the Maastricht treaty (see Sinn and Feist (1997)), states that seignorage has to be redistributed according to each member's equity share in the ECB. This is calculated by taking the average of a country share in European GDP (for the years 1992-96) and of its share in European population (for 1997) [13]. According to our interpretation, this rule is a commitment device that insures that seignorage be redistributed in a *lump-sum* fashion, i.e. according to a rule that is not manipulable by national governments. Yet simple rules like this present another danger. We have shown that under such a rule, lack of commitment to *inflation* may lead to multiple inefficient equilibria. In our example, one country ends up on the wrong side of the Laffer curve, with excessive spending and taxation. If more elaborate (state-contingent) rules for redistributing seignorage are not feasible, institutions fostering the coordination/harmonization of fiscal policies on the right equilibrium are required. In this light, both the European Commission's attempt to "harmonize" taxation among EMU members, and the priority assigned to price stability among the ECB's goals can be interpreted as appropriate means for avoiding inefficient equilibria.

5. Appendix

5.1. An Example

Assume that the utility function

$$U = c + v(1 - L) + w(\frac{M'}{p}) + H(g)$$

takes the form $v(s) = w(s) = \alpha^{-1}H(s) \equiv s - \frac{s^2}{2}$. This specification allows for Laffer-curve type of results in our computations of optimal tax and inflation rates. The parameter α represent the relative weight of public vs private goods in the utility function. In Table 1 we compare the equilibrium with Monetary Independence and the (asymmetric) equilibria with a Common Currency [14]

	τ	π	L	$\frac{M'}{p}$	g	c	$W(1-\beta)$
MI	0.059	0.059	0.941	0.941	0.111	0.830	1.511
CCA	0.620	0.015	0.38	0.985	0.251	0.129	1.320
	0.074	0.015	0.926	0.985	0.084	0.842	1.510

Table 1: Numerical simulation of Equilibria under Monetary Independence and Common Currency with no precommitment to inflation.

In the second best solution of Monetary Independence, labor tax rates and inflation are low, below 6% (see the first row of the table). Hence output is only 6% below potential [15], while private consumption and real money holdings are high (83% and 94.1% of potential output, respectively). Public goods absorb about 11% of potential output. This equilibrium obtains in both countries. The second and third row show the asymmetric equilibrium in a Common Currency Area. One country (which can clearly be either one) taxes labor income very heavily at a rate of 62%, and ends up on the "wrong" side of the Laffer curve. Here workers work only 40% of what they did in the previous case, and the economy suffers a corresponding output and consumption loss. Public expenditures rise, but obviously much less than the tax rate, due to the adverse labor supply effect. The other country manages to stay rather close to the second best. Since labor taxation in equilibrium exceeds the efficient level in both countries, inflation is lower than before. Notice that distortions are not equalized neither across tax bases nor across countries. Both countries would benefit from lowering income taxes, particularly the high tax country, which experiences a 12.6% welfare loss compared with the second best. However, since both fiscal authorities are playing the optimal response to each other, neither has an incentive to cut its rate unilaterally.[16]

5.2. Proof of Lemma 1

Substitute the CCB's reaction function $S(.)$ (2.11) into domestic welfare. This yields

$$(1-\beta)\,W(\tau,\tau^*,\ S(\tau,\tau^*),\pi)\ = (1-\tau)l(\tau) - \pi m(\pi) + v(1-l(\tau)) + \tag{5.1a}$$

$$+w(m(\pi)) + H\left(\frac{\tau^* l(\tau^*)+\tau l(\tau)}{2} + m(\pi)\pi\right) \tag{5.1b}$$

This expression makes clear that, when the CCB redistributes seignorage, fiscal authorities expect to "waste" half of their revenue from income tax. Clearly, they will attempt to "undercut" their opponent in order to attract seignorage revenue. Differentiating the previous expression, the optimal domestic tax rate now satisfies

$$H_g\left(\frac{\tau^* l(\tau^*)+\tau l(\tau)}{2} + m(\pi)\pi\right) = \frac{2}{1-\eta(\tau)}$$

The l.h.s of this expression equals the l.h.s of equation (2.8) from symmetry. Since $H_{gg} < 0$ this expression is decreasing in τ. Comparing the r.h.s of this expression and (2.8) and recalling $\eta'(\tau) > 0$ establishes that $\tau^c < \tau^m$.Finally, equation (2.11) implies that $\sigma^c = 1/2$ as the tax rates are equal. Finally, consider that, from a), the rate of inflation in CCA is defined as follows:

$$\pi^c = \arg\max_{\pi}\left(W(\tau^c,\tau^c,\ 1/2,\pi) + W(\tau^c,\tau^c,\ 1/2,\pi)\right) \tag{5.2}$$

Hence, it satisfies

$$H_g(\tau^c l(\tau^c) + \pi m(\pi)) = \frac{1}{1 - \varepsilon(\pi)} \tag{5.3}$$

Part c) of the Lemma follows immediately by comparing this expression with (2.9) and recalling

$\varepsilon_\pi(\pi) > 0$ ■

6. References

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7. Notes

1. In the Working paper version of this work, see Bottazzi and Manasse (1998), we study how a common currency regime affects the international spillover effects via the real exchange rate.

2. Since we need to justify why individuals hold real money balances, we need a model of intertemporal choice. An alternative approach would be to assume that money economizes on transaction costs. In this case real balances enter the budget constraint rather than the utility function. Under certain regularity conditions the two approaches are equivalent. See Feenstra (1986).

3. Here we are assuming that the sequence of prices in the two countries is the same when they share the same currency.

4. From the first-order condition for real balances one can see that a constant rate of inflation implies constant money demand $\frac{M_{t+1}}{p_t}$. But since $\frac{M_{t+1}}{p_t} \equiv \frac{M_{t+1}}{p_{t+1}}\frac{p_{t+1}}{p_t}$, constant inflation and money demand require that $\frac{M_{t+1}}{p_{t+1}}$ is also constant. Thus the rate of money growth must equal the inflation rate.

5. With a slight abuse of notation, fromn now on we will call π,rather than $\widetilde{\pi}$, the inflation rate.

6. To derive this expression we use the fact that $w'(.) = \pi$ for β sufficiently close to one. For the second order condition to be satisfied it is sufficient that the elasticities $\varepsilon(\pi)$ and $\eta(\tau)$ be increasing in their respective tax rates, as we assume.

7. The issue of redistribution and credibility is also discussed in Bordignon, Manasse and Tabellini(2001)

8. We have used the fact that $\widetilde{m}(\pi) = 2m(\pi)$: the overall demand for the common currency is twice the demand of each country, since inflation is the same at home and abroad.

9. An equilibrium in the CCA regime without commitment to inflation is now defined as a set of policy variables, $(\tau, \tau^*, \pi)^c$, such that, given the inflation policy of the CCB, $\Pi(\tau, \tau^*)$, each tax rate is the optimal response to the other government's tax rate, and $\pi^c = \Pi(\tau^c, \tau^{c*})$.

10. The first order condition for the optimal domestic tax rate is now $W_\tau(\tau, \pi) + W_\pi(\tau, \pi)\ \Pi_\tau(\tau, \tau^*) = 0$ (see the Appendix). This condition implicitly defines the domestic tax rate as a function of the foreign rate, $\tau = T(\tau^*)$.

11. Intuitively, the average willingness to pay $1/2(H_g + H_{g^*}) = H_g$, so that the conditions for an optimum in CCA concides with those in MI.

12. Strategic substitutability of the tax rates is therefore a necessary condition for multiple asymmetric equilibria. See Cooper and John (1988)

13. The figures are updated every 5 years.

14. In the table whe choose $\alpha = 1.2$. Different values for α yield similar results. The displayed solution satisfies the sufficient conditions for a maximum.

15. Recall that the maximum output level is equal to 1.

16. The calculations above overstate the welfare loss associated to a CCA. The reason is that, by assumption, the Central Bank is redistributing according to the ex ante optimal shares, $\sigma = \sigma^* = 1/2$, which are clearly sub-optimal in an asymmetric equilibrium.