Money, Sovereignty, and Optimal Currency Areas*

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Abstract

We propose a new theory of Optimum Currency Areas (OCAs) based on monetary sovereignty. We consider two economically integrated countries with separate currencies and monetary policies, but with exchange rate underreaction. We show that the two countries are then engaged in a *strategic monetization* game, which may generate excessive inflation in equilibrium. A monetary union between the two countries can eliminate this excess inflation cost, but also removes a nation's *monetary sovereignty*. By eliminating the option to monetize debt in times of exigency, a monetary union may give rise to costly debt defaults. Joining a monetary union therefore involves trading excess monetization costs for debt default costs. Allowing for fiscal transfers within the union and for the option of debt monetization in a generalized crisis are optimal features of a monetary union. Our model also provides a coherent analytical framework that helps shed light of the recent history of OCAs.

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"... Leuco, son of Satyrus I, who reigned in Panticapaeum from 389 to 349 BC. This was a king renowned for political and economic cunning, who spent much of his reign successfully manipulating the Greek business community into subsidizing his budget for war and internal security. Leuco, in fact, managed to defy the laws of orthodox economics: he financed the budget by increasing money supply, without precipitating inflation. In his Stratagems of War, Polyaenus relates that Leuco, "when his treasury was very low, issued a proclamation for a new coinage, and directed everyone to carry in his money and to receive the same in value struck in a new die. A new die was accordingly struck, and every piece of money bore a value double to that it possessed before. One half he kept for himself, and every individual received the same current value he gave in"." [Neal Ascherson, 1995, page 226]

"All these pieces of paper are, issued with as much solemnity and authority as if they were of pure gold or silver... with these pieces of paper, made as I have described, Kublai Khan causes all payments on his own account to be made; and he makes them to pass current universally over all his kingdoms and provinces and territories, and whithersoever his power and sovereignty extends... and indeed everybody takes them readily, for wheresoever a person may go throughout the Great Khan's dominions he shall find these pieces of paper current, and shall be able to transact all sales and purchases of goods by means of them just as well as if they were coins of pure gold" [Marco Polo, 1300, printed in London 1818, pages 353–355.]

1 Introduction

In this paper we propose a new theory of Optimum Currency Areas (OCAs). We consider a model with two countries that are economically integrated, but with separate currencies and monetary policies. We ask: When is it preferable for these countries to have a single currency and a unified monetary policy? What is the optimal form of a monetary union?

In an integrated economy with two countries running separate monetary policies the effects of one country's monetary policy cannot in general be confined to that country. It is only in the pure situation where the exchange rate is perfectly flexible and immediately adjusts to any relative changes in money supply that one country's monetary policy has no effect on other countries. This result is a reformulation of Hayek's *International Monetary Neutrality* proposition**,** whereby a change in money supply in one country does not affect equilibrium allocations of goods in the other country when foreign exchange markets operate frictionlessly.

But, when exchange rates underreact or overreact, the effects of a change in money supply in one country do spill over to the other country, the two countries are engaged in a strategic monetization game, which may generate excessive monetization in equilibrium. When exchange rates underreact a country can temporarily gain purchasing power at the expense of the other country by increasing its money supply. The increase in money supply gets spent partially in the other country, resulting in an increase in the current account deficit. A country has stronger incentives to monetize, if this not only forestalls a debt default but also allows the country to gain purchasing power. Furthermore, the best response for the other country to the *strategic monetization* of the neighboring country may be to undo the effects of the monetization by also monetizing its debt. Therefore, in our model the cost of maintaining monetary sovereignty in an economically integrated area is excess monetization and inflation.

A *monetary union* between the two countries can eliminate this excess monetization cost. We begin by considering a monetary union with the main institutional features of the European Monetary Union.[1] Monetary policy under the single currency regime is entrusted to an independent central bank that is constitutionally barred from any debt monetization. Moreover, the monetary union involves no fiscal transfers between the two countries. Under such a monetary union there is a cost in giving up *monetary sovereignty* to a single, supranational, central bank, namely the loss of the option to monetize in times of exigency. In our model such a monetary union would give rise to costly debt defaults when a member country's economy is in a bad state. For in such a state the country would not have the fiscal resources to fully service its debt and would therefore be forced to default. By joining such a monetary union a country would trade one cost for another: debt default costs instead of excess monetization costs.

When a monetary union is associated with default costs, it is not obvious a priori whether joining such a monetary union is beneficial. We show that when the equilibrium under monetary sovereignty is such that there is no monetization when both economies are in a good state, and only partial monetization by the country experiencing low productivity in other states of the world, then monetary union is dominated by monetary sovereignty. It is only when the equilibrium outcome under monetary sovereignty results in maximum monetization in some states of the world that monetary union may be preferable, and only if the costs of debt default under a monetary union are not too high.

We further consider the possibility of a monetary union with fiscal transfers and possibly even some debt monetization. We show that fiscal transfers can improve a monetary union to the extent that they allow a country in a bad economic state to avoid a costly default by relying on the fiscal transfers of the other country in a

[1] See Fratianni and von Hagen, 1992, Meade and Weale, 1995, James, 2012, Brunnermeier, James and Landau, 2016, among others, for discussions and debates on the European Monetary Union.

better economic state to service part of the debt. Fiscal transfers, in effect, are a form of co-insurance policy against costly defaults. We further show that the best possible arrangement is a monetary union with not only fiscal transfers but also the option for the single central bank to monetize debt to avoid a costly default in the state of the world where both countries' economies are in bad shape. Such a monetary union always dominates monetary sovereignty in our model.

With fiscal transfers and the possibility of debt monetization by the single central bank, a natural concern is that each country may respond by issuing excessive debt. We do not consider this moral-hazard-in-borrowing problem in our analysis. However, we suggest that the presence of such a moral hazard problem is the main reason why a *fiscal union* along with a monetary union would be preferable to a monetary union with fiscal transfers. What is the difference? Under a fiscal union, the debt limit and federal debt obligations for each country would be set by a single supranational fiscal authority, precisely to avoid the moral-hazard-in-borrowing problem. But, each country could retain sovereignty over how it otherwise spends its fiscal revenues (see Maskin, 2016, for such a proposal).

Concerns over moral-hazard-in-borrowing have been invoked as the main reason why any form of debt monetization should be excluded from the European monetary union (see Weidmann, 2012). However, as we point out in our discussion of history's lessons on monetary unions and past experiments with fixed exchange rates, it is usually the inability to monetize in times of exigency that is the cause of the breakdown of past monetary unions and fixed exchange-rate regimes. Moreover, irrespective of where one stands on this issue, an important observation from our analysis is that the pressure to monetize is alleviated if fiscal transfers are available to service the debts of member countries in economic difficulty. That is, a fiscal union along with a monetary union strengthens the single central bank's ability to limit debt monetization, and thereby improves the efficiency of the monetary union.

The literature on optimal currency areas begins with a seminal contribution by

Mundell (1961), who frames the question in terms of trade costs. The benefit of a single currency is that it facilitates trade. Given that more trade between more countries increases the surplus from trade it would logically follow that a single world currency would be best. Mundell, however, realizes that when unemployment is difficult to reduce through labor mobility, exchange rate adjustments may be helpful to speed up the return to full employment. He therefore advocates the extension of a single currency to economic areas in which the factors of production are mobile:

> "Money is a convenience and this restricts the optimum number of currencies....If the world can be divided into regions within each of which there is factor mobility and between which there is factor immobility, then each of these regions should have a separate currency which fluctuates relative to all other currencies." [Mundell, 1961, pages 662-663]

The literature following Mundell (1961) has mostly focused on the question of how much trade is hindered by exchange-rate volatility and how big the increase in trade is following a monetary union. Several empirical studies have explored the link between exchange-rate volatility and trade. The overall conclusion of these studies is that if there is a negative relationship between exchange-rate volatility and trade, the effect is small and non-robust (see Clark et al, 2004). As for the effect of the European monetary union on trade, while the first study by Rose (2000) found large positive effects of monetary union on trade, subsequent studies have found that these results are not robust. The general consensus emerging from multiple studies of this question is that the positive impact of European monetary union on trade has been small (see e.g. Baldwin, 2006, and Glick and Rose, 2016).

Mundell's OCA theory ignores any benefits of monetary sovereignty beyond faster factor reallocation. In particular, it ignores the benefit of monetization in

times of fiscal exigency.[2] The Euro-area sovereign debt crisis of 2010-2013, triggered by the 2008 global financial crisis, has revealed the importance of this gap in Mundell's theory. Before the Euro-area sovereign debt crisis, Goodhart (1996) among others has forcefully argued that what is missing from Mundell's theory is any notion of sovereignty:

> "All separate nation states that are larger than Panama, Liberia or Liechtenstein have a single currency. Are they all really optimal currency areas? Is Western Australia really part of an optimal currency area with Victoria, or Alberta with Quebec? No sovereign countries allow more than one currency as legal tender within their borders, and only a few tiny countries share a currency with a larger neighbour or trading partner. ... What is clear is that currency union is essentially a function of political cohesion. One crucial component of political cohesion is the centralisation of fiscal competences," [page 1084, Goodhart, 1996]

Our theory focuses on monetary sovereignty, but assumes away any effects of exchange-rate fluctuations on trade. By doing so, our theory identifies a different reason for monetary union: the internalization of the negative externalities of excessively lax monetary policies. Our theory also identifies the costs of monetary union: the loss of monetary sovereignty, which concretely manifests itself through a sovereign debt crisis when a member country faces an economic crisis.[3] Our analysis shows that the sovereignty attribute of fiat money is an additional non-trivial attribute to the three other attributes of money traditionally emphasized.

Along with Goodhart (1996, 1998), our theory also points out the importance of "political cohesion" and "centralization of fiscal competences" in sustaining a

[2] Mundell (2002) touches on the issue of monetary sovereignty, but mainly to point out that a true monetary union involves abandoning monetary sovereignty. He distinguishes between different forms of currency areas and argues that a "monetary union without a centralization of decision making with respect to monetary policy would quickly fail."

[3] See Corsetti and Dedola, 2014 for related discussions on money and sovereign debt crisis.

monetary union. The history of US monetary unification, in particular, but also that of the Bretton Woods system, reveals how fragile a monetary union is without a strong federal political structure. Our model also provides a coherent analytical framework that also helps understand the adoption of the gold standard to its collapse, the examples of modern currency board systems, and the ongoing debates on how to reform the Euro system.

Our model builds on the framework developed in Bolton and Huang (2018a) for a single open economy. In this single-country model the optimal fiscal and monetary policy for the country is to finance public expenditures with domestic-currency debt, which is serviced with tax revenues whenever possible. In a good state of the economy tax revenues are sufficient to service the debt, but in a bad state the debt must be partially monetized or else the government is forced into a costly default. Unless faced with an impending default the government prefers to avoid monetizing the debt in order to preserve the real value of household savings. However, the costs of an outright debt default exceed the welfare costs associated with debt monetization.

The remainder of the paper is structured as follows. Section 2 lays out the basic building blocks of the model. Section 3 characterizes the optimal fiscal and monetary policy for a single country in autarky. Section 4 analyzes the strategic monetization game between two economically integrated countries, each with its own currency and independent fiscal and monetary policies. Section 5 introduces the monetary union and analyzes when a monetary union is preferable. Section 6 characterizes the optimal monetary union with fiscal transfers and contingent debt monetization. Section 7 provides an overview of the recent history of monetary unions from the perspective of our theory. Section 8 concludes.

2 Model

The model comprises two countries, A and B, each composed of two classes of agents, savers and workers, who live for two periods $t = 0, 1$. In each country the two classes start out with a given endowment of fiat money and labor inputs in period 0. Each worker is self-employed and runs her worker-owned firm. Production in each country begins with each government producing a public good g_i with labor inputs against a debt repayment promise b_i in period 1, where $i = A, B$. After the public good has been produced, firms use the remaining labor inputs available to produce a private consumption good. In period 1 production is realized and sold in competitive markets after the government has levied a sales tax and serviced its debt obligations. Let y_i denote the final output in country $i = A, B$.

The final output price p_i, measured as units of money per unit of goods, clears the goods market in each country. Both savers and workers in each country spend their cash holdings to purchase the final consumption good. We assume that the two countries' final goods are perfect substitutes. When the two countries have their own separate currencies we assume that only the domestic currency can be used to purchase goods or labor inputs in each country. However, there is a competitive currency market where one unit of currency of country A can be exchanged at rate e against country B' currency, and vice-versa.

The masses of savers and workers in each country are each normalized to 1. A saver has an endowment of fiat money $s_i > 0$ in period 0. A worker has an endowment of labor inputs $l_i > 0$ and an endowment of money of $m_i > 0$. Both savers and workers are risk neutral. Their utility functions are the same in each country and given respectively by:

$$U(c_i) = c_i \text{ for savers,} \tag{1}$$

and

$$U(c_i, m_i^c) = c_i + \varphi m_i^c / p_{i1} \text{ for workers,}$$

where c_i stands for consumption in period 1 and m_i^c stands for continuation money balances obtained by workers from the sale of their output. The real value of continuation money balances m_i^c bequeathed to the next generation is m_i^c/p_{i1} and the value of these bequests to the workers is given by $\varphi m_i^c/p_{i1}$, where $1 > \varphi > 0$.[4]

This simple two-period model can be thought of as representing two periods of an infinite-horizon overlapping generations (OLG) model, where each generation lives for two periods. In the first period of their life agents are workers, and in the second period they are retirees consuming out of their savings. The only difference with the standard OLG model is that bequests to the next generation are made in the middle instead of the end of life. That is, the representative worker at the end of the first period splits m_i^c into s_i for her retirement and m_i for her offspring.

All worker-firms in each country are identical and have the following production function: $y_i \equiv \theta_i l_i$, where θ_i is a productivity shock and l_i is the total labor input available to the firm. For simplicity there is no discounting. Consumers must use cash to purchase firms' output in period 1; a worker is not allowed to consume the output of her own firm. For simplicity we assume that θ_i can only take two values $\theta \in \{\theta_L, \theta_H\}$, with $\theta_H > \theta_L > 0$, and with $\pi_i = \Pr(\theta_i = \theta_H)$.

In each country, fiscal and monetary policy are determined by two separate government agencies, an independent central bank charged with the conduct of monetary policy and a finance ministry, or treasury department, charged with fiscal policy. The fiscal authorities incur exogenously fixed public good expenditures g_i at time 0 that are financed by issuing debt b_i. This debt is repaid in period 1 through a combination of tax revenues $\tau_i m_i$ and possible monetization of the debt by the

[4] When $\varphi \geq 1$, workers strictly prefer to hoard money rather than purchase goods whatever the price level is. Savers cannot hoard money and must spend s. The market-clearing price level is then only related to s and not m, resulting in no possible monetary interactions.

central bank.[5] The combined agencies' objectives are to maximize the sum of the utilities of savers and workers, but they put slightly different weights on the utilities of each class: while in each country the welfare weight of a worker is 1, the welfare weight of a saver is $\kappa > 1$. This is a simple way of modeling concerns over dilution of savers through monetization. In each country there is a maximum income tax rate $\bar{\tau}_i > 0$ determined exogenously that the fiscal agency can set, and taxes must be paid in the country's own fiat money.

3 One Country

Consider first how the model works in the case of a single country. We begin by solving for the competitive equilibrium in the presence of no government. We then proceed to characterize the equilibrium with a government as an active agent in the economy.

Equilibrium with no government. A saver's problem in period 1 is trivial, as the only action a saver takes is to spend all of her endowment s and to consume what she was able to purchase $c = s/p$. The worker's problem in period 0 is also trivial: she supplies all her labor inputs l to her firm, which produces output θl in period 1. This output is then sold to other workers and savers at the market-clearing prices p_L or p_H such that

$$p_L = \frac{s+m}{l\theta_L} \text{ and } p_H = \frac{s+m}{l\theta_H}.$$

Accordingly, workers' and savers' respective utility is

$$\left(\frac{m}{s+m}\right) l\theta \text{ and } \left(\frac{s}{s+m}\right) l\theta,$$

[5] Note that tax revenues are a fraction τ of the money balances of workers m. Whatever the tax base is, income or sales, it results in a reduction in disposable money balances since taxes must be paid in fiat money. When taxes are paid in fiat money there is an obvious link between money balances and tax revenues as Alexander Hamilton observed as early as 1787: "The ability of a country to pay taxes must always be proportioned, in a great degree, to the quantity of money in circulation and to the celerity with which it circulates." [The Federalist Papers: No. 12.]

and total welfare is

$$\left(\frac{\kappa s+m}{s+m}\right) l\theta.$$

Equilibrium with public good provision by a government. In the presence of a government, the worker's problem is somewhat more complicated. First, we need to determine for what debt claim b a worker is willing to supply labor inputs g to the government. Second, we need to determine whether the government is able to service the debt claim in period 1 with income tax receipts τm, and if not, to what extent the government will monetize the debt by expanding the money base by δm. Third, we need to derive the after-tax budget constraint for savers and workers.

We model the state-contingent nominal debt obligations of the government as follows. The debt obligation b incurred in period 0 will be partially repaid by the government at an interim period when the state of nature is revealed. The partial repayment will be larger in state H than in state L, so that the remaining (state-contingent) debt obligation of the government is (b_H, b_L) such that $b_H < b_L$. Without much loss of generality, we set $b_H = b/\theta_H$ and $b_L = b/\theta_L$. This modeling device captures in a simple way the idea that the debt-to-GDP ratio is counter-cyclical.

We proceed backwards in time.

The period 1 *solution:* Consider first the outcome in the high output state θ_H, in which the government is able to service the debt out of tax receipts. In this case, the worker's budget constraint in period 1 is given by

$$m(1-\tau_H) + b_H \geq p_H x_H,$$

where x_H is the quantity of goods purchased by the worker in the high output state θ_H.

The proceeds from selling the worker's output in period 1 are

$$(l-g)p_H\theta_H.$$

These proceeds are obtained at the end of period 1, after the worker has already consumed and are either bequeathed to the next generation or held as savings for retirement. In other words, they become the money endowment for the next period's savers and workers. Without loss of generality we set $(l-g)=1$.

The saver's budget constraint in period 1 is given by

$$s \geq p_H z_H,$$

where z_H is the quantity of goods purchased by the saver in the high output state θ_H. Note that savers are not taxed. In other words, there are no taxes on capital income in this economy. As will become clear below, this is welfare efficient whenever the government puts more weight on savers' welfare than on workers.

The fiscal agency will set the tax rate $\tau \leq \bar{\tau}$ such that the government budget constraint balances:

$$m\tau_H = b_H. \tag{2}$$

Replacing b_H in the workers' budget constraints we then get

$$m \geq p_H x_H,$$

so that in equilibrium

$$x_H = \frac{m}{p_H} \text{ and } z_H = \frac{s}{p_H}.$$

Moreover, from market clearing we have

$$\frac{s+m}{\theta_H} = p_H,$$

so that

$$x_H = \left(\frac{m}{s+m}\right)\theta_H \text{ and } z_H = \left(\frac{s}{s+m}\right)\theta_H. \tag{3}$$

Consider next the outcome in the low output state θ_L, in which the government is unable to service the debt out of maximum tax receipts $\bar{\tau}m$. In this case, we

assume that the government monetizes the fraction of its debt it cannot service with tax revenues by printing money δm, so that

$$\delta m = b_L - \bar{\tau} m. \tag{4}$$

The worker's and saver's budget constraints in state θ_L are then

$$m(1-\bar{\tau}) + b_L \geq p_L x_L,$$

and

$$s \geq p_L z_L,$$

where x_L and z_L are respectively the quantity of goods purchased by the worker and saver in the low output state θ_L.

Replacing for b_L in the workers' budget constraints we then get

$$(1+\delta)m \geq p_L x_L,$$

so that in equilibrium

$$x_L = \frac{(1+\delta)m}{p_L} \text{ and } z_L = \frac{s}{p_L}.$$

Moreover, from market clearing we have

$$\frac{s + (1+\delta)m}{\theta_L} = p_L,$$

so that

$$x_L = \left(\frac{(1+\delta)m}{s+(1+\delta)m}\right)\theta_L \text{ and } z_L = \left(\frac{s}{s+(1+\delta)m}\right)\theta_L. \tag{5}$$

The period 0 *solution:* Moving to period 0, a worker must be indifferent between getting b in exchange for supplying labor g and not supplying g.

Under the former choice the worker's expected utility is

$$\pi[\frac{m(1-\tau_H) + b/\theta_H}{p_H} + \varphi\theta_H] + (1-\pi)[\frac{m(1-\bar{\tau}) + b/\theta_L}{p_L} + \varphi\theta_L]$$

And if the worker does not supply g her expected utility is (assuming that the worker has negligible mass):

$$\pi[\frac{m(1-\tau_H)}{p_H}+\varphi(1+g)\theta_H]+(1-\pi)[\frac{m(1-\bar{\tau})}{p_L}+\varphi(1+g)\theta_L]$$

Setting these two expressions equal we get:

$$b=\frac{\varphi g\overline{\theta}}{\pi/p_H\theta_H+(1-\pi)/p_L\theta_L},$$

where $\overline{\theta}=\pi_H\theta_H+\pi_L\theta_L$.

Closing the model, equilibrium consumption for workers in state L is given by

$$x_L=\frac{(1+\delta)m\theta_L}{s+(1+\delta)m},$$

where

$$(1+\delta)m=b/\theta_L+(1-\bar{\tau})m=\frac{\varphi g\overline{\theta}/\theta_L}{\pi/p_H\theta_H+(1-\pi)/p_L\theta_L}+(1-\bar{\tau})m.$$

To summarize, the one country solution is such that the government partially monetizes the debt in state L, resulting in a transfer of purchasing power from savers to workers, which gives rise to a net welfare loss from monetization of:

$$(\kappa-1)[\underbrace{\left(\frac{s}{s+m}\right)\theta_L}_{\substack{\text{saver's consumption}\\ \text{without monetization}}}-\underbrace{\left(\frac{s}{s+(1+\delta)m}\right)\theta_L}_{\substack{\text{saver's consumption}\\ \text{with monetization}}}]$$

$$=(\kappa-1)\underbrace{\left(\frac{\delta m}{s+m+\delta m}\right)}_{\substack{\text{monetary dilution}\\ \text{coefficient}}}\underbrace{\left(\frac{s}{s+m}\right)\theta_L}_{\substack{\text{saver's consumption}\\ \text{without monetization}}}$$

relative to a world in which the government can always repay the debt out of tax revenues.[6]

[6]Note that unlike in Bolton and Huang (2018a), where both government bonds and money are treated as government equities and can be exchanged freely, the worker's initial endowment of government securities at period 0 in this paper are akin to government promises to workers, such as state pensions, Medicare and other social benefits. These are real claims. In addition, they usually do not have liquid secondary markets. As a result, at period 0 savers only hold cash balances, whereas workers hold government bonds. This convenient assumption brings two important simplifications. First, it decouples the budget constraints of savers and workers in period 1. Second, it results in a very simple after-tax and after debt-servicing budget constraint for workers.

Note that the first order derivative of the welfare loss function with respect to δ is positive, so that the net welfare loss from monetization is always increasing in δ. It follows that the country should only partially monetize is debt as needed. Partial rather than full monetization is optimal given that the government puts more weight on savers' than workers' welfare.

However, partial monetization is still better than no monetization in state θ_L, which would mean a default on the debt b_L with a deadweight cost $\phi\left(\frac{\kappa s+m}{s+m}\right)\theta_L$ that exceeds the welfare loss resulting from monetization:

$$\phi\left(\frac{\kappa s+m}{s+m}\right)\theta_L > (\kappa-1)\theta_L\left(\frac{s}{s+m}\right)\left(\frac{\delta m}{s+(1+\delta)m}\right),$$

or

$$\phi > (\kappa-1)\left(\frac{s}{\kappa s+m}\right)\left(\frac{\delta m}{s+(1+\delta)m}\right).$$

Substituting for δm and $(1+\delta)m$, we therefore obtain the following lemma:

Lemma 1: Partial monetization rather than default is optimal if

$$\phi > (\kappa-1)\left(\frac{s}{\kappa s+m}\right)\left(\frac{\overline{\theta}g-\bar{\tau}m}{\overline{\theta}g+(1-\bar{\tau})m+s}\right). \tag{6}$$

Proof: See the discussion above. ■

4 Two Countries

The model with two countries inherits all the characteristics of the model with a single country. The new elements are that in the final period consumers can purchase goods in each country, so that international trade is allowed. To purchase a good in the foreign country, however, a consumer must use that country's currency. There is therefore also a foreign currency market and an exchange rate, which depends on the relative quantities of money of each country and their relative output.

The main strategic interaction is that each country's government can increase the money supply with the goal of allowing its own consumers to purchase more

foreign goods. Of course, a country's attempt to increase its purchasing power by increasing its money supply is self-defeating if the exchange rate instantaneously and fully reflects changes in the relative quantities of money. We begin by establishing this result in our first proposition, the *International Financial Neutrality Theorem*. We then proceed to the characterization of the equilibrium monetary policy of each country in the presence of underreacting foreign exchange rates.

4.1 Equilibrium with perfect foreign-exchange markets.

Let m_i denote the money supply of country $i = A, B$. To simplify the analysis we impose some symmetry on the model and assume that $s^A = s^B = s$ and $l^A = l^B = l$. Given m_i, the two-country equilibrium in period 1 is given by final goods prices p_1^i and an exchange rate e such that the goods markets in each country and the foreign exchange market clear. We conjecture and verify that a candidate equilibrium when the foreign exchange market is frictionless is such that a country's output is entirely consumed by its residents. In other words, there is no international trade in equilibrium, as there are no strict gains from trade in our model by construction.

For such an equilibrium, goods prices must be such that

$$p_1^i = \frac{s + m^i}{\theta^i}, \tag{7}$$

and the exchange rate must be such that the terms of trade are equal to 1, or

$$e = \left(\frac{s + m^A}{s + m^B}\right) \frac{\theta^B}{\theta^A} \equiv \left(\frac{s + m^A}{s + m^B}\right) \Gamma_{BA}. \tag{8}$$

To see this, note that a resident of country A can purchase one unit of the consumption good either in country A for a nominal price in country A's currency p_1^A or in country B for a price in country A's currency $\hat{p}_1^A = e p_1^B$. The law of one price then requires that

$$p_1^A = e p_1^B.$$

Substituting for p_1^i and rearranging we obtain the expression in (8). It is immediate to verify that when e satisfies condition (8) and p_1^i satisfies condition (7) then no trade is an equilibrium in which all the relevant markets clear.

The foreign exchange market is frictionless if e immediately and fully responds to any change in money supply, or more formally, if

$$\frac{\partial e}{\partial m^A} = \left(\frac{1}{s+m^B}\right)\Gamma_{BA} \tag{9}$$

and

$$\frac{\partial e}{\partial m^B} = -\frac{s+m^A}{(s+m^B)^2}\Gamma_{BA}. \tag{10}$$

When the foreign exchange market is frictionless we obtain the basic result first stated by Hayek (1931) that money is neutral even in an international competitive economy:

Theorem 1. (Hayek) International Monetary Neutrality: *A change in money supply in one country does not affect equilibrium allocations of goods in the other country in a competitive international economy with frictionless foreign exchange markets.*

Proof: This result follows from the observation that the final allocations of goods in our candidate equilibrium remain unchanged when either m^A or m^B are changed provided that e satisfies (9) and (10). ■

Hayek (1931) formulated this basic result in his public lectures at the London School of Economics and later in his debate with Friedman on whether the supply of money should be a state monopoly or be left to competitive market forces.[7] If all markets are frictionless, he argued, then all production and consumption choices in all markets are neutral to all forms of money that are used as payment. In contrast, Friedman argued that money supply should be a state monopoly, for otherwise competitive forces in the supply of money would result in excess supply of money and inefficient production and consumption decisions. Implicit in Friedman's argument is

[7] See Hayek (1976) and Hellwig's (1985) critique of this result.

that foreign exchange markets are imperfect, as we show next. Friedman's argument is all the more remarkable in light of his other sweeping positions in favor of free markets and limited government. He draws a strong line against free markets when it comes to money.

4.2 Equilibrium with imperfect foreign-exchange markets

We now introduce a friction into foreign exchange markets: exchange rate underreaction. We shall assume that the exchange rate adjust imperfectly to changes in the money supply of one country:

$$\frac{\partial e}{\partial m^A} = \eta \left(\frac{1}{s + m^B} \right) \Gamma_{BA} \tag{11}$$

and

$$\frac{\partial e}{\partial m^B} = -\eta \frac{s + m^A}{(s + m^B)^2} \Gamma_{BA}, \tag{12}$$

where $0 \leq \eta < 1$.

Under $0 \leq \eta < 1$ the exchange-rate underreacts. The effect of an increase in m^A then is to reduce the purchasing power of residents of country B and to commensurately increase the purchasing power of residents of country A. The increase in m^A also results in a current account deficit for country A that is exactly offset by an increase in foreign currency holdings of country B.

The case of exchange-rate underreaction best captures the monetary and exchange rate interaction between advanced economies. Partly for institutional reasons exchange rates have adjusted only gradually to relative changes in money supply among advanced countries after WW II. Exchange-rate overreaction (when $\eta > 1$), however, may well reflect the experience of two competing economies at different development stage, such as between Japan and the US from the 1970s to 1990s. In this case the effect of a relative increase in m^A is for country A's currency to overly depreciate, thereby boosting its exports and current account, by increasing the purchasing power of the residents of country B. The current account

improvement for country A is then exactly offset by a decrease in foreign currency holdings of country B.

In both situations, there may be an incentive for a country to issue more money to gain an advantage over the other country, whether to boost the country's own purchasing power, in the case of exchange rate underreaction, or to boost its export and current account, in the case of exchange rate overreaction. Although our model allows for both under and over-reaction, we focus our analysis on the most pertinent case for a monetary union, the case when $0 \leq \eta < 1$. What is more, for most of our analysis we assume that the exchange rate is *fixed*, so that $\eta = 0$, as this is significantly more tractable. The effects of a change in money supply under fixed exchange rates capture in the simplest way the basic strategic interaction between the two countries. Indeed, it is this basic strategic consideration that led to the break-down of the Bretton Woods system.

Under $\eta = 0$, an increase in m^A must result in the following change in goods prices p_1^i for markets to clear:

$$\frac{\partial p_1^A}{\partial m^A} = e \frac{\partial p_1^B}{\partial m^A}.$$

The decision a government then faces in this two-country model with fixed exchange rates is to decide when it is worth boosting domestic workers' welfare through debt monetization at the expense of domestic savers' welfare and the other country's residents. Note that when a country decides to boost the purchasing power of its workers in this way, it wants to do so maximally in our linear model. To obtain a determinate equilibrium we impose the constraint that a country can only increase its money supply in any given period up to the point when it has fully monetized its debt, so that $\delta \leq \bar{\delta}$, where $\bar{\delta} m = b$.

In this two country model with fixed exchange rates, where the two countries are engaged in a strategic debt monetization game, the natural equilibria to consider are the subgame-perfect Nash equilibria in which each country's optimal debt mon-

etization policy is a best response to the other country's optimal debt monetization policy.

To be able to characterize the set of subgame-perfect Nash equilibria we need to determine each country's best-response functions. Accordingly, we next proceed by characterizing the best responses of each country to the monetization decisions of the other country in each state of the world

$$(\theta^A, \theta^B) = \{(\theta^H, \theta^H), (\theta^L, \theta^H), (\theta^H, \theta^L), (\theta^L, \theta^L)\}.$$

To further simplify the analysis we also set $m^A = m^B = m$.

Consider first state (θ^H, θ^H). If neither country changes its money base we know from the previous section that the consumption allocation in the two country model will be a carbon copy of the allocation in the one country model, which in each country is given by:

$$x_H = \left(\frac{m}{2(s+m)}\right) 2\theta_H = \left(\frac{m}{s+m}\right) \theta_H$$

and

$$z_H = \left(\frac{s}{2(s+m)}\right) 2\theta_H = \left(\frac{s}{s+m}\right) \theta_H,$$

for respectively workers and savers. Total welfare in each country is then

$$\left(\frac{\kappa s + m}{2(s+m)}\right) 2\theta_H = \left(\frac{\kappa s + m}{s+m}\right) \theta_H.$$

More generally, if country A increases its money base by monetizing its debt by $\delta^A m$, and country B monetizes its debt by $\delta^B m$, then the consumption allocations of respectively savers and workers in both countries in state (θ^H, θ^H) are given by:

$$z_H^A = z_H^B = \left(\frac{2s}{2(s+m) + \delta^A m + \delta^B m}\right) \theta_H,$$

$$x_H^A = \left(\frac{2(m + \delta^A m)}{2(s+m) + \delta^A m + \delta^B m}\right) \theta_H,$$

and

$$x_H^B = \left(\frac{2(m + \delta^B m)}{2(s+m) + \delta^A m + \delta^B m} \right) \theta_H,$$

with full monetization in country $i = A, B$ given by $\delta^i m = b_H$, and no monetization by $\delta^i = 0$.

Accordingly the payoff functions for country $i = A, B$ in terms of $\delta^i m$ and $\delta^j m$ $(j = A, B; j \neq i)$ are given by:

$$\Pi^i(\delta^i, \delta^j) = x_H^i + \kappa z_H^i = \frac{2(\kappa s + m + \delta^i m)\theta_H}{2(s+m) + \delta^i m + \delta^j m}. \tag{13}$$

Differentiating $\Pi^i(\delta^i, \delta^j)$ with respect to δ^i, we find that the welfare of country $i = A, B$ increases with δ^i (i.e. more monetization) if:

$$\kappa < \frac{2s + (1 + \delta^j)m}{s}.$$

We therefore obtain the following lemma characterizing the conditions under which respectively a *no-monetization* and *maximum-monetization* equilibrium obtains in state (θ_H, θ_H).

Lemma 2: In state (θ_H, θ_H), a necessary condition for the existence of a *no-monetization equilibrium* is

$$\kappa > \frac{2s + m}{s};$$

and a necessary condition for the existence of a *maximum-monetization equilibrium* is

$$\kappa < \frac{2s + m + b_H}{s}.$$

Proof: Based on the analysis above, if

$$\kappa > \frac{2s + (1 + \delta^i)m}{s}$$

for $i = A, B$, then neither country would have any incentive to monetize, so that they set $\delta^i = 0$.

If instead

$$\kappa < \frac{2s + (1 + \delta^i)m}{s},$$

then country j's best response to δ^i is to maximally monetize, setting $\delta^j m = b_H$, so that a maximum monetization equilibrium obtains. ■

Consider next state $(\theta^A, \theta^B) = (\theta^L, \theta^H)$. We shall restrict attention to parameter values such that in the absence of any strategic considerations the low-productivity country (θ_L) is always better off partially monetizing its debt rather than defaulting on its debt. This is the case when the default-cost parameter ϕ satisfies the following condition.

Assumption A1: Efficiency of Partial Monetization in state (θ^L, θ^H):

$$\phi > \left(\frac{\theta_H + \theta_L}{\theta_L}\right)(\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{b_L - \overline{\tau} m}{2(s+m) + b_L - \overline{\tau} m)}\right).$$

Given that partial monetization is efficient, the low-productivity country will always engage in at least partial monetization to avoid default. The question, however, is whether the low-productivity country is also strategically better off engaging in maximum monetization.

The payoff functions for country $i = A, B$ in state $(\theta^A, \theta^B) = (\theta^L, \theta^H)$ are given by:

$$\Pi^i(\delta^i, \delta^j) = \left(\frac{\kappa s + m + \delta^i m}{2(s+m) + \delta^i m + \delta^j m}\right)(\theta_L + \theta_H). \tag{14}$$

Differentiating $\Pi^i(\delta^i, \delta^j)$ with respect to δ^i we observe that the welfare of country $i = A, B$ increases with δ^i (i.e. more monetization) if:

$$\kappa < \frac{2s + (1 + \delta^j)m}{s}.$$

We therefore obtain the following two lemmas characterizing the two countries' best responses in states (θ_L, θ_H) and (θ_H, θ_L).

Lemma 3: In states (θ_L, θ_H) and (θ_H, θ_L) the country hit by the low productivity shock (θ_L) prefers full to partial monetization, if

$$\kappa \leq \frac{2s + m}{s},$$

when the high-productivity country (θ_H) does not monetize its debt.

And when the high-productivity country fully monetizes its debt, the low-productivity country prefers full to partial monetization if

$$\kappa \leq \frac{2s + m + b_H}{s}.$$

Proof: The lemma immediately follows from differentiating the welfare functions $\Pi^i(\delta^i, \delta^j)$ with respect to δ^i and noting that when country A is hit by the low productivity shock (θ_L), and country B by the high productivity shock (θ_H), $\delta^B m = 0$ corresponds no monetization and $\delta^B m = b_H$ to maximum monetization by country B. ■

Lemma 4: In states (θ_L, θ_H) and (θ_H, θ_L), the high-productivity country best-responds by fully monetizing its debt if

$$\kappa \leq \frac{2s + m + b_L - \overline{\tau} m}{s},$$

when the low-productivity country only partially monetizes its debt.

And when the low-productivity country fully monetizes its debt, the high-productivity country best responds by fully monetizing its debt if

$$\kappa \leq \frac{2s + m + b_L}{s}.$$

Proof: Again, the lemma immediately follows from differentiating the welfare functions $\Pi^i(\delta^i, \delta^j)$ with respect to δ^i, and noting that when country A is hit by the low productivity shock (θ_L), $\delta^A m = b_L$ corresponds to full monetization, and $\delta^A m = b_L - \overline{\tau} m$ to partial monetization. ■

Finally, consider state (θ^L, θ^L). We shall again assume that each individual country is always better off partially monetizing its debt than defaulting on its debt.

Assumption A2: Efficiency of Partial Monetization in state (θ^L, θ^L):

$$\phi > (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{b_L - \overline{\tau} m}{s + m + b_L - \overline{\tau} m}\right).$$

The payoff functions for country $i = A, B$ in state (θ^L, θ^L) are given by:

$$\Pi^i(\delta^i, \delta^j) = \left(\frac{\kappa s + m + \delta^i m}{2(s + m) + \delta^i m + \delta^j m}\right) 2\theta_L. \tag{15}$$

Again, differentiating $\Pi^i(\delta^i, \delta^j)$ with respect to δ^i we find that the welfare of country i increases with δ^i if:

$$\kappa < \frac{2s + (1 + \delta^j)m}{s}.$$

The following lemma characterizing the two countries' best responses in state (θ_L, θ_L) immediately follows from this observation.

Lemma 5: In state (θ_L, θ_L), a necessary condition for the existence of a *partial monetization equilibrium* is

$$\kappa > \frac{2s + m + b_L - \overline{\tau}m}{s};$$

and a necessary condition for the existence of a *maximum monetization equilibrium* is

$$\kappa \leq \frac{2s + m + b_L}{s}.$$

Proof: If

$$\kappa > \frac{2s + (1 + \delta^i)m}{s}$$

for $i = A, B$ then country j is better off minimizing its debt monetization, and neither country would have any incentive to monetize beyond $\delta^i m = b_L - \overline{\tau}m$.

If

$$\kappa \leq \frac{2s + (1 + \delta^i)m}{s},$$

then country j's best response to δ^i is maximum monetization. The second condition in the lemma immediately follows from this observation. ■

Putting together the characterizations in the lemmas above, we obtain the following proposition describing the set of (pure-strategy) subgame-perfect equilibria of the debt-monetization game between the two countries.

Proposition 1: Subgame-Perfect Nash equilibria.

1. In state (θ_H, θ_H) two pure strategy equilibria coexist when $\frac{2s+m+b_H}{s} \geq \kappa \geq \frac{2s+m}{s}$, one is a *no monetization equilibrium* and the other is a *maximum mon-*

etization equilibrium. When $\kappa < \frac{2s+m}{s}$ there is a unique *maximum monetization equilibrium*, and when $\kappa > \frac{2s+m+b_H}{s}$ there is a unique *no monetization equilibrium*.

2. In states (θ_L, θ_H) and (θ_H, θ_L) two pure-strategy coexist when $\frac{2s+m+b_H}{s} \geq \kappa \geq \frac{2s+m+b_L-\overline{\tau}m}{s}$, in one equilibrium the low-productivity country *partially monetizes* its debt and the high-productivity country does *not monetize its debt*; in the other equilibrium both countries engage in *maximum debt monetization*.[8] When $\kappa > \frac{2s+m+b_H}{s}$ a unique pure strategy equilibrium exists, which involves *partial monetization* by the low-productivity country and *no monetization* by the high productivity country. When $\kappa < \frac{2s+m+b_L-\overline{\tau}m}{s}$, the unique pure strategy equilibrium is such that both countries engage in *maximum debt monetization*.

3. In state (θ_L, θ_L) there is a unique pure strategy equilibrium: a *partial monetization equilibrium* when $\kappa > \frac{2s+m+b_L}{s}$, and a *maximum monetization equilibrium* when $\kappa \leq \frac{2s+m+b_L}{s}$.

Proof: The existence of these equilibria follows immediately from lemmas 2 to 5. ■

Compared with the situation faced by a country in economic isolation, proposition 1 illustrates that countries have stronger incentives to monetize their debts when their economies are integrated but exchange rates underreact. The reason is that monetization provides an additional benefit besides avoiding a costly default. It gives the workers of the monetizing country greater purchasing power to acquire foreign goods. Accordingly, in state (θ_H, θ_H) a maximum monetization equilibrium may obtain in an integrated economy whereas under economic isolation a country would not chose to monetize its debt. Similarly, in states (θ_L, θ_H), (θ_H, θ_L)

[8] This range equilibrium outcomes obtains if $b_H > b_L - \overline{\tau}m$.

and (θ_L, θ_L) an equilibrium with maximum debt monetization may obtain, when only partial monetization in the low productivity country is needed to avoid default. We highlight these central results about inefficient monetization under monetary sovereignty in the proposition below.

Proposition 2: Inefficient monetization. Under condition

$$\frac{2s+m+b_H}{s} > \kappa > \frac{2s+m}{s},$$

the international monetary equilibrium may involve excessive monetization.

1. In state (θ_H, θ_H) there is inefficient monetization in the *maximum monetization* equilibrium. Monetization is not required and is not desirable if $\kappa > \frac{2s+m}{s}$.

2. In states (θ_L, θ_H) and (θ_H, θ_L) only *partial monetization* in the low-productivity country is necessary. Any additional monetization is not desirable for either countries.

3. In state (θ_L, θ_L) only *partial monetization* is each country is required, but the unique equilibrium involves *maximum monetization* whenever $\kappa \leq \frac{2s+m+b_L}{s}$.

Proof: Obvious. ■

Propositions 1 and 2 capture in a succinct way the breakdown of international monetary neutrality when exchange rates do not instantaneously respond to changes in relative money supply. In the presence of such exchange-rate stickiness competition in money supply by independent countries will generally result in inefficient outcomes, with excess supply of money and inflation, as envisioned by Friedman but contrary to Hayek's predictions. In other words, the reconciliation between Hayek and Friedman regarding the free competition or the state monopoly in money supply lies in the view one takes of foreign exchange markets. If these markets are deemed

to be perfectly flexible and efficient then Hayek's prediction may prevail, but if there is any stickiness in the exchange rate then Friedman's fears of excess money supply and inflation may materialize.

We conclude this section by stating the equilibrium payoffs under monetary sovereignty.

Proposition 3. Welfare payoffs under monetary sovereignty: Under condition

$$\frac{2s+m+b_H}{s} > \kappa > \frac{2s+m}{s},$$

1. In state (θ_H, θ_H) each country's welfare payoff in the *no monetization equilibrium* and the *maximum monetization equilibrium* are respectively:

$$\theta_H \left(\frac{\kappa s + m}{s+m} \right) \text{ and } \theta_H \left(\frac{\kappa s + m + b_H}{s+m+b_H} \right).$$

2. In state (θ_L, θ_H) the payoffs of respectively country A and B in the *maximum monetization* equilibrium are:

$$(\theta_L + \theta_H) \left(\frac{m + \kappa s + b_L}{2(s+m) + b_L + b_H} \right) \text{ and } (\theta_L + \theta_H) \left(\frac{m + \kappa s + b_H}{2(s+m) + b_L + b_H} \right).$$

   And in the respectively *partial and no monetization* equilibrium for country A and B, they are:

$$(\theta_L + \theta_H) \left(\frac{m + \kappa s + b_L - \overline{\tau} m}{2(s+m) + b_L - \overline{\tau} m} \right) \text{ and } (\theta_L + \theta_H) \left(\frac{m + \kappa s}{2(s+m) + b_L - \overline{\tau} m} \right).$$

3. In state (θ_H, θ_L) for country A and B the respective country payoffs are the same as in state (θ_L, θ_H) but with the superscripts A and B interchanged.

4. In state (θ_L, θ_L) each country's welfare payoff under *partial monetization* and *maximum monetization* are respectively:

$$\theta_L \left(\frac{\kappa s + m + b_L - \overline{\tau} m}{s + m + b_L - \overline{\tau} m} \right) \text{ and } \theta_L \left(\frac{\kappa s + m + b_L}{s + m + b_L} \right).$$

5 Monetary Union

Under a monetary union there is a single currency, a single central bank, but there are two separate fiscal authorities, one in each country. The objective function of the fiscal authorities is as before to maximize the welfare of the country's residents. We assume in this section that the single central bank's objective is to maintain price stability and to avoid any debt monetization. For simplicity, we take the two countries to be symmetric and their output shocks to be independently distributed.

5.1 Welfare payoffs under a monetary union

Under a monetary union each country's fiscal authority issues debt denominated in the union's single currency. Without a fiscal union each country's debt can only be serviced out of the country's tax receipts. We assume for now that there are no fiscal transfers from one country to the other, as is the case under the European monetary union.

Following monetary unification at $t = 0$ savers and workers in each country have an endowment of the common currency of respectively s_u and m_u. Otherwise the model is as before. Each country simultaneously produces a public good g_i by issuing debt denominated in the common currency (b_u^H, b_u^L) and workers in each country supply labor $(l - g) = 1$ to produce private goods θ_{if}, where $i = A, B$ and $f = L, H$. In period 1 each country's fiscal authority taxes income to raise funds towards the repayment of b_u^i. Then households use their after-tax nominal income to purchase final output. The final output market is a single market with price p_u^j, where $j = LL, LH, HL, HH$.

Consider first the state of the world HH. Total output in the union is then $2\theta_H$. Workers' budget constraint is

$$m_u(1 - \tau_i) + b_u^H \geq p_{HH} x_{HH}^i,$$

where p_{HH} is the single price of the consumption good in the union and x_{HH}^i is the

quantity of goods purchased by the workers in country $i = A, B$. Savers' budget constraint is

$$s_u \geq p_{HH} z^i_{HH},$$

where z^i_{HH} is the quantity of goods purchased by savers in country i.

The fiscal authority in each country sets the tax rate τ_i such that the country's government budget constraint balances:

$$m_u \tau_i = b^H_u.$$

Replacing b^H_u in the workers' budget constraints we then get

$$m_u \geq p_{HH} x^i_{HH},$$

so that in equilibrium

$$x^i_{HH} = \frac{m_u}{p_{HH}} \text{ and } z^i_{HH} = \frac{s_u}{p_{HH}}.$$

Market clearing requires that

$$\frac{2(m_u + s_u)}{2\theta_H} = p_{HH},$$

so that

$$x^i_{HH} = \left(\frac{m_u}{m_u + s_u}\right)\theta_H;\ z^i_{HH} = \left(\frac{s_u}{m_u + s_u}\right)\theta_H.$$

Consider next state LH, in which the government of the country with output θ_L is unable to service the debt out of maximum tax receipts $\bar{\tau} m_u$. Unable to rely on any monetization of this debt by the union's central bank, the government of this country has no choice but to default on its debt obligations.[9]

In the event of default, country A simply cancels all debts owed b^A_u and therefore does not levy any taxes. By cancelling all debts owed the country incurs a dead-weight cost $\phi\theta_L$. The workers' budget constraint in the country in default (country

[9]The low output state could also be interpreted as leading to no default but instead to a debt overhang problem with associated costs $\phi\theta_L$.

A) is then

$$m_u \geq p_{LH} x^A_{LH},$$

where p_{LH} is the single price of the consumption good in the union and x^A_{LH} is the quantity of goods purchased by the workers in the defaulting country. Savers' budget constraint in the defaulting country is

$$s_u \geq p_{LH} z^A_{LH},$$

where z^A_{LH} is the quantity of goods purchased by savers in that country.

The fiscal authority in the rich country (country B) sets the tax rate τ_B such that the country's government budget constraint balances:

$$m_u \tau_B = b^H_u.$$

Replacing b^H_u in the workers' budget constraints for country B we then get

$$m_u \geq p_{LH} x^B_{LH},$$

so that in equilibrium

$$x^A_{LH} = \frac{m_u}{p_{LH}};\ z^A_{LH} = \frac{s_u}{p_{LH}} \text{ and } x^B_{LH} = \frac{m_u}{p_{LH}};\ z^B_{LH} = \frac{s_u}{p_{LH}}.$$

Finally, market clearing requires that

$$\frac{2(m_u + s_u)}{\theta_H + (1-\phi)\theta_L} = p_{LH},$$

so that

$$x^A_{LH} = \frac{m_u(\theta_H + (1-\phi)\theta_L)}{2(m_u + s_u)}\ ;\ z^A_{LH} = \frac{s_u(\theta_H + (1-\phi)\theta_L)}{2(m_u + s_u)},$$

$$x^B_{LH} = \frac{m_u(\theta_H + (1-\phi)\theta_L)}{2(m_u + s_u)};\ z^B_{LH} = \frac{s_u(\theta_H + (1-\phi)\theta_L)}{2(m_u + s_u)}.$$

Note that consumption is symmetric in both rich and poor country because defaulting on the debt is a form of repayment and because everyone in the union

is hurt by the lower output in the low-productivity country that is caused by the deadweight cost of default.

State HL is the symmetric version of state LH.

Consider finally state LL, where both countries have output θ_L and are unable to service their respective debts. Both countries then default and incur a deadweight cost $\phi\theta_L$. The workers' budget constraint in each country $i = A, B$ is then

$$m_u \geq p_{LL} x^i_{LL}.$$

Savers' budget constraint is

$$s_u \geq p_{LL} z^i_{LL},$$

so that in equilibrium

$$x^i_{LL} = \frac{m_u}{p_{LL}};\ z^i_{LL} = \frac{s_u}{p_{LL}}.$$

Market clearing requires that

$$\frac{2(m_u + s_u)}{2(1-\phi)\theta_L} = p_{LL}.$$

so that

$$x^i_{LL} = \frac{m_u(1-\phi)\theta_L}{m_u + s_u};\ z^i_{LL} = \frac{s_u(1-\phi)\theta_L}{m_u + s_u}.$$

We summarize this analysis in the following proposition.

Proposition 4. Welfare payoffs under monetary union: Assuming that output shocks are *i.i.d.*, total expected welfare for each member country under monetary union is:

$$\left(\frac{\kappa s_u + m_u}{s_u + m_u}\right)[\pi^2_H \theta_H + \pi_H \pi_L(\theta_H + (1-\phi)\theta_L) + \pi^2_L(1-\phi)\theta_L]. \qquad (16)$$

5.2 When is monetary union preferable?

Assuming that nothing else changes as a result of monetary union, we set $s_u = s$ and $m_u = m$. From an aggregate welfare perspective monetary union is preferable

if total welfare under monetary union is greater that total welfare under monetary sovereignty for each country.

Total welfare under monetary sovereignty depends on which equilibrium outcome obtains. The best possible outcome is the equilibrium where there is no monetization in state HH, and only partial monetization by countries experiencing low productivity in states LH, HL, and LL. This equilibrium obtains only if $\kappa > \frac{2s+m+b_L}{s}$, otherwise the unique equilibrium in state (θ_L, θ_L) involves maximum monetization.

The best possible outcome under monetary sovereignty cannot be improved upon by monetary union because partial monetization is preferable to a costly default in states LH, HL, and LL under assumptions A1 and A2. The outcome under monetary sovereignty is then efficient while the outcome under monetary union involves excessively costly default in these states.

Consider next the situation where

$$\frac{2s+m+b_L}{s} > \kappa > \frac{2s+m}{s}. \tag{17}$$

In this situation the unique equilibrium in state LL involves maximum monetization. Suppose furthermore that $\frac{2s+m+b_H}{s} \geq \kappa$, so that two possible equilibria obtain in states LH and HL. The best equilibrium under monetary sovereignty then involves no monetization in state HH, partial monetization by the low-productivity country in states LH and HL, and maximum monetization in state LL.

In that equilibrium total expected welfare for each country under monetary sovereignty is:

$$\pi_H^2 \theta_H \left(\frac{\kappa s + m}{s+m} \right) + \pi_H \pi_L (\theta_L + \theta_H) \left(\frac{2(\kappa s + m) + b_L - \overline{\tau} m}{2(s+m) + b_L - \overline{\tau} m} \right) + \pi_L^2 \theta_L \left(\frac{\kappa s + m + b_L}{s + m + b_L} \right). \tag{18}$$

Subtracting (18) from (16) we then obtain that monetary union is preferable if the welfare loss from joining a monetary union in states LH and HL is smaller

than the welfare gain in state LL:

$$\phi < (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{\pi_H(\theta_H + \theta_L)}{\theta_L}\frac{b_L - \overline{\tau}m}{2(s+m) + b_L - \overline{\tau}m} + \frac{\pi_L b_L}{s + m + b_L}\right). \tag{19}$$

There is a welfare loss from excess monetization in state LL if

$$\phi < (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\frac{b_L}{s + m + b_L}. \tag{20}$$

When π_L approaches 1, condition (19) becomes (20). In general, when conditions (17) and (20) hold, monetary union is preferable to monetary sovereignty when π_L, the probability of the low-productivity state, is high enough $\pi_L \geq \overline{\pi}_L$, where $\overline{\pi}_L$ is the solution to the equation

$$\phi = (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{\pi_H(\theta_H + \theta_L)}{\theta_L}\frac{b_L - \overline{\tau}m}{2(s+m) + b_L - \overline{\tau}m} + \frac{\overline{\pi}_L b_L}{s + m + b_L}\right). \tag{21}$$

Monetary union is then a guarantee against excess monetization in state LL.

Suppose next that

$$\frac{2s + m + b_L - \overline{\tau}m}{s} > \kappa > \frac{2s + m}{s}. \tag{22}$$

In this situation the unique equilibrium in states in states LH, HL and LL is maximum monetization and the total expected welfare for each country under monetary sovereignty is:

$$\pi_H^2\theta_H\left(\frac{\kappa s + m}{s + m}\right) + \pi_H\pi_L(\theta_L + \theta_H)\left(\frac{2(\kappa s + m) + b_L + b_H}{2(s+m) + b_L + b_H}\right) + \pi_L^2\theta_L\left(\frac{\kappa s + m + b_L}{s + m + b_L}\right). \tag{23}$$

Again subtracting (23) from (16) we obtain that monetary union is then preferable if:

$$\phi < (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{\pi_H(\theta_H + \theta_L)}{\theta_L}\frac{b_L + b_H}{2(s+m) + b_L + b_H} + \frac{\pi_L b_L}{s + m + b_L}\right). \tag{24}$$

Note that when π_L approaches 1 condition (24) becomes (20); also, condition (24) is much weaker than condition (19).

Monetary union is a guarantee against excess monetization in states LH, HL, and LL. The dark side of monetary union, however, is the cost of default in these states. Under condition (24) these default costs are smaller than the excess monetization costs.

Consider finally, the worst possible equilibrium under monetary sovereignty, in which there is maximum monetization in all states of nature. In this situation the total expected welfare for each country under monetary sovereignty is:

$$\pi_H^2\theta_H\left(\frac{\kappa s+m+b_H}{s+m+b_H}\right)+\pi_H\pi_L(\theta_L+\theta_H)\left(\frac{2(\kappa s+m)+b_L+b_H}{2(s+m)+b_L+b_H}\right)$$
$$+\pi_L^2\theta_L\left(\frac{\kappa s+m+b_L}{s+m+b_L}\right). \tag{25}$$

The condition for monetary union to be preferred is then even weaker than condition (24) , as an additional term is added to the right-hand side of (24):

$$\phi < (\kappa-1)\left(\frac{s}{\kappa s+m}\right)[\frac{\pi_H^2\theta_H}{\pi_L\theta_L}\frac{b_H}{s+m+b_H}+\frac{\pi_H(\theta_H+\theta_L)}{\theta_L}\frac{b_L+b_H}{2(s+m)+b_L+b_H}$$
$$+\frac{\pi_L b_L}{s+m+b_L}]. \tag{26}$$

Now monetary union is a guarantee against excess monetization in *all* states. However, the dark side of monetary union remains the cost of default in states LH, HL, and LL.

We summarize this analysis in the proposition below.

Proposition 5: Preference for monetary union. A simple monetary union without debt monetization or fiscal transfers is not necessarily preferable to monetary sovereignty. It is only preferred if the welfare costs from excess monetization exceed the default costs under monetary union.

1. If $\kappa > \frac{2s+m+b_L}{s}$ and the equilibrium under monetary sovereignty is such that there is no monetization in state HH, and only partial monetization by countries experiencing low productivity in states LH, HL, and LL, then monetary union is dominated by monetary sovereignty;

2. If $\frac{2s+m+b_H}{s} > \kappa > \frac{2s+m}{s}$, the unique equilibrium in state LL involves maximum monetization. If there is no monetization in state HH, and only partial monetization by countries experiencing low productivity in states LH and HL, then monetary union is preferable to monetary sovereignty if

$$\phi < (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{b_L}{s + m + b_L}\right), \tag{27}$$

and the probability of the low productivity state is high enough, $\pi_L \geq \overline{\pi}_L$, where $\overline{\pi}_L$ is the solution to equation (21). Monetary union is then a guarantee against excess monetization in state LL.

3. If $\frac{2s+m+b_L-\overline{\tau}m}{s} > \kappa > \frac{2s+m}{s}$ the unique equilibrium under monetary sovereignty in states in states LH, HL and LL involves maximum monetization. Monetary union is then preferred if:

$$\phi < (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{\pi_H(\theta_H + \theta_L)}{\theta_L}\frac{b_L + b_H}{2(s+m) + b_L + b_H} + \frac{\pi_L b_L}{s + m + b_L}\right); \tag{28}$$

4. Finally, if the equilibrium with maximum monetization obtains under monetary sovereignty in all states, then monetary union is preferred if:

$$\begin{aligned}\phi \quad < \quad & (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)[\frac{\pi_H^2 \theta_H}{\pi_L \theta_L}\frac{b_H}{s + m + b_H} + \frac{\pi_H(\theta_H + \theta_L)}{\theta_L}\frac{b_L + b_H}{2(s+m) + b_L + b_H} \\ & + \frac{\pi_L b_L}{s + m + b_L}].\end{aligned} \tag{29}$$

Proof: See the discussion above. ■

The tradeoff involved in forming a simple monetary union is that, while monetary union is a guarantee against excess monetization, it also has a dark side: debt default costs in states of the world where member countries cannot service their debt obligations out of their tax revenues. It might be argued that debt default costs could be avoided if there is sufficient fiscal discipline in each country and strict debt limits are enforced. However, such debt limits would come at the cost

of underinvestment in public goods. The dark side of monetary union would then just take a different form.

The next question we address is whether a monetary union could be improved by allowing for debt monetization instead of debt default, and/or by allowing for fiscal transfers from high-productivity to low-productivity member countries.

6 Debt Monetization and Fiscal Transfers in a Monetary Union

Consider first the alternative arrangement under monetary union whereby the central bank partially monetizes the debt of a member country with a low productivity shock θ_L so as to avoid a costly default.

Under this arrangement the total expected welfare for each member country is

$$\pi_H^2\theta_H\left(\frac{\kappa s+m}{s+m}\right)+\pi_H\pi_L(\theta_H+\theta_L)\left(\frac{2(\kappa s+m)+\delta m}{2(s+m)+\delta m}\right)$$
$$+\pi_L^2\theta_L\left(\frac{\kappa s+m(1+\delta)}{s+m(1+\delta)}\right), \tag{30}$$

where $\delta m = b_L - \overline{\tau} m$.

It is straightforward to verify that under assumptions A1 and A2, a monetary union with partial monetization is always preferable to a monetary union with no monetization (and debt default). This is not altogether surprising. If partial monetization is more efficient for the low-productivity country under monetary sovereignty then it must also be more efficient under a monetary union.

However, a more striking result is that fiscal transfers in states LH and HL are better than monetization and also better than debt default. Suppose that in states LH and HL the high productivity country has sufficient taxation capacity to close the gap in tax revenues to repay the debt b_L:

$$2m\overline{\tau} \geq b_L + b_H.$$

In that case the workers in the low-output country get after-tax income:

$$(1-\overline{\tau})m + b_L,$$

receiving a fiscal transfer of $(b_L - \overline{\tau}m)$ and the workers in the high output country get:

$$m(1-\tau_{LH}) + b_H,$$

where

$$\tau_{LH}m = b_H + b_L - \overline{\tau}m.$$

So that, the workers in the high-output country get after-tax income

$$m - (b_L - \overline{\tau}m).$$

When productivity shocks are *i.i.d.* workers in the union are equally likely to be in either state LH or HL, so that the expected net fiscal transfer for workers in each country is zero and the expected consumption for workers in states HL and LH is

$$(\theta_H + \theta_L)\frac{m}{s+m}.$$

Consider first a monetary union with fiscal transfers but no debt monetization. The welfare payoff of each country is then:

$$\left(\frac{\kappa s + m}{s+m}\right)[\pi_H^2\theta_H + \pi_H\pi_L(\theta_H+\theta_L) + \pi_L^2(1-\phi)\theta_L]. \tag{31}$$

Comparing the payoff (31) to the payoff under monetary sovereignty (18) (in the equilibrium where there is maximum monetization in state LL, but partial monetization in states LH and HL), we find that each country then gains by joining such a monetary union, if

$$\begin{aligned}\phi \quad < \quad & (\kappa-1)\left(\frac{s}{\kappa s+m}\right)[\frac{\pi_H(\theta_H+\theta_L)}{\theta_L}\frac{b_L-\overline{\tau}m}{2(s+m)+b_L-\overline{\tau}m} \\ & + \frac{\pi_L b_L}{s+m+b_L}]. \end{aligned} \tag{32}$$

Note that condition (32) always holds when $\pi_H \longrightarrow 1$. Thus, consider the opposite situation where $\pi_H \longrightarrow 0$ (and $\pi_L \longrightarrow 1$). In this case condition (32) reduces to

$$\phi < (\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{b_L}{s + m + b_L}\right).$$

We summarize this analysis in the following proposition.

Proposition 6: Monetary union with fiscal transfers and no monetization. A monetary union with fiscal transfers but without debt monetization is preferred to monetary sovereignty when

$$\frac{2s + m + b_L}{s} > \kappa > \frac{2s + m}{s},$$

and

$$(\kappa - 1)\left(\frac{s}{\kappa s + m}\right)\left(\frac{b_L}{s + m + b_L}\right) > \phi.$$

Proof: See the discussion above. ■

Finally, note that a monetary union with fiscal transfers and partial debt monetization only in state LL always dominates monetary sovereignty:

$$2\pi_H \pi_L(\theta_H + \theta_L)\left(\frac{\kappa s + m}{s + m} - \frac{2(\kappa s + m) + b_L - \overline{\tau} m}{2(s + m) + b_L - \overline{\tau} m}\right) > 0.$$

Proposition 7: Monetary union with fiscal transfers and debt monetization. Combining a monetary union with fiscal transfers and partial debt monetization always generates greater efficiency than monetary sovereignty.

Proof: See the discussion above. ■

In sum, whether a monetary union is desirable ultimately depends on how bad the excess monetization is under monetary sovereignty on the one hand, and on how the monetary union is organized on the other. However, the best possible arrangement is always a monetary union with fiscal transfers and the option of debt monetization to avoid a costly debt default.

This is not altogether surprising since we have not introduced any political or incentive considerations into the model that might introduce inefficiencies into a full

fiscal and monetary union. One may be concerned, in particular, that fiscal transfers and debt monetization could result in a moral-hazard-in-sovereign-debt problem. If debt is always serviced then why not borrow more? Especially if the servicing costs are shared between the member countries.

The presence of such a moral-hazard-in-borrowing problem may be the reason why a fiscal union could be superior to simple fiscal transfers. A fiscal union would result in a transfer of authority to set aggregate spending and borrowing limits in each member country by a supranational agency, preferably an independent fiscal agency, with a similar appointment process as the central bank of the union (see Maskin, 2016). Moral hazard considerations may also be foremost among the central bank's concerns and may explain why it may only envisage debt monetization interventions in extreme and exigent circumstances. An important general observation, however, is that the pressure to monetize is alleviated if fiscal transfers are available to prevent a debt crisis.

7 Historical Perspective

Our theory of optimal currency areas and the costs and benefits of relinquishing monetary sovereignty is motivated not only by the precedent of the creation of the Euro, but also by the history of US monetary unification, the creation and collapse of the Bretton Woods system after World War II, and other examples of currency areas. Here we briefly discuss the main lessons we draw from these historical examples in the light of our model.

7.1 The Protracted Struggle towards US Monetary Unification

The prominent analysis of monetary history of the United States by Friedman and Schwartz (1963) begins shortly after the American Civil War ended, when the US had essentially completed monetary unification. Unlike the creation of the Euro,

US monetary unification was not the outcome of voluntary surrender of monetary sovereignty by all member states. Instead, the dollar was imposed on Confederate states following their defeat. During the civil war each side issued its own currency, the 'greenback' for the Union states, and the 'grayback' for the Confederate states.

Although the examples of American and European monetary unification could not be more different, both ultimately were products of conflict. In America, the process of monetary unification began with the American revolutionary war, during which the Continental Congress of the newly independent states issued paper money to finance the war of independence, the so-called *continentals*. Interestingly, as Murphy (2017) argues, the issuance of fiat money was seen as the least costly way of financing the war:

> "Because the Americans were unable to raise enough revenue from borrowing or direct taxation, their remaining option was to issue paper money, which functioned both as a type of borrowing against the nation's citizens and as an indirect tax on those citizens." [page 21, Murphy, 2017]

Continentals were issued against promised tax revenues from the member states, as the federal government had no right to raise taxes under the Articles of Confederation. The states' reluctance to give up sovereignty to the federal government, however, was fatal to the continental dollar, which eventually was devalued by Congress in 1781 to 2.5 cents of specie.

The next attempt at monetary unification came with the creation by Congress of the first Bank of the United States in 1791. There was strong opposition by some states to the creation of this bank, so much so that it was only granted a twenty year charter. The states essentially were opposed to the creation, or transfer, of monetary sovereignty to a federal entity. Despite the success of the bank, opposition remained so strong that it was abolished when its charter expired in 1811 (see Gordon, 1997

and Murphy, 2017).

It is again the challenge of financing a war effort that led to the subsequent federal monetary initiative, with the creation of the second Bank of the United States in 1816. Although the creation of the second bank met with less opposition, the non-renewal of its twenty-year charter in 1836 was caused, among other issues, by widespread resentment over the perceived encroachment of state sovereignty by the federally chartered bank. The other prominent concern was over the use of paper money more generally and the financial panics associated with fractional reserve banking.

As alluded to above, the civil war effort led to each side issuing its own fiat currency. The Confederate states, in particular, faced the major obstacle of issuing currency that would be accepted as a means of payment given that in the event of defeat the grayback could become worthless. Even though the Confederacy only printed a limited amount of graybacks, hyperinflation resulted towards the end of the war:

> "By the end of the war, prices were ninety-two times higher than they were at the start; a $1 item in 1860 cost $92 in 1865. The discounts on graybacks were not just the result of too much paper money. Markets were also responding to military victories and defeats. Whenever the South suffered a major military setback, such as at Antietam in 1862 or Gettysburg in 1863, the grayback experienced a sudden depreciation in value. It declined 15% after Antietam...and 20% after Gettysburg. Conversely, when Confederate General Robert E. Lee temporarily stopped the Union advance on Richmond, Virginia, in April 1864, the grayback market stabilized and the southern economy experienced little inflation until the end of the summer." [page 143, Murphy, 2017]

This admittedly succinct account of American monetary unification still contains

several important observations for monetary economics and for the theory of optimal currency areas. First, fiat money has important attributes in common with corporate equity, as we emphasized in Bolton and Huang (2018a). Its value rises and falls in proportion with the strength of the issuer. Second, when a large expenditure is required, such as a war effort, its financing may be best accomplished through fiat money issuance, just as a major capital expenditure for a firm is often best met with an equity offering. Third, the question of optimal currency areas is closely tied to the issue of monetary sovereignty. It is not predominantly tied with trade and factor mobility, as Mundell's (1961) theory suggests, but rather with sovereignty and the reach of the state. Fourth, the sustainability of a monetary union critically depends on the power of the federal authorities. If the fiscal and monetary powers of the union are extremely limited, then there is little to keep the union together and to back the common currency.

7.2 Collapse of the Gold Standard and Competitive Devaluations

An alternative way of realizing an optimal currency area $\grave{a}$ la Mundell is to fix the exchange rate to gold. Indeed, the *gold standard* was often the preferred monetary regime of industrialized nations for prolonged periods of time up to the great depression. Besides reducing trade transaction costs the gold standard was also seen as providing a commitment to low inflation. However, two main drawbacks are associated with the gold standard. First, the strict limits it imposes on money supply growth may severely constrain growth of economic activity. Indeed, in the aftermath of a financial crisis the gold standard tends to magnify and perpetuate deflationary pressures. Second, major one-time expenditures such as a war effort could only be financed with great difficulty under a gold standard. This is why, as highlighted above, the United States went repeatedly off the gold standard. The gold standard, in effect, was an optimal currency area with an opt-out in times of

exigency. It preserved monetary sovereignty when it matters most.

Just as with the financial panics of the 1830s, the *great depression* also led to a general collapse of the gold standard: Britain, Germany, and Austria abandoned the gold standard in 1931, the US in 1933, and eventually France in 1936. By then international trade had significantly subsided. According to Eichengreen and Irwin (1995),

> "As late as 1938, trade volume was still barely 90 percent of 1929 despite the complete recovery of global production of primary products and manufactured goods." [page 2, Eichengreen and Irwin, 1995]

A common perception is that this collapse in trade is somehow associated with currency wars, and the competitive devaluations that have been unleashed by the breakdown of the gold standard (Nurkse, 1944, and Kindleberger, 1973). The basic logic behind this argument is that when a country devalues it gains a competitive advantage because its production costs as expressed in the other currencies are lower. The devaluing country can then gain new markets and increase economic activity at the expense of the other countries. But this is a short-lived gain because other countries will respond by devaluing their currencies in turn (Keynes, 1923). Somehow these tit-for-tat devaluations are supposed to end up hurting trade and economic activity although exactly how is not entirely clear.[10]

We have not introduced the possibility of competitive devaluations into our model because of the added complexity of the analysis. To allow for competitive devaluations we would have to introduce nominal rigidities in wages and the possibility of unemployment. A negative productivity shock would then cause unemployment, which could be reduced through debt monetization and devaluation. How the devaluation affects the other country, however, is not entirely obvious. Nor is the other country's best response. It is not clear that without a monetary union

[10] See Plantin and Shin, 2016, for an insightul analysis on this issue.

there would necessarily be a monetization externality taking the form of competitive devaluations. The reason is that the increased activity generated by the reduced unemployment in the devaluing country may actually benefit the other country. Indeed, in a rather different model than ours, Eichengreen and Sachs (1986) have pointed out that competitive devaluations may increase output in all countries. In addition, Eichengreen and Irwin (1995) have found little evidence that successive devaluations following the breakdown of the gold standard have directly harmed trade. Nevertheless, the perception that the collapse of international trade following the great depression was amplified by competitive devaluations is one reason why the victorious (Western) Allies of World War II sought a return to fixed exchange rates under the Bretton Woods system after the war.

7.3 The Bretton Woods System and the return of a Quasi Gold Standard

The Bretton Woods system was yet another attempt at establishing some form of optimal currency area. In some ways it was a much more ambitious project than a simple gold standard and in other ways it allowed for more flexibility. Its ambition was to establish a new world financial order around fixed exchange rates, with the US dollar playing the role of reserve currency, through a quasi gold standard with the US tying the US dollar to gold at $35 an ounce.

It was a more flexible system because, unlike a gold standard, other countries' exchange rates could be adjusted to reflect trade imbalances. In addition, member countries could impose capital controls when faced with an exchange rate crisis. The Bretton Woods system also established the International Monetary Fund (IMF), a multilateral agency charged with monitoring member countries' economic policies (through Article IV surveillance) so as to ensure their consistency with the fixed exchange rates. The IMF could also provide funding to finance temporary shortages in foreign exchange reserves.

From its inception the Bretton Woods negotiators had to confront the inconvenient issue of monetary sovereignty. The ambitious British proposal, conceived by John Maynard Keynes, was to create a world reserve currency, the *bancor*, issued by a world central bank. The *bancor*, if issued, could have facilitated exchange rate adjustments to correct trade imbalances, according to Keynes. But it was never conceived as truly fiat money; in particular, debt monetization was ruled out under Keynes's plan.

As the sole superpower by the end of WW II, the US was naturally unwilling to surrender its monetary sovereignty to a supranational monetary authority. Under the system favored by the US, which was eventually adopted, the authority of the IMF was significantly curtailed and the supremacy of the US dollar as the world's reserve currency was affirmed (see Eichengreen, 1996).

The Bretton Woods system survived as long as the benefits for its main member country, the United States, exceeded the costs. The US initially benefitted from the dollar's reserve asset status and from the strong global economic recovery that was rooted in and supported by the new system. But, when the total supply of dollars reached the point where the sustainability of the $35 per ounce of gold rate was being questioned, the costs of the US commitment to the gold anchor became increasingly apparent. Triffin (1960) was the first to identify a basic *dilemma* faced by the US as the sole supplier of reserve assets: To meet the rising global demand for such assets when world economic activity expanded, the US had to supply more dollars and run current account deficits. But the increase in the supply of dollars and current account deficits cut into the US ability to maintain its gold reserves. Indeed, from 1945 to 1973, the total fraction of global gold reserves held by the US declined from 63 percent to 23 percent. When the constraints imposed by the fixed gold exchange rate also began to hamper the US ability to fund the Vietnam War effort through fiat money issuancethe US decided to abandon the gold standard in 1971, which then led to the demise of the Bretton Woods system in 1973.

7.4 From the Collapse of Bretton Woods to the advent of the Euro

The collapse of the Bretton Woods system created a new challenge for the European Union: how to reconcile exchange rate movements with the idea of a single market. Of course, if exchange rates are perfectly flexible, as Hayek surmised, there is no inconsistency between a single market and floating exchange rates. But this was not the perception of the members of the European Union, who saw the potential of larger exchange rate movements within the European Union post Bretton Woods as an existential threat to the single market.

Accordingly, the European Union quickly sought to implement a system of jointly managed exchange rates, first under the monetary snake, and later under the exchange rate mechanism (ERM) (see James, 2012). The monetary snake did not withstand the oil price shock of 1973. It did not prevent multiple unilateral devaluations by Italy and France and it ultimately failed to provide adequate exchange rate stability, so that the snake arrangement was abandoned by the end of 1978. Confronted with a major adverse macroeconomic shock, Italy and France exercised their monetary sovereignty by, in effect, monetizing the oil price shock. But, this strategic monetization resulted in a jump in their current account deficits and came at the expense of other members of the European Union. Moreover, it fuelled risky inflationary expectations. Therefore, implementing some form of exchange rate stability remained a major goal to sustain deeper European economic integration.

Following protracted negotiations, a more ambitious and constraining exchange rate arrangement–the ERM–was eventually introduced in 1979. As with the snake, it proved to be a short-lived experiment. Indeed, the collapse of the Soviet Union and the reunification of Germany in 1990 exacerbated growing economic imbalances within the European Union, which in due course led Italy, and shortly thereafter the UK, to exit the ERM in 1992.

Ironically, what caused the demise of the ERM is also what created new political conditions in France and Germany that made a full monetary union politically possible: France was willing to abandon monetary sovereignty in an effort to restrain a resurgent reunified Germany. And Germany was willing to join a monetary union that would be sculpted on German monetary dogma, with the European Central Bank headquartered in Frankfurt.

Importantly for our analysis, the boundaries of the Euro zone were not determined by economic boundaries within which there was greater factor mobility, as Mundell's theory would predict. Such economic boundaries would encompass the UK, Denmark, Sweden and Switzerland. But these countries remain outside because they are not prepared to give up their monetary sovereignty.

7.5 Currency Boards and other forms of Monetary Union

Multiple other attempts at creating some form of currency area have been tried, especially currency boards. A currency board is a unilateral commitment by a country to fix the exchange rate of its currency to an international reserve currency or basket of currencies. By doing so, the country adopting a currency board essentially surrenders its monetary sovereignty. We briefly discuss two currency board experiments and one recent effort to form a monetary union among six Gulf states, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

Argentina introduced such a currency board in 1991 by unequivocally fixing the exchange rate of the Argentine peso into the US dollar and promising full convertibility of the peso into dollars at that rate. The goal of the currency board was to provide a commitment against inflation by imposing a strict nominal anchor. The currency board experiment ended in a calamitous financial crisis in 2002, when it became clear that Argentina could not maintain its exchange rate and full convertibility without continued financial support from the IMF. As with other past episodes of abandonment of a fixed exchange rate, the primary cause was an adverse

term-of-trade shock caused by the Asian and Russian financial crisis of 1997-1998. The political pressure to dampen the economic cost of this shock through some form of monetization proved too strong to credibly maintain the currency board arrangement. When Argentina's foreign exchange reserves dwindled it turned to the IMF for support. But, the support the IMF granted only delayed the inevitable.

Hong Kong has had greater success with its currency board. Its credibility was severely tested during the Asian financial crisis, but thanks to some unconventional policy interventions by the Hong Kong Monetary Authority and the backing from China it survived the massive attack of its fixed exchange rate.[11] The Hong Kong currency board continues to this day and has firmly established the reputation of its sustainability. Nevertheless, the currency board has not been without cost. The strict limits it imposes on monetary sovereignty have hampered the economic expansion of Hong Kong, as a comparison with the economic performance of Singapore– which does not have a currency board– illustrates. During and immediately after the Asian financial crisis, Hong Kong clearly suffered a more severe deflation and weaker economic recovery than Singapore over the same period: In 1996 GDP per capita in Hong Kong was about 120% that of Singapore; twenty years later it is the reverse, Singapore's GDP-per-capita is about 120% of Hong Kong's.

Finally, it is worth mentioning the difficulties encountered by the six Gulf states forming the Gulf Cooperation Council (GCC) in completing their planned monetary union announced in 2009. A major sticking point in the completion of the monetary union was, not surprisingly, the transfer of monetary sovereignty it implied and the strict debt limits included in the agreement. Both Oman and the UAE have pulled out of the planned monetary union for fear of giving up too much sovereignty and further affirming the dominant position of Saudi Arabia (see Pinto, 2018).

[11] See Goodhart and Dai, 2003, for an insightful discussion on this episode and McKinnon, 2000, for a more general discussion of problems in the East Asian dollar standard.

8 Conclusion

By extending the one-country framework in Bolton and Huang (2018a) to two countries, we have been able to develop a theory of Optimum Currency Areas based on monetary sovereignty. Mundell's (1961) classical OCA theory, which provides the intellectual foundation behind the formation of the euro-area in 1999 and the creation of the European Central Bank (ECB), does not consider monetary sovereignty and mostly focuses on the trade benefits of a single currency. The Euro-area sovereign debt crisis of 2010-2013 triggered by the 2008 global financial crisis, however, has revealed the importance of this gap in Mundell's theory.

We argue that there is an important tradeoff involved in joining a monetary union: the monetary discipline of the single currency and the elimination of strategic monetary expansions comes at the opportunity cost of the option value imbedded in a nation's monetary sovereignty. We further show that a monetary union is best combined with a fiscal union, which allows for fiscal transfers to help a member-country in a crisis deal with its debt-servicing burden. In addition, debt monetization remains desirable in a monetary union in the state of the world where both member-countries simultaneously face an economic crisis. Our model provides a coherent analytical framework that helps shed light on the recent history of OCAs, from the adoption of the gold standard to its collapse, the birth and collapse of the Bretton Woods system, the examples of modern currency board systems, and the ongoing debates on how to reform the Euro system.

Why is money so closely tied to sovereignty? We argue in our theory of the capital structure of Nations in Bolton and Huang (2018a) that, just as with corporations, for which the value of the option to issue new shares is intimately tied to the value of ownership, the value of monetary sovereignty is the value of the option to finance through "the printing press" in times of economic or political exigency. A gold standard, like a monetary union, is tantamount to giving up monetary

sovereignty. The originally envisaged monetary union by Mundell (1961), however, is like a currency snake with no bandwidth (Bolton and Huang, 2018b). But, monetary sovereignty is not forsaken indefinitely under a gold standard, as the history of US monetary unification illustrates. When the US was confronted with a major war effort or persistent deflation it abandoned the gold standard.

But there is a downside to monetary sovereignty in a multi-country integrated economy. The monetary history of the European Union up to the creation of the Euro plainly illustrates the problem of multiple currencies in an economically integrated union: a member country may be tempted to respond to an adverse economic shock by printing more money, thereby partially "exporting" the negative shock to other member countries.

The sovereignty attribute of fiat money is an additional non-trivial attribute to the three other attributes of money traditionally emphasized. It is the requirement to pay taxes with fiat money that is unique and directly tied to sovereignty. Again, as the monetary history during the US civil war reveals, the value of fiat money is directly tied to the demand for fiat money to honor tax obligations. What is typically seen by monetary economists as a quick fix, a trick to motivate the value of money in a finite-horizon competitive economy, namely the need to pay taxes with fiat money (as initially suggested by Frank Hahn, 1965, and further analyzed in Hahn, 1982), we argue is a defining feature of fiat money. The requirement to use fiat money for tax purposes is also what separates cryptocurrencies from fiat money. Cryptocurrencies may be substitutes for species but cannot be substitutes for fiat money.

Sovereignty is tied to the protection of property rights, but unlike in economic theory (Coase, 1960, and Grossman and Hart, 1986) where property rights are exogenously given and enforced, a nation must ultimately rely on itself to defend its sovereignty. The strength of a nation's sovereignty is linked to its ability to finance defense and other public good efforts when needed, and vice-versa the value

of fiat money is linked to the sovereign's ability to enforce tax payments. This basic observation offers a new angle on hyperinflation. The classic economic explanation of hyperinflation is that it is exclusively a monetary phenomenon. Hyperinflation is caused by a potentially unlimited increase in money supply (Cagan, 1956, Sargent and Wallace, 1973, Malmendier and Nagel, 2016). However, hyperinflation can also occur without any major changes in money supply as a result of a collapse in sovereignty, as was the case with the value of graybacks towards the end of the US civil war.

We focus our analysis on exchange-rate underreaction in this paper. The case of exchange-rate overreaction is also interesting, whereby an increase in money supply in one country overly devalues its currency and boosts its exports, while increasing the purchasing power of residents of the importing foreign country. This may give rise to familiar trade tensions between an emerging economy and its advanced economy counterpart, such as those seen between Japan and the US from the 1970s to the 1990s.

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