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Currency substitution, seigniorage, and currency crises in interdependent economies

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This paper applies a two-country framework that allows for currency substitution in an environment in which policymakers optimally vary interest rates in light of utility-based objectives, one country pegs the value of its currency to the other nation's currency, and government revenue is generated via explicit taxes and seigniorage. The analysis illustrates the roles that currency substitution, currency preferences, and efficiency of tax systems play in contributing to the likelihood of a "run" on one nation's currency. We explore how these factors interact to influence the probability of a currency crisis in the country that fixes its exchange rate.

1. Introduction

Recent crises in Mexico, East Asia, Russia, Brazil, and Argentina have spurred a renewed interest in understanding the sources of currency crises. As a result, an already large literature has expanded further within the past few years. Most research on currency crises have examined variants of two families of theoretical models of speculative attacks. One strand of the literature emphasizes, how inconsistencies between a nation's economic fundamentals and its exchange-rate target can engender a run on its currency. Another strand focuses on the potential role of self-fulfilling anticipations that can induce crises even when underlying fundamentals are consistent with a pegged exchange rate.

Thus far, surprisingly little attention has been given to the role of international interdependence as a factor influencing the likelihood of currency crises (one noteworthy exception to this is the World Bank, 2000). This paper develops one approach to addressing this issue. We explore how currency substitution, monetary policy (via settings of interest rates), and fiscal policy (through taxation) can produce an environment in which there is a general unwillingness by foreign and/or domestic residents to hold a nation's currency, creating a more fertile environment for a potential "run" on its nation's currency. Because of the importance that pegged exchange rates played in the recent financial crises, our analysis centers on a regime of fixed exchange rates. We thereby examine factors, in addition to those already identified in the literature, that may contribute to an increase in the likelihood of a currency crisis.

In addition to the slight attention paid to the role of interdependence as a factor influencing the likelihood of a currency crisis, there have been relatively few recent studies of

currency substitution. Most of these use money demand formulations to estimate degrees of currency substitution for nations within selected regions of the world (see Mizen & Pentecost, 1996, for more detailed discussions). As Giovannini and Turtelboom (1992) indicate, these and other approaches to measuring the extent of currency substitution suffer from a number of conceptual and data problems. Nevertheless, because currency substitution affects real money demand, it necessarily influences a nation's susceptibility to currency crises. Studies of currency substitution in Latin American nations that historically have been prone to such events, such as Canto and Nickelsburg (1987), typically conclude that there is evidence of a significant degree of substitution among national and foreign currencies by residents of these nations.

This relationship between currency substitution and currency crises is inherently complex. The degree of substitution among national currencies can influence the probability of a crisis, but it is also likely that currency-market instabilities can affect the willingness of agents to seek to substitute among currencies. In this exploratory analysis, we focus solely on the former linkage. Our purpose, therefore, is to evaluate how agents' fundamental preferences regarding currency substitution influences the underlying favorability of conditions that contribute to currency crises through its effects on the demand for real money balances.

As van Aarle and Budina (1996) and Imrohoroglu (1996) have recently re-emphasized, the demand for real money balances form the tax base for seigniorage revenues. Click (1998) measures seigniorage in a cross-section of 90 countries. He finds that seigniorage, on an average, finances 10.5% of government spending while conventional taxation covers 78.5% of government spending. In general, seigniorage is more important in developing and emerging nations than in developed nations. For instance, Click's estimates indicate that seigniorage finances 2% of government spending in the US, 2.4% in Germany, and 5.6% in Japan. In contrast, seigniorage finances 6.3% in Thailand, 6.9% in Indonesia, 5.3% in Malaysia, 13.7% in Brazil, 19.0% in Mexico, and 62.0% in Argentina. Hence, even though seigniorage is not as important as conventional taxation as a source of government revenue for most nations, it is nonetheless an important component, particularly for developing nations that have experienced currency crises.

Consequently, the extent of currency substitution impinges on the ability of fiscal and monetary authorities to fund public expenditures via inflation taxes. Our analysis highlights the interaction between currency substitution and seigniorage within the context of a two-country setting. A clear implication is that seigniorage can play a fundamental role in shaping the prospects of currency crises.

In the model we develop below, residents of two nations that are trading partners may

substitute between currencies issued by both governments. Within this framework, we consider how currency substitution influences the likelihood of a currency crisis when there is a stochastic increase in a foreign risk premium. In this regard, our conceptual approach mirrors the aims of authors such as Kaminsky (1998), who seek to develop "early-warning signals" of currency crises. In the analysis that follows, we attempt to identify various factors that tend to increase the likelihood of a crisis. We find that one key factor influencing the probability of a crisis is the extent of currency substitution. Other factors also affect the likelihood of a currency crisis, however. Our approach adds to the existing literature on currency crises by delineating the nature of the interactions among currency substitution and additional factors that together can create an environment that is susceptible to an exogenous crisis event.

The paper is organized as follows: Section 2 describes the model that is used to analyze these issues; Section 3 derives the optimal policy settings when one nation pegs its exchange rate; Section 4 analyzes factors that influence the likelihood of currency crises; Section 5 concludes with a summary and discussion of the policy implications of the analysis.

2. A two-country model of currency substitution

The model follows Canzoneri and Diba (1992), in which there are two countries and a single, homogeneous good. Each country issues its own currency. Agents in each country can hold currency issued by the monetary authorities of both nations. The model is extended by considering the marginal preferences of agents for their home currency relative to the other nation's currency, and it allows for the possibility of a risk premium that results in deviations of the foreign interest rate from the domestic interest rate.

2.1. Basic structure of the model

Each nation is composed of infinitely lived households with utility functions, ∞ [1]

$$U = \sum_{t=0}^{\infty} (\frac{1}{1+\beta})^t \, [c_t + v * m_t, n_t;\ \sigma, \alpha)], \tag{1a}$$

$$U^* = \sum_{t=0}^{\infty} (\frac{1}{1+\beta})^t \, [c_t^* + v^*(m_t^*, n_t^*;\ \sigma, \alpha^*)], \tag{1b}$$

where c_t and c_t^* are domestic and foreign consumption, m_t and m_t^* are domestic and foreign real holdings of domestic currency balances, n_t and n_t^* are domestic and foreign real holdings of foreign currency balances, and β is the household's rate of time preference. The functions v and v^* denote the individual household's utility derived from real money balances.

The form of these functions and the parameters σ, α, and α * are discussed in more detail below.[1]

The budget constraints faced by domestic and foreign households are given by

$$c_t + m_t + n_t + b_t \leq y_t - \tau_t + \left(\frac{p_{t-1}}{p_t}\right) m_{t-1} + \left(\frac{p^*_{t-1}}{p^*_t}\right) n_{t-1} + (1 + r_{t-1}) b_{t-1}, \tag{2a}$$

$$c^*_t + m^*_t + n^*_t + b^*_t \leq y^*_t - \tau^*_t + \left(\frac{p_{t-1}}{p_t}\right) m^*_{t-1} + \left(\frac{p^*_{t-1}}{p^*_t}\right) n^*_{t-1} + (1 + r^*_{t-1}) b^*_{t-1}, \tag{2b}$$

where y_t and y^*_t are domestic and foreign income endowments, τ_t and τ^*_t are lump-sum taxes imposed by the nations' policy authorities, r_t and r^*_t are the real returns on bonds issued by domestic and foreign governments, b_t and b^*_t are the real quantities of bonds demanded, and p_t and p^*_t are the domestic and foreign prices of the consumption good. Because there is only one good, the domestic currency price of foreign exchange is equal to p_t/p^*_t.

First-order conditions for domestic households' constrained utility maximization (those for foreign households are symmetric with α^* replacing α, so we focus only on the domestic solutions below) are given by

$$v_m(m_t, n_t; \sigma, \alpha) = \left(\frac{i_t}{1 + i_t}\right), \tag{3a}$$

$$v_m(m_t, n_t; \sigma, \alpha) = \left(\frac{i^*_t}{1 + i^*_t}\right), \tag{3b}$$

and

$$r_t = \beta, \tag{3c}$$

where $i_t = \{(1 + r_t)/[1 - (p_{t+1} - p_t)/p_{t+1}]\} - 1$ is the nominal bond rate. In words, the marginal utility of a currency is equal to the opportunity cost of holding the currency and, in the long run, the real interest rate equals agents' rate of time preference.

The inflation rate is defined in a standard manner as

$$\pi_{t+1} = \left(\frac{p_{t+1} - p_t}{p_{t+1}}\right). \tag{4}$$

Given this definition for inflation and using (3c), the following relationship among inflation, the real interest rate and the nominal interest rate must hold at an optimum

$$\pi_{t+1} = \frac{1 + r_t}{1 + i_t} = \frac{1 + \beta}{1 + i_t}. \tag{5}$$

The government budget constraints are given by

$$g_t + \kappa(\tau_t) + (1 + r_{t-1}) bs_{t-1} = \tau_t + s_t + bs_t\,, \tag{6a}$$

$$g^*_t + \kappa(\tau^*_t) + (1 + r^*_{t-1}) bs^*_{t-1} = \tau^*_t + s^*_{t\,t} + bs^*_t\,, \tag{6b}$$

where $\kappa(\tau_t)$ and $\kappa(\tau_t^*)$ are tax collection costs, with $\kappa' > 0$ and $\kappa'' \geq 0$ (that is, marginal tax collection costs are positive), and where bs_t and bs_t^* denote the quantities of government bonds supplied. The real domestic monetary base consists of real currency holdings of both domestic residents and foreign residents, or $m_t + m_t^*$. Likewise, the foreign monetary base is $n_t + n_t^*$. Hence, seigniorage revenues s_t and s_t^* are

$$s_t = (m_t + m_t^*) - (1 - \pi_t)(m_{t-1} + m_{t-1}^*) \tag{7a}$$

and

$$s_t^* = (n_t + n_t^*) - (1 - \pi_t^*)(n_{t-1} + n_{t-1}^*)\,. \tag{7b}$$

Because there is a cost associated with collecting explicit taxes, there is an incentive for policymakers to inflate, to raise seigniorage, and to fund public expenditures. Furthermore, because currencies are substitutable, seigniorage shifts some of the burden of financing government expenditures from domestic agents to foreign agents. Producing inflation in order to generate seigniorage revenues, however, reduces domestic currency holdings below the satiation point, thereby reducing domestic utility.

The discounted present values of seigniorage revenues earned by the two governments are equal to

$$s_0 = \sum_{t=0}^{\infty}\left(\frac{1}{1+\beta}\right)^t\left(1 - \frac{1-\pi_{t+1}}{1+\beta}\right)(m_t + m_t^*) = \sum_{t=0}^{\infty}\left(\frac{1}{1+\beta}\right)^t\left(\frac{i_t}{1+i_t}\right)(m_t + m_t^*)\,, \tag{8a}$$

and

$$s_0^* = \sum_{t=0}^{\infty}\left(\frac{1}{1+\beta}\right)^t\left(1 - \frac{1-\pi_{t+1}^*}{1+\beta}\right)(n_t + n_t^*) = \sum_{t=0}^{\infty}\left(\frac{1}{1+\beta}\right)^t\left(\frac{i_t^*}{1+i_t^*}\right)(n_t + n_t^*)\,, \tag{8b}$$

where it has been assumed that initial (carried into time zero) real high-powered monies are equal to zero.

2.2. Currency demand functions

We next provide a parameterization of currency substitution. The function $v(m_t, n_t; \sigma, \alpha)$ for domestic agents is assumed to take the form

$$v(m_t, n_t; \sigma, \alpha) = -\left(\frac{1}{2}\right)[\alpha(V - m_t) + (V - n_t)]^2 - \left(\frac{1}{2\sigma}\right)[\alpha^2(V - m_t)^2 + (V - n_t)^2]\,, \tag{9a}$$

where $\sigma > 0$ is a measure of the degree of substitutability across national monies. We extend the model of Canzoneri and Diba (1992, p. 835, footnote 14) by allowing agents to show a preference for their home currency. Hence, $\alpha > 0$ captures domestic agents' marginal preference for the domestic currency relative to the foreign currency. A value exceeding unity

indicates a greater preference for the domestic currency relative to the foreign currency, ceteris paribus.[2] As σ increases, domestic and foreign monies approach perfect substitutability internationally. For foreign agents, the function $v^*(\,,n\,t;\sigma,\alpha\ *)$ is given by

$$v^*(m_t^*,n_t^*;\sigma,\alpha^*) = -\left(\frac{1}{2}\right)[(V-m_t^*)+\alpha^*(V-n_t^*)]^2 - \left(\frac{1}{2\sigma}\right)[(V-m_t^*)^2+\alpha^{*2}(V-n_t^*)^2]\,, \qquad (9b)$$

where α^* plays the same role in the foreign utility function that α does in the domestic utility function.

Using the appropriate derivative of Eq. (9a) in (3) yields a system of domestic first-order conditions that may be used to solve for the currency demand functions of domestic agents

$$m_t = V - \left[\frac{\lambda}{\alpha^2(\lambda^2-1)}\right]\left(\frac{i_t}{1+i_t}\right) + \left[\frac{1}{\alpha(\lambda^2-1)}\right]\left(\frac{i_t^*}{1+i_t^*}\right), \qquad (10a)$$

$$n_t = V - \left[\frac{\lambda}{(\lambda^2-1)}\right]\left(\frac{i_t^*}{1+i_t^*}\right) + \left[\frac{1}{\alpha(\lambda^2-1)}\right]\left(\frac{i_t}{1+i_t}\right), \qquad (10b)$$

where $\lambda = (\sigma^{-1}+1) \geq 1$, so that a decrease in λ toward unity indicates increased currency substitution. Likewise, substituting appropriate derivatives of (9b) into the foreign analogues to Eqs. (3) yields solutions for the currency demand functions of foreign agents:

$$m_t^* = V - \left[\frac{\lambda}{(\lambda^2-1)}\right]\left(\frac{i_t}{1+i_t}\right) + \left[\frac{1}{\alpha^*(\lambda^2-1)}\right]\left(\frac{i_t^*}{1+i_t^*}\right), \qquad (10c)$$

$$n_t^* = V - \left[\frac{\lambda}{\alpha^{*2}(\lambda^2-1)}\right]\left(\frac{i_t^*}{1+i_t^*}\right) + \left[\frac{1}{\alpha^*(\lambda^2-1)}\right]\left(\frac{i_t}{1+i_t}\right), \qquad (10b)$$

The first square-bracketed term within each equation reflects the effect of a change in the opportunity costs of holding the home currency. In (10a), for example, an increase in the domestic interest rate causes a reduction in the quantity of the domestic currency demanded. As currency substitution increases, this effect is larger, whereas an increase in α reduces the extent of this change in responsiveness. The second square-bracketed term denotes the effect of a change in the opportunity cost of holding the other nation's currency.

Eq. (10b) indicates that as the foreign interest rate rises, the quantity of the foreign currency demanded by domestic agents falls. This effect increases with greater degrees of currency substitution but is not altered by a change in α. To maintain some of the benefits of holding currency, however, domestic agents increase their demand for the domestic currency, as indicated by (10a). Eq. (10b) indicates that if the domestic interest rate rises, the domestic demand for the foreign currency increases, and this effect rises with a greater degree of currency substitution and falls with an increase in α. Thus, an increased marginal preference by domestic residents for their own currency reduces the domestic interest sensitivity of the domestic demand for the domestic currency. This induces the domestic policymaker to raise the domestic interest

rate in an effort to increase seigniorage flows, thereby relying less on tax receipts.

Because of the pegged exchange rate arrangement, the foreign authorities raise the foreign interest rate to match the increase in the domestic interest rate. As Eq. (10b) indicates, the increase in the foreign interest rate tends to induce domestic agents to raise their holdings of domestic currency. Eq. (10b) also implies that with a greater marginal domestic preference for domestic currency (an increase in α), this tendency to substitute into foreign currency holdings is dampened somewhat. The reduction in the sensitivity of domestic currency demand to an increase in the foreign interest rate is proportionately less than the fall in the sensitivity of domestic currency demand to the change in the domestic interest rate, however. On net, therefore, the overall effect of an increase in α is an unambiguous *increase* in desired holdings of the domestic currency by domestic residents.

From (10b), the increase in the domestic interest rate induced by an increase in α tends to increase the domestic demand for foreign currency. By definition, however, an increase in α implies a greater marginal domestic preference for domestic currency. Thus, the willingness of domestic residents to substitute into foreign currency holdings in response to an increase in the domestic interest rate is dampened, while the responsiveness of domestic residents' demand for foreign currency to a change in the foreign interest rate is unaltered.

From (10d), a change in α does not affect the interest sensitivities of foreign demand for the foreign currency. It does, however, affect the foreign demand for the foreign currency through changes in interest rates. Whether an equiproportionate rise in the interest rates leads to an increase or decrease in equilibrium foreign holdings of the foreign currency thereby depends on the size of α^*—that is, the marginal preference for the foreign currency—relative to λ, which decreases with greater currency substitution. Evaluating the interaction between these parameters in affecting the likelihood of a crisis is addressed in the following section.

3. Optimal monetary policies

In principle, the model could be solved for cases of floating or pegged exchange rates. In the former situation and with non-coordinated policymaking, the domestic authorities would choose the domestic interest rate (which from (5) implies an inflation choice) and taxes to maximize domestic agent utility as in (1a), subject to the intertemporal budget constraint implied by (6a). The foreign authorities would choose the foreign interest rate and taxes to maximize foreign agent utility as in (1b), subject to the intertemporal constraint implied by (6b).

Our interest is focused on the types of crises that occurred since 1994. Hence, we apply the model to a situation where the domestic country is a relatively larger country with a

high-quality currency and the domestic authority chooses the domestic interest rate and taxes to maximize domestic utility. The foreign country, on the other hand, is relatively smaller and more likely to experience dollarization of its economy. Given the prominent role of regimes of pegged exchange rate regimes in these crises, we concentrate on a pegged-exchange-rate version of the model and consider only factors that induce agents to choose not to hold the foreign currency.

We assume that the foreign authorities peg the value of the foreign currency relative to the domestic currency, which in this model requires setting the foreign nominal interest rate equal to the domestic nominal interest rate. Thus, in this regime of a pegged exchange rate, the domestic authorities recognize that $i_t^*/(1+i_t^*) = i_t/(1+i_t) + p_t$ ex ante when determining the optimal setting of the domestic interest rate and the domestic tax rate, where p_t is a stochastic foreign risk premium. The authorities in the relatively larger domestic country, therefore, act as a Stackelberg leader when determining i_t and π_t.

Note that in this application, the foreign policymaker makes appropriate choices for interest rate and tax settings to maintain the exchange rate regime. This allows us to concentrate on the role of the key parameters of the model. If a crisis were to occur, then the foreign policymaker would be the buyer of the foreign currency that is liquidated by domestic and foreign agents. Otherwise, it would have to abandon the exchange rate peg. We are not, however, concerned with the adjustment that might occur following a crisis. Instead, our objective is to identify the conditions that increase the likelihood that such a crisis could occur.

The domestic authorities choose $i_t/(1+i_t)$ to maximize the discounted present value of the infinite-horizon stream of utility accruing to domestic agents, which, after substituting in for the present value of domestic consumption, is given by

$$\sum_{t=0}^{\infty}\left(\frac{1}{1+\beta}\right)^t\left[(y_t-\tau_t)-\left(\frac{i_t}{1-i_t}\right)m_t-\left(\frac{i_t^*}{1+i_t^*}\right)n_t+v(m_t,n_t;\sigma,\alpha)\right]$$
$$-\mu\sum_{t=0}^{\infty}\left(\frac{1}{1+\beta}\right)^t\left\{[g+\kappa(\tau_t)]-\tau_t-\left(\frac{i_t}{1+i_t}\right)(m_t+m_t^*)\right\}. \tag{11}$$

Eq. (11) illustrates the impact of government spending, explicit taxation, and seigniorage on domestic agents. By relying on seigniorage, policymakers are able to avoid some of the tax collection costs associated with explicit taxes by shifting some of the tax burden onto foreign agents and thereby increasing the disposable income of domestic agents.

Maximization of (11) yields the following solution for the domestic interest rate, which the foreign authorities match (taking into account the exogenous risk premium ρ_t) in order to peg the

foreign currency's nominal exchange value to the domestic currency

$$\frac{\hat{\imath}_t}{1+i_t} = \frac{2(\mu-1)(\lambda^2-1)\alpha^*\alpha^2 V + \mu(\alpha+\alpha^*)\alpha\rho_t}{[(2\mu-1)(\lambda-\alpha)-\alpha(\alpha\lambda-1)]\alpha^* + 2\mu\alpha^2(\alpha^*\lambda-1)}, \tag{12}$$

where $\mu = 1/[1-\kappa'(\tau)]$ is the shadow price associated with the government budget constraint. Because the foreign authorities peg the exchange rate, they set $i_t^*/(1+i_t^*) = i_t/(1+i_t^*) + \rho_t$. Taking into account the foreign risk premium, the solution in (12) yields the optimal domestic and foreign interest rate settings, given the constraints that the domestic policymaker faces and the exchange rate regime implemented by the foreign authority.

These policy settings adjust to changes in the foreign risk premium ρt, the only random variable in the model and hence the source of a potential currency crisis. An unexpected increase in the foreign risk premium raises the foreign interest rate. This allows the domestic authority to increase the domestic interest rate, relying to a greater extent on seigniorage and a lesser extent on direct taxes. Thus, $\partial\hat{\imath}_t/\partial\rho_t > 0$, so that when there is an increase in the foreign risk premium, the domestic authority can shift more of the tax burden onto foreign residents via an increase in the domestic interest rate. Maintaining a fixed exchange rate requires the foreign monetary authority to increase i_t^* as well.

The sensitivity of the optimal policy settings to a rise in the foreign risk premium depends on the structural parameters of the model α, α^*, μ, and σ (imbedded within the λ parameter). Consider the effect of an increased marginal preference by domestic residents for their own currency (a rise in the value of α), which reduces the domestic interest sensitivity of the domestic demand for the domestic currency. This gives the domestic policymaker an incentive to raise the domestic interest rate by a greater extent in an effort to increase seigniorage flows, thereby relying less on income tax receipts, so that $(\partial\hat{\imath}_t/\partial\rho_t)/\partial\alpha > 0$. To match the increased responsiveness of the domestic interest rate to a rise in the foreign risk premium and maintain the fixed exchange rate, the foreign monetary authority likewise increases the extent to which it responds by raising the foreign interest rate.

As shown in Eq. (10b), an increased marginal preference for foreign currency by foreign residents (a rise in the value of α^*) causes foreign residents to respond more strongly to an increase in the domestic interest rate by reducing their demand for domestic currency. Thus, the magnitude of the domestic authority's interest rate response to a higher foreign risk premium decreases as the domestic authority attempts to continue encouraging foreign residents to hold domestic currency, thereby shifting some of the burden of funding domestic expenditures from domestic residents to foreign residents by maintaining seigniorage revenues. Consequently,

$(\partial \hat{\imath}_t/\partial \rho_t)/\partial \alpha^* < 0$. Within the pegged exchange regime, the foreign interest rate responsiveness to an increase in the risk premium declines as well.

A decline in the efficiency of tax collections generates an increase in marginal domestic tax collection costs (a rise in $\kappa'(\tau)$ that brings about increase in μ), which gives the domestic policymaker an incentive to shift away from explicit taxes in favor of seigniorage. To try to maintain seigniorage in the face of a higher foreign risk premium, therefore, a domestic authority that confronts relatively high tax collection costs will restrain somewhat from boosting the interest rate as much as it would have otherwise. Thus, $(\partial \hat{\imath}_t/\partial \rho_t)/\partial \mu < 0$. The foreign monetary authority must respond in kind by reducing the sensitivity of its own interest rate response to a rise in the foreign risk premium.

An increase in currency substitution (an increase in σ and hence a reduction in λ) simplifies portfolio diversification, so that domestic and foreign residents' desired holdings of domestic currency are more responsive to a given change in the domestic interest rate. This gives the domestic policymaker an incentive to respond to a higher foreign risk premium by increasing the domestic interest rate by a larger amount in response to an increase in currency substitution. Thus, the response of the domestic interest rate setting to an increase in the foreign risk premium is magnified by greater currency substitution; that is, $(\partial \hat{\imath}_t/\partial \rho_t)/\partial \sigma > 0$. Following a rise in the foreign risk premium, the foreign monetary authority also maintains a fixed exchange rate in response to a ceteris paribus increase in currency substitution by adjusting the foreign interest rate upward in greater proportion.

4. Currency substitution, endogenous policies, and currency crises

To identify factors contributing to an increased likelihood of currency crises, we evaluate reduced-form expressions for domestic and foreign holdings of the foreign currency. As an intermediate step toward obtaining these reduced-form values on n_t and n_t^*, we first substitute $[i_t/(1+i_t)] + \rho_t$ for the foreign interest rate, $[i_t^*/(1+i_t^*)]$, in the currency demand functions (10b) and (10d). This yields

$$n_t = V - \left[\frac{\lambda}{\lambda^2 - 1}\right]\rho_t - \left[\frac{\alpha\lambda - 1}{\alpha(\lambda^2 - 1)}\right]\left(\frac{i_t}{1+i_t}\right) \tag{13a}$$

and

$$n_t^* = V - \left[\frac{\lambda}{(\alpha^*)^2(\lambda^2 - 1)}\right]\rho_t - \left[\frac{\lambda - \alpha^*}{(\alpha^*)^2(\lambda^2 - 1)}\right]\left(\frac{i_t}{1+i_t}\right). \tag{13a}$$

Finally, reduced-form expressions for domestic and foreign holdings of the foreign

currency can be obtained by substituting the optimal interest rate solution into the demand equations to obtain

$$\hat{n}_t = \frac{(\lambda^2 - 1)[\Delta - (\alpha\lambda - 1)2(\mu - 1)\alpha^*\alpha]V - [\lambda\Delta - \mu(\alpha^* + \alpha)]\rho_t}{(\lambda^2 - 1)\Delta} \tag{14a}$$

and

$$\hat{n}_t^* = \frac{[(\alpha^*)^2(\lambda^2 - 1)\Delta - (\lambda - \alpha^*)2(\mu - 1)(\lambda^2 - 1)\alpha^*\alpha]V}{(\alpha^*)^2(\lambda^2 - 1)\Delta} - \frac{[\lambda\Delta + (\lambda - \alpha^*)\mu(\alpha^* + \alpha)\alpha]\rho_t}{(\alpha^*)^2(\lambda^2 - 1)\Delta}, \tag{14b}$$

where $\Delta = [(2\mu - 1)(\lambda - \alpha) - \alpha(\alpha\lambda - 1)]\alpha^* + 2\mu\alpha^2(\alpha^*\lambda - 1)$. We can use these expressions to determine conditions that would make agents more likely to "dump" their holdings of the foreign currency in response to a sudden increase in the foreign risk premium ρ_t, thereby creating a currency crisis.

Eq. (13a) shows that an unexpected increase in the foreign risk premium affects the domestic demand for the foreign currency through a direct channel—driving a wedge between the foreign interest rate and the domestic interest rate—and through an indirect channel—affecting the optimal setting for the domestic interest rate (shown in Eq. (12)). The direct effect of an increase in the foreign risk premium is lower domestic demand for foreign currency holdings, ceteris paribus. This direct effect depends only on the degree of currency substitution and the magnitude of the risk premium, and it increases with a greater degree of currency substitution (an increase in σ that pushes the value of λ closer to unity). The indirect effect also leads to a lower domestic demand for foreign currency. As discussed above the magnitude of this indirect effect through endogenous policy adjustments increases in response to a greater degree of currency substitution (a decrease in λ), greater domestic marginal preference for the domestic currency (an increase in α), reduced foreign preference for the foreign currency (a decrease in α^*), and increased tax collection efficiency (reflected in a decrease in μ). Thus, examination of (14a) ultimately reveals greater currency substitution increases the likelihood of a major drop in desired domestic holdings of the foreign currency.

Eq. (13b) illustrates the direct and indirect influence of a sudden increase in the foreign risk premium on foreign residents' desired holdings of their own currency. The direct channel is reduced foreign demand. Greater relative marginal preference for the foreign currency reduces the importance of the direct channel. In contrast, a greater degree of currency substitution increases the importance of the indirect channel that operates through the interest rate. The sign of the coefficient on the indirect channel may be positive or negative depending on the degree of currency substitution and the relative marginal preference for the foreign currency, α^*. A greater

degree of currency substitution increases the importance of the indirect channel, because foreign residents can more easily shift to domestic currency holdings in light of a risk premium shock. Relatively larger values of α^* could make the indirect channel positive, but as Eq. (12) shows, larger values of α^* lead to a lower domestic interest rate setting, ceteris paribus. Hence, the effect of a positive indirect channel is offset somewhat by a lower interest rate setting. The indirect channel through the interest rate is likely to be negative, therefore, over the range of most values of α^*.

In any event, we focus on the case in which α^* is less than unity, so that the currency of the smaller foreign nation is an inferior currency. In this case, the indirect effect of a higher risk premium is unambiguously negative, and the likelihood of a significant drop in foreign residents' desired holdings of their own currency also is increased by greater currency substitution, an increased domestic preference to hold domestic currency, a decreased foreign preference to hold foreign currency, and lower marginal tax collection costs.

Our analysis, therefore, implies that in an environment in which the monetary authority of a relatively small nation fixes the value of its currency relative to the currency of a larger country, greater currency substitution increases the likelihood that residents of both nations will dramatically reduce their holdings of foreign currency in response to a sudden increase in the perceived riskiness of foreign assets. Consequently, a greater relative degree of currency substitution increases the potential for a currency crisis.

5. Policy implications and conclusion

In this paper we developed a two-country framework that allows agents to substitute among domestic and foreign currencies. With this framework, we have analyzed the case in which the domestic country is a relatively large country that determines monetary policy settings optimally, while the foreign country is smaller and pegs the value of its currency relative to the domestic currency. Within this example we have examined the role that currency preferences, currency substitution, and tax policies play in contributing to the potential for agents in both nations to dump their holdings of the foreign currency. Each of these factors influences the extent to which currency substitution increases the likelihood of a currency crisis for the foreign country. Our most important conclusion is that increased currency substitution increases the likelihood of a currency crisis in response to a sudden perception that foreign assets are more risky.

Our analysis indicates that there are number of important policy considerations for a small country that chooses to peg its exchange rate. In general, changes in optimal interest rate

settings by the monetary authority of the large nation determine the spreading of taxes from explicit taxation to seigniorage revenues, creating a backdrop for a potential currency crises as agents substitute the currency of the large nation for that of the pegging nation. Small-country policymakers must pay particular attention to marginal currency preferences and the tax collection efficiency of the large country, lest they be forced to be the buyer of their currency or to abandon the exchange rate regime. Structural parameters also are important. In our analysis, the marginal preference for the small country currency is an exogenous parameter. In fact, this parameter realistically is affected by microeconomic policies, such as the regulatory framework for the nation's system of intermediaries. Such regulatory policies, therefore, are critical in the face of increasing currency substitution.

Future research should expand the type of analysis conducted here by considering the demand for the bank deposits within each nation (as in the models of Miller, 1998a, 1998b; Daniels & VanHoose, 1996, for example). In this way, currency *and* banking crises may be considered simultaneously in the context of international interdependence. This will allow for an analysis of the undoubtedly important role of reserve requirements as a factor affecting the risk of international crises.

A further issue is the likely endogeneity of currency substitution to currency crises. In this paper we have examined a unidirectional causality in which greater currency substitution contributes to a climate favorable to a crisis. In the event that shocks actually induce a crisis, of course, the resulting instabilities undoubtedly affect agents' willingness to substitute currencies. Broadening our framework to allow for a full bidirectional relationship between currency substitution and crises is another area for future research.

Notes

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1. See Holman (1998) for evidence concerning the relevance of this money-in-the-utility function approach.

2. As in Canzoneri and Diba (1992) and Daniels and VanHoose (1996), the parameter V in the utility function defines agents' satiation level (quantity) of currency holdings.

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