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Currency Substitution and Financial Innovation

DURING THE LAST DECADE, the financial systems of industrial countries have undergone a process of substantial transformation. Most of the changes have been the result of two events: technological progress in the area of financial services and significant changes in the regulatory environment affecting financial markets. These structural changes have coincided with an increased interdependence across major industrialized economies.

The recent decision adopted within the European Economic Community to accelerate the process of economic integration by setting the objective of achieving a "single market" by 1992 has prompted renewed interest in the macroeconomic effects of major changes in financial regulations coupled with an almost complete liberalization of capital movements.[1] In particular, in a European context, some attention is being focused on the role of currency substitution in the process of financial integration, particularly on the likelihood that it might lead to increased instability of monetary aggregates and have undesirable effects on the ability of governments to conduct economic policy.

This paper provides a framework in which the macroeconomic effects of structural changes in the financial system, and more importantly, their international transmission, as well as the role played by currency substitution, can be analyzed.[2] The focus is placed on structural changes that affect the transactions demand for curren-

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[1]See, for instance, Canzoneri and Diba (1990) and Giovannini (1990).

[2]Fisher (1983) and Englund and Svensson (1988) provide alternative general equilibrium models which are well suited to analyze the effects of financial innovation.

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cies. Therefore, money is motivated as an asset held only for transactions purposes, since, as a store of value, money is return-dominated by interest-bearing assets.

The model employed in this paper, which is based on Feenstra (1986) and Guidotti (1989), develops a cash-in-advance framework where individuals are required to use domestic money to purchase domestic goods and foreign money to purchase foreign goods, and in which income velocity is variable because of inventory-type consideration à la Baumol (1952) and Tobin (1956). Unlike other cash-in-advance models with a variable income velocity (Svensson 1985a and 1985b), this model maintains a variable velocity despite being a perfect-foresight model. Moreover, in this framework, currency substitution results endogenously.[3] Despite the use of each currency being linked to a specific good, currency substitution is generated in this model through the interaction that the two monies have in affecting the total amount of time devoted to transaction activities.[4]

The term "financial innovation" is used in this paper to encompass changes in the technological environment affecting the way individuals carry out their transactions. In particular, financial innovation—a consequence both of technical progress and of changes in financial regulations—affects the time-costs involved in transacting.[5]

A number of insights emerge from the analysis. First, because of the nature of the cash-in-advance constraints faced by individuals, financial considerations are shown to affect the effective relative prices of consumption goods. Therefore, the international transmission of the effects of financial innovation, as well as the domestic effects, depend significantly on how financial innovation alters the relative cost of using different currencies and, hence, on how it affects the equilibrium relative price of consumption goods.

Second, it is shown that financial innovation may lead to a negative co-movement between the nominal and the real exchange rate. In particular, a country in which there is a lowering of the relative cost of using foreign currency may face a nominal appreciation and a real depreciation of its currency. The negative co-movement between the nominal and the real exchange rate in response to financial innovation has a clear interpretation in terms of monetary effects, on one hand, and real effects, on the other hand. While the response of the nominal exchange rate to financial

[3]The term "currency substitution" may be understood in two ways: (1) that foreign money is used along with domestic money in transacting, and (2) that a change in the relative cost of holding one currency induces a change in the ratio of domestic to foreign money holdings demanded (Calvo and Rodriguez 1977). While the model presented in this paper does not provide a theory of *why* foreign currency is used, it provides a theory of *how* the ratio of domestic to foreign demand holdings depends on factors that affect the relative cost of holding the two currencies.

[4]This framework generates reduced forms that are similar to other optimizing models of currency substitution (Liviatan 1981; Calvo 1980 and 1985; Boyer and Kingston 1987; Végh 1988 and 1989). As opposed to, for instance, including directly domestic and foreign money in the utility function, the present model provides microfoundations for a utility function of that sort. This allows for a clearer interpretation of the parameters whose changes are associated with financial innovation.

[5]Calvo's (1980) analysis of the effects of "financial opening" in the context of a small open economy is similar to the analysis carried out in this paper. In Calvo's (1980) model, financial opening is assumed to generate changes in a "real liquidity" function that enters the utility function. Unlike this paper, in Calvo's (1980) currency substitution model, money serves both as store of value and as medium of exchange.

innovation is driven by changes in the relative demand for currencies, the response of the real exchange rate depends on how the relative "effective" price of consumption goods is affected by financial innovation.

Third, cross-border transfers of seigniorage, which occur because of the presence of currency substitution, play a significant role in the international transmission of the effects of financial innovation. It is shown that a change in the regulatory environment that reduces the cost of transacting in foreign currency results in a net seigniorage inflow from the rest of the world. This cross-border transfer of seigniorage has general equilibrium effects on consumption, the real exchange rate, and the demand for domestic and foreign currency.

The paper is organized as follows. Section 1 presents the basic model and characterizes the consumer's maximum problem. Section 2 characterizes the world economic equilibrium. Specific functional forms for the utility function and the transactions technology generate a recursive structure which allows a simple analytical solution for the equilibrium. Section 3 discusses the effects of both global as well as country-specific financial innovation. Implications for the consequences of unifying financial regulations across countries are drawn. Section 4 concludes.

1. THE BASIC MODEL

Consider a two-country world. Each country is inhabited by identical, infinitely lived individuals. There are two goods, two monies, and two bonds. Preferences of the domestic representative consumer are described by

$$W = \sum_{t=0}^{\infty} \beta^t u(c_t, c_t^*, x_t) , \tag{1}$$

where c_t and c_t^* denote consumption of the domestic and the foreign good in period t, respectively, and x_t denotes leisure in period t. The utility function $u(.)$ is assumed to be strictly concave, twice continuously differentiable, with positive and decreasing marginal utilities.

The representative consumer holds four assets: a domestic and a foreign money, and a domestic and a foreign bond which pay a fixed interest rate of i_t and i_t^* per period, respectively. There is no uncertainty. For expositional convenience, each time period can be thought of as being divided into two subperiods. In the first subperiod, consumption takes place while in the second subperiod asset trading takes place. It is assumed that the representative consumer is subjected to a cash-in-advance constraint during the consumption subperiod. However, the individual is allowed to finance consumption by withdrawing money from bonds as in Baumol's (1952) or Feenstra's (1986) models. Specifically, it is assumed that the representative individual holds two accounts, one denominated in foreign and the other in domestic currency, respectively. While domestic currency is obtained from the stock of domestic bonds, foreign currency is obtained from the stock of foreign bonds.[6] In the second subperiod, individuals receive an endowment income, pay taxes, receive interest payments on their bond holdings, and engage in asset trade to choose the new composition of their asset portfolio.

Since the flow of consumption to be financed occurs continuously, cash withdrawals are evenly distributed within each period. Define by N and N^* the frequency of withdrawals in domestic and foreign currency, respectively. As in Guidotti (1989), instead of monetary transactions costs like in Baumol (1952) and Feenstra (1986), it is assumed that cash withdrawals involve time. Given an endowment T of time available, it may be used either as leisure or in withdrawing cash:

$$T = x_t + f(N_t, N_t^*); f_N > 0, f_{N^*} > 0 \tag{2}$$

where $f(.)$ is a time-cost function with positive first derivatives.[7] The fact that the time-costs involved in transacting depend on the frequencies of cash withdrawals, N and N^* (or, in the spirit of the Baumol-Tobin approach, the amount of times the consumer goes to the bank), implies that those costs are not proportional to the amount of cash withdrawn.[8]

Assuming that interest is paid on the initial stock of bond holdings, the flow budget constraint of the domestic consumer (expressed in domestic currency) is given by:[9]

$$\begin{aligned} A_{t+1} + e_t A^*_{t+1} = A_t + e_t A_t^* + i_t B_t + e_t i_t^* B_t^* \\ + P_t(y_t - c_t + \tau_t) - e_t P_t^* c_t^* , \end{aligned} \tag{3}$$

where A_t $(=M_t + B_t)$ is the sum of domestic money balances, M_t, and domestic-currency-denominated bonds, B_t, at the beginning of period t; A_t^* $(=M_t^* + B_t^*)$ is the

[6]This assumption could be relaxed without affecting qualitatively the ensuing analysis of the effects of financial innovation. The fact that, during the consumption subperiod, individuals can only withdraw currency from bonds in this predetermined way is in the spirit of cash-in-advance models; namely, while consumption takes place only a limited set of financial transactions (in this case only cash withdrawals) can be made.

[7]Equation (2) allows for fairly general forms of the transaction cost function $f(.)$, as long as it satisfies convexity. If $f(.)$ is linear, as it will be assumed later on, then the concavity of the utility function implies that the welfare cost of transacting is strictly convex. The specific form of the transactions technology may depend on production decisions like choosing the optimal amount of ATMs per geographical area, the optimal type of services performed by ATMs in different locations, etc.

[8]When thinking of time costs, this is a natural assumption. In the context of monetary costs, as the original work of Baumol (1952) or as in Feenstra (1986), one could consider costs that are proportional to the amount of cash withdrawn.

[9]The assumption that interest is paid on initial bond holdings is made for simplicity and does not affect the results. If interest is paid on average bond holdings the budget constraint would be modified using the fact that average bond holdings (in nominal values), B^a and B^{*a}, are related to initial holdings, B and B^*, by the following equations:

$$B^a = B + M - (M/2)(N + 1);$$
$$B^{*a} = B^* + M^* - (M^*/2)(N^* + 1).$$

sum of foreign currency balances, M_t^*, and foreign-currency-denominated bonds, B_t^*, at the beginning of period t; e_t is the nominal exchange rate; y_t denotes the (real) endowment; τ_t denotes real government transfers; P_t and P_t^* denote, respectively, the price of domestic and foreign goods.

Individuals are rational and domestic and foreign bonds are pure assets in their portfolios—that is, bonds do not provide direct liquidity services; hence, in equilibrium, the following interest parity condition holds:

$$(1 + i_t) = (1 + i_t^*)e_t/e_{t-1} \,. \tag{4}$$

Dividing by the price of domestic goods, P_t, and using equation (4), the consumer flow constraint (3) may be expressed in real terms as

$$\begin{aligned} a_{t+1} + q_t a_{t+1}^* = (1 + r_t)[a_t + q_{t-1}a_t^*] - i_t m_t - q_t i_t^* m_t^* \\ + y_t - c_t - q_t c_t^* + \tau_t \,, \end{aligned} \tag{3'}$$

where $a_t \equiv A_t/P_{t-1}$; $a_t^* \equiv A_t^*/P_{t-1}^*$; q_t ($\equiv e_t P_t^*/P_t$) denotes the relative price of foreign goods—which will also be referred to as the "real exchange rate"; m_t ($\equiv M_t/P_t$) and m_t^* ($\equiv M_t^*/P_t^*$) denote real domestic and foreign cash balances, respectively. By definition, $(1 + r_t) \equiv (1 + i_t)P_{t-1}/P_t$ and $(1 + r_t^*) \equiv (1 + i_t^*)P_{t-1}^*/P_t^*$, where r_t and r_t^* are the domestic and foreign real interest rates, respectively.

The representative individual is assumed to face a cash-in-advance constraint during each period. With two currencies, the specification of the cash-in-advance constraint entails an assumption about the way transactions must be carried out. Following Stockman (1980), Lucas (1982), and Svensson (1985a), it is assumed that individuals are required to use foreign currency to purchase foreign goods while they are required to use domestic currency to purchase domestic goods. Thus, with two currencies, the individual faces two cash-in-advance constraints, which are given by[10]

$$m_t N_t = c_t \tag{5}$$

$$m_t^* N_t^* = c_t^* \,. \tag{6}$$

The L.H.S. of equations (5) and (6) equals the total amount of (domestic and foreign, respectively) cash withdrawn per period; it equals the frequency of withdrawals multiplied by the amount of cash withdrawn each time.

The representative consumer maximizes the value of utility function (1) subject to the time constraint (2), the budget constraint (3'), and the cash-in-advance constraints (5) and (6). The first-order conditions for an interior optimum imply[11]

[10]With no uncertainty and positive interest rates, the cash-in-advance constraints are always binding.
[11]When no risk of confusion arises, time subscripts are dropped for notational simplicity.

$$[u_{c*} - (u_x f_{N*}/m^*)]/[u_c - (u_x f_N/m)] = q \tag{7}$$

$$(u_x f_N N/m)/[u_c - (u_x f_N/m)] = i \tag{8}$$

$$(u_x f_{N*} N^*/m^*)/[u_{c*} - (u_x f_{N*}/m^*)] = i^* \tag{9}$$

$$[u_c - (u_x f_N/m)]_t = (R/\beta)[u_c - (u_x f_N/m)]_{t-1} \; . \tag{10}$$

To facilitate the interpretation of equations (7)–(10), it is useful to recognize that the solution to the consumer's problem is equivalent to a money-in-the-utility-function problem where the indirect utility function is given by $U(c,c^*,m,m^*) \equiv u[c,c^*,T-f(c/m,c^*/m^*)]$, which implies that $U_c = u_c - (u_x f_N/m)$, $U_{c*} = u_{c*} - (u_x f_{N*}/m^*)$, $U_m = u_x f_N N/m$, and $U_{m*} = u_x f_{N*} N^*/m^*$.[12] In these expressions, $N = c/m$ and $N^* = c^*/m^*$, by the cash-in-advance constraints (5) and (6). Equation (7), thus, states that the marginal rate of substitution between foreign and domestic goods equals their relative price. The marginal rate of substitution in consumption takes account of the fact that an increase in consumption of a particular good, for a given level of real cash balances, requires an increase in the amount of time spent transacting in the currency used to purchase that good. The increased time spent transacting is the result of an increase in the frequency of cash withdrawals.

Because, by the cash-in-advance constraints, the consumer must use domestic currency to purchase domestic goods and foreign currency to purchase foreign goods, equation (7) can be reinterpreted as showing that the "effective" prices of consumption goods are affected by financial considerations. Equation (7) can be written as

$$u_{c*}/u_c = q[N(N^* + i^*/N^*(N + i))] \equiv \tilde{q} \; , \tag{7'}$$

where $\tilde{q}$ denotes the "effective" relative price of foreign goods.[13]

In terms of the indirect utility function $U(c,c^*,m,m^*)$, equations (8) and (9) state that the marginal rate of substitution between real cash balances and consumption equals the opportunity cost of holding money. The marginal utility of holding money is the marginal utility of additional leisure obtained by decreasing the frequency of cash withdrawals through an increase in real cash balances. Given that domestic (foreign) currency is withdrawn from domestic (foreign) bonds, the opportunity cost of holding domestic (foreign) money is given by the domestic (foreign) nominal interest rate. Equation (10) is a standard Euler equation.

Using the first-order conditions that describe the behavior of the domestic consumer, and an analogous set of conditions describing the behavior of the foreign consumer, we proceed to characterize the world economy's equilibrium.

[12]See Guidotti (1989) for a more detailed discussion.

[13]The interpretation of (7') is similar to that which obtains in models that introduce money in the production function or money as reducing transaction costs (Dornbusch and Frenkel 1973; McCallum 1983; Kimbrough 1986; Végh 1989).

2. EQUILIBRIUM IN A TWO-COUNTRY WORLD

This section characterizes the world economy's equilibrium under flexible exchange rates. Assuming for simplicity that there is no public sector borrowing or lending, the budget constraint faced each period by the domestic government is given by

$$\tau_t + g = \mu_t m_t^s , \tag{11}$$

where $\mu_t \equiv (M_{t+1}^s - M_t^s)/M_t^s$ denotes the rate of growth of the domestic money supply, M^s, and g denotes government expenditure, hereinafter assumed to be constant over time. The foreign government faces an analogous constraint. It is important to note that, since individuals in both countries hold both currencies, the domestic (foreign) government earns seigniorage from holdings of domestic (foreign) money in the foreign (domestic) country. That is reflected in the R.H.S. of equation (11) where seigniorage is earned on the total quantity of money.

In a world of perfect capital mobility, assuming that the two countries have the same rate of time preference and that all exogenous variables are constant over time, it can be shown that there are no intrinsic dynamics in the model (Obstfeld and Stockman 1985) and that each country is always in a steady-state equilibrium; that is, adjustment to changes in exogenous variables is instantaneous.

Goods and asset market equilibria imply the following conditions:

$$c + c^f = y - g \equiv z \tag{12}$$

$$c^* + c^{*f} = y^* - g^* \equiv z^* \tag{13}$$

$$M^s/P \equiv m^s = m + m^f \tag{14}$$

$$M^{*s}/P^* \equiv m^{*s} = m^* + m^{*f} , \tag{15}$$

where a superscript f indicates that the variable corresponds to the foreign country, and time subscripts have been dropped for notational convenience since the economy is in a steady-state equilibrium.

Equations (12) and (13) incorporate the assumption that each country is specialized in the production of one good and that each government consumes only the domestic good. This can be easily modified to consider other cases. A case worth focusing on is one that simplifies the world economy's equilibrium to a "symmetric equilibrium." A symmetric equilibrium is obtained when the two countries are identical in all respects (including wealth). This requires transfers across countries such that each country's endowment is composed of half of the endowment of each good (net of government expenditure), and each country rebates the seigniorage earned from foreign (domestic) money holdings to the foreign (domestic) individual (or, alternatively, the rates of money growth must equal zero). Thus, in the symmetric equilibrium, instead of equations (12)–(15), one obtains that each country consumes half of the endowment of each good, and holds half of the stock of each currency. The symmetric equilibrium will prove to be particularly simple to work with and will be used in the next section to analyze the effects of global financial innovation.

In the more general, nonsymmetric equilibrium, assuming that each country's net bond position is zero in the steady-state equilibrium (that is, $b + qb^* = 0$), the domestic economy's budget constraint reduces to the following expression:

$$c + qc^* + \mu^* q m^* = z + \mu m^f , \tag{16}$$

where μ^* is the rate of expansion of the foreign money supply. Equation (16) indicates that aggregate spending plus the payment of seigniorage to the foreign country must equal the sum of domestic output net of government expenditure plus seigniorage earned from foreign holdings of domestic currency.

In the steady-state equilibrium, the domestic and foreign real interest rates equal the common rate of time preference (that is, $\beta(1 + r) = \beta(1 + r^*) = 1$). Any divergence between the domestic and foreign nominal interest rates i and i^* is determined by differences between the domestic and foreign rates of monetary expansion, since $(1 + i) = (1 + \mu)/\beta$ and $(1 + i^*) = (1 + \mu^*)/\beta$. Moreover, a divergence between the domestic and foreign rates of monetary expansion generates a proportional change in the nominal exchange rate.

In order to simplify the ensuing discussion and to sharpen intuition we adopt the following specific functional forms for the representative individual's utility function and transactions technology:

$$u(c,c^*,x) = \ln(c) + \ln(c^*) + \ln(x) ; \tag{17}$$

$$f(N,N^*) = N + \alpha N^* . \tag{18}$$

The parameter α affects the relative marginal cost of using a particular currency and it may be greater or smaller than one; if $\alpha > 1$, then holding a given level of foreign relative money balances, m^*/c^*, is more costly than holding a given level of domestic relative money balances, m/c; namely, $\alpha u_x > u_x$.

The world economy's equilibrium is characterized by the interest parity condition (4), the set of first-order conditions (5)–(10), and equations (12)–(16), for each country. After some algebraic manipulation, equations (7)–(9) may be rewritten as follows:

$$c^*\phi q = \psi(\alpha,N,N^*)c \tag{19}$$

$$(N + i)N = ix \tag{8'}$$

$$(N^* + \phi i)\alpha N^* = \phi i x , \tag{9'}$$

where $x = T - N - \alpha N^*$ by equation (2), $\phi \equiv i^*/i$, and $\psi(\alpha,N,N^*) \equiv \alpha N^{*2}/N^2$, where $\psi_\alpha > 0$, $\psi_N < 0$, and $\psi_{N^*} > 0$. Equation (19) is obtained by using the fact that equations (7)–(9) can be shown to imply that $U_{c^*}/U_c = U_{m^*}/\phi U_m$. A set of equations analogous to (19), (8'), (9'), and the finance constraints (5) and (6) applies to the foreign economy.

Under the functional specification chosen in (17) and (18), the system is block recursive. In particular, equations (8') and (9') determine alone the equilibrium levels of N and N^* as functions of i, i^*, and α:[14]

$$N = \hat{N}(i,i^*,\alpha)\ ,\ \hat{N}_i > 0,\ \hat{N}_{i^*} < 0,\ \hat{N}_\alpha < 0\ ; \tag{20}$$

$$N^* = \hat{N}^*(i,i^*,\alpha)\ ,\ \hat{N}^*_i < 0,\ \hat{N}^*_{i^*} > 0,\ \hat{N}^*_\alpha < 0\ . \tag{21}$$

The interpretation of the sign of the partial derivatives of N and N^* is the following. An increase in domestic nominal interest rate (that is, the opportunity cost of holding domestic currency) generates, ceteris paribus, an increase in the frequency of withdrawals of domestic currency. For a given consumption level, this leads to a fall in domestic real cash balances. The increase in N (which by the finance constraint (5) implies a fall in the ratio m/c) requires spending more time transacting and, hence, increases the marginal utility of reducing the frequency of foreign currency withdrawals. Therefore, the partial derivative of N^* with respect to i has a negative sign. This interaction between the holdings of domestic and foreign currency through the amount of time used in financial activities explains the phenomenon of currency substitution in this model. An analogous interpretation applies to the signs of the derivatives of N and N^* with respect to the foreign nominal interest rate.

An increase in α raises the marginal cost of using foreign currency; namely, the amount of time associated with a given frequency N^* is higher. As a result, N^* falls implying by equation (6) that the ratio m^*/c^* increases. Since the increase in α raises the total amount of time devoted to transactions activities (hence, reducing leisure), it is also optimal to reduce N because the marginal utility of holding domestic currency increases as leisure falls.[15]

Given N and N^* determined by equations (8') and (9'), and N^f and N^{*f} determined by an analogous set of equations corresponding to the foreign country, equation (19), along with the following conditions, determines the equilibrium values of c, c^*, and q.

$$\psi^f(\alpha^f,N^f,N^{*f})(z - c) = \phi q(z^* - c^*)\ ; \tag{22}$$

$$c + q[1 + (\mu^*/N^*)]c^* = z + \mu(z - c)/N^f\ . \tag{16'}$$

[14]Equations (8') and (9') are quadratic and yield real roots of opposite signs. Equations (20) and (21) describe the solutions of (8') and (9') for which N and N^* are positive.

[15]One can show that $\partial(\alpha N^*)/\partial\alpha = -\partial x/\partial\alpha > 0$. This implies that, ceteris paribus, an increase in α increases the amount of time devoted to cash withdrawals and, hence, reduces leisure.

Equation (22) is the foreign country's counterpart of equation (19), combined with the goods market equilibrium conditions (12) and (13). Equation (16') is obtained by combining equations (16), (12), and the cash-in-advance constraints (5) and (6).

Given c, c^*, and q determined by equations (19), (22), and (16'), equations (12) and (13) determine c^f and c^{*f}, and the finance constraints determine the level of real cash balances in the two countries. Finally, the money market equilibrium conditions determine the price levels and the nominal exchange rate, as functions of the domestic and foreign money supplies.

3. FINANCIAL INNOVATION IN THE PRESENCE OF CURRENCY SUBSTITUTION

In this section, we examine the effects of changes in the parameter α that affect the relative cost of holding foreign currency in the transaction technology given in equation (18). As indicated earlier, changes in this parameter may reflect technical progress in the financial system as well as changes in the regulatory environment. Both phenomena are encompassed under the expression "financial innovation."

Financial innovation may occur simultaneously in all countries or be country-specific. The symmetric equilibrium will be used to explore the effects of *global* financial innovation, while the more general, nonsymmetric equilibrium will be used to explore the domestic effects and the international transmission of *country-specific* financial innovation as well as the effects of unifying financial regulations across countries. The use of the symmetric equilibrium will prove useful to isolate a number of effects which will also be present in the non-symmetric case.

A. *Global Financial Innovation*

A symmetric equilibrium is characterized by the fact that each individual consumes half of the world's endowment of each good, and holds half of each money supply. The equilibrium is described by the following equations:[16]

$$c = c^f = y\ ;\ c^* = c^{*f} = y^*\ ;\ m = m^f = m^s/2\ ;\ m^* = m^{*f} = m^{*s}/2 \tag{23}$$

$$m = \Omega\,(i,i^*,\alpha)y\ ;\ \Omega_i < 0,\ \Omega_{i^*} > 0,\ \Omega_\alpha > 0 \tag{24}$$

$$m^* = \Omega^*(i,i^*,\alpha)y^*\ ;\ \Omega^*_i > 0,\ \Omega^*_{i^*} < 0,\ \Omega^*_\alpha > 0 \tag{25}$$

$$q = \psi[\alpha,\theta,\hat{N}(i,i^*,\alpha),\hat{N}^*(i,i^*,\alpha)]y/y^*\phi \tag{26}$$

$$e = (M^s/M^{*s}\phi)\alpha\hat{N}^*(i,i^*,\alpha)/\hat{N}(i,i^*,\alpha)\ , \tag{27}$$

where $\Omega \equiv \hat{N}^{-1}$ and $\Omega^* \equiv \hat{N}^{*-1}$. Equation (23) is the counterpart of equations (12)–(15). Equations (24) and (25) are the money demand functions, which exhibit

[16]In a symmetric equilibrium $\alpha = \alpha^f$. In addition, we assume for simplicity that $g = g^* = 0$, and the goods endowments equal $2y$ and $2y^*$.

unitary income elasticities. Because of the cash-advance-constraints, the demand for domestic currency is a function of domestic but not of foreign output, while the opposite is true of the demand for foreign currency. Equation (26) shows the equilibrium relative price of foreign goods being affected by foreign and domestic output and, as previously discussed, by financial variables. Equation (27) determines the nominal exchange rate, which—under the functional forms given by equations (17) and (18)—depends on financial considerations but is independent of domestic and foreign output.

Consider the effects of a global decrease in the relative cost of transacting in the foreign currency, represented by a reduction in α. From the money demand equations, it follows that a fall in α reduces the demand for both currencies. This follows from the fact that the frequency of withdrawals of both currencies increases. The frequency N^* increases because, as withdrawing foreign currency uses less time, it is optimal to increase the consumption velocity of foreign money (that is, N^*, since by equation (6) $N^* = c^*/m^*$) and, hence, to reduce average holdings of foreign currency. Since the fall in α makes transacting less costly in general because it induces an increase in leisure, it is optimal to increase the frequency of withdrawals of domestic currency as well and, hence, to reduce average holdings of domestic money. It can be shown that, as one would expect, the ratio of foreign to domestic cash balances increases as a result of a reduction in α.

The fall in the demand for both currencies prompts an increase in both P and P^*. The relative price of foreign goods also increases, as the effect of the increase in N^*—in equation (26)—can be shown to outweigh both the direct effect of α and the effect via the increase of N. Intuitively, the relative price of foreign goods increases because the fall in the marginal cost of using foreign currency affects the relative cost of consuming foreign goods. The effective prices of consumption are affected by monetary considerations because the cash-in-advance constraints imply that consumers must use domestic currency to purchase domestic goods and foreign currency to purchase foreign goods. In particular, a fall in the cost of using foreign currency reduces, *at the initial relative market price,* the relative *effective* price of foreign goods. As a result, an excess demand of foreign goods would be generated at the initial relative market price. Since consumption is not affected by the change in α—recall equation (23)—the relative price of foreign goods must increase in equilibrium. Formally, for an initial level of q, the monetary term of the effective relative price $\tilde{q}$ in equation (7') decreases when α falls. This leads to an increase in the equilibrium level of q, which ultimately leaves consumption as well as $\tilde{q}$ unchanged.

Interestingly, it can be shown that the nominal exchange rate, e, falls following a reduction in α; namely, there is a nominal appreciation of the domestic currency. This reflects the fact that the relative demand for domestic money increases as withdrawing domestic currency has become relatively more costly compared to the foreign currency. Since

$$e = (M^s/M^{*s})(qm^*/m) , \tag{28}$$

it is clear that the fall in the ratio m^*/m outweighs the increase in the real exchange rate, q.

The negative co-movement of the nominal exchange rate and the real exchange rate in response to a reduction in α implies that the fall in the nominal exchange rate is outweighed by the rise in the price ratio P^*/P. Such negative co-movement shows clearly the distinction between monetary and real effects. While the nominal appreciation occurs because of a change in the relative demand for monies, the increase in the real exchange rate reflects a change in the relative effective price of consumption goods.

B. International Transmission of Financial Innovation, and Financial Unification

This section discusses the effects of country-specific changes in α, using the more general, nonsymmetric framework. The analysis of country-specific changes in α allows us to explore the effects of unifying financial regulations across countries. Moreover, the effects of financial innovation on consumption and on the net transfers of seigniorage across countries—present because of currency substitution—can be analyzed.

Consider the effects of a reduction in α, which occurs only in the domestic economy—that is, α^f remains unchanged. The reduction in α may be thought of as resulting from the requirement that, as part of a process of financial unification, the domestic economy adjust its financial regulations concerning transactions in foreign currency to those existing in the foreign economy. Formally, this form of financial unification can be viewed as moving from an initial situation in which $\alpha > \alpha^f$ to a situation in which $\alpha = \alpha^f$ by reducing α.[17]

For the same reasons discussed earlier, a reduction in α results in higher consumption velocity of circulation of both currencies; namely, both N and N^* increase. Unlike the symmetric equilibrium, country-specific financial innovation affects consumption both in the domestic as well as in the foreign economy. The effect of a reduction in α on the levels of consumption and the real exchange rate are found by calculating the comparative statics of the system composed by equations (19), (22), and (16'):

$$dc/d\alpha = -(1/\Delta)q\phi z^*\{c(1 + \mu^* N^{*-1})(d\psi/d\alpha) - \mu^* N^{*-1}\phi q c^* \hat{N}^*_\alpha\} \tag{29}$$

$$dc^*/d\alpha = (1/\Delta)(\mu^*/N^{*2})\{\phi q c^* \hat{N}^*_\alpha[\psi(z^* - c^*) + \psi^f c^*]\} < 0 \tag{30}$$

$$\begin{aligned} dq/d\alpha = (q/\Delta)\{&c(d\psi/d\alpha)[\phi(1 + \mu N^{f-1}) + \psi^f(1 + \mu^* N^{*-1})] \\ &- (\psi^f - \psi)(\mu^*/N^{*2})\phi q c^* \hat{N}^*_\alpha\}\,, \end{aligned} \tag{31}$$

where $\Delta = q\phi z^*(\phi + \Psi) > 0$ and $d\psi/d\alpha = \psi_\alpha + \psi_N \hat{N}_\alpha + \psi_{N^*}\hat{N}^*_\alpha < 0$.

[17]In some cases, unification of financial regulations may involve changes in both countries; for instance, unification may involve eliminating some regulations in one country and imposing additional regulations in the other country. This would imply studying—along the same lines—the combined effects of two country-specific changes: moving from an initial situation in which $\alpha > \alpha^f$ to a situation in which $\alpha = \alpha^f$ by simultaneously reducing α and increasing α^f. The results from this alternative exercise do not provide significant additional insights to those obtained from the case discussed in the paper.

First, consider the effects of a reduction in α abstracting from the changes in net seigniorage transfers across countries. This is obtained by setting μ and μ^* equal to zero in equations (29)–(31).[18] When there are no seigniorage revenues, a reduction in α decreases domestic consumption of the domestic good, and has no effect on domestic consumption of the foreign good. As in the case of global financial innovation, a reduction in α induces an increase in the real exchange rate. In this case, however, since the ratio of domestic to foreign goods falls, there is a fall, in equilibrium, of the effective relative price of foreign goods. This implies that the increase in the *market* relative price of foreign consumption goods does not fully offset the fall in the monetary term—in equation (7')—affecting the *effective* relative price of foreign consumption goods.

The demand for domestic money in the domestic economy falls because of two reasons. First, the shift in consumption away from domestic goods reduces the amount of domestic money used. Second, there is an increase in N, as the fall in α makes transactions less costly in terms of time. Similarly, given that N^* increases while c^* remains unchanged, there is a fall in the domestic demand for foreign currency.

The effects of financial innovation in the domestic economy are transmitted to the foreign economy. Through the goods market equilibrium condition, it is easy to see that the level of consumption of domestic goods in the foreign country increases, while foreign consumption of foreign goods remains unchanged. The increase in c^f is induced by the increase in the real exchange rate. (It is worth noting that, in the foreign country, the increase in the market relative price of foreign consumption goods also implies an increase in the effective relative price of foreign consumption goods, since the monetary term in the equation analogous to (7') for the foreign country is not affected by a change in α.) Since N^f and N^{*f} remain unaffected by financial innovation in the home country, it is clear that the foreign demand for domestic currency increases due to the higher consumption of domestic goods, while the foreign demand for foreign currency remains unaffected.

Since the demand for foreign currency falls at home and remains unchanged abroad, the world demand for foreign currency falls. This increases the equilibrium price level of the foreign good, P^*. The effect on the equilibrium price of the domestic good is ambiguous because the demand for domestic currency falls at home but increases abroad. The expression for the effect of α on $(m + m^f)$ is the following:

$$d(m + m^f)d\alpha = (N^{-1} - N^{f-1})(dc/d\alpha) - (c/N^2)\hat{N}_\alpha \, . \tag{32}$$

The sign of (32) depends on a "transfer problem" criteria, namely, the difference between the consumption velocities of circulation of the domestic currency in the two countries. If, at the initial equilibrium, those velocities are equal, that is, $N = N^f$, a reduction in α results in a fall in the world demand for the domestic currency. In this case, the equilibrium price of the domestic good increases.

[18]This implies that $\phi = 1$.

Also the effect of a reduction in α on the nominal exchange rate depends on transfer problem criteria, as can be seen from the following expression for the equilibrium nominal exchange rate:[19]

$$e = (M^s/M^{*s})[\Theta(qm^*/m) + (1 - \Theta)(qm^{*f}/m^f)]$$
$$= (M^s/M^{*s}\phi)[\Theta(\alpha N^*/N) + (1 - \Theta)(\alpha^f N^{*f}/N^f)] \,, \tag{33}$$

where $\Theta \equiv m/(m + m^f)$. Two effects may be distinguished. First, there is an increase in the ratio qm^*/m. Second, there is a fall in Θ. If, at the initial equilibrium, the two countries have the same ratio of domestic to foreign monies, then the second effect disappears and the reduction in α induces a fall in the nominal exchange rate, as in the previous section. In this case, there is a negative co-movement between the nominal and the real exchange rate; namely, a reduction in α generates a nominal appreciation of the domestic currency but a real depreciation in the sense that there is an increase in the equilibrium relative price of foreign goods.

Consider next the additional effects that appear because of the transfer of seigniorage across countries.[20] These are the terms in equations (29)–(31), which involve the rates of monetary expansion. Since a lower α induces a fall in the domestic demand for foreign currency, there is a reduction in seigniorage paid by the domestic to the foreign country. In addition, since there is an increase in foreign holdings of domestic money, the domestic country receives more seigniorage from abroad. These two effects imply that there is increase in net transfers from the foreign to the domestic economy. For the domestic economy, these higher net seigniorage inflows constitute a positive wealth effect, which results in a net increase in consumption of foreign goods, and has a positive effect on consumption of domestic goods. The net effect on c, however, is ambiguous and depends on the magnitude of this wealth effect. In the foreign country, the effects are reversed, leading to a net decrease in consumption of foreign goods and an ambiguous effect on consumption of domestic goods. With these additional effects stemming from cross-border transfers of seigniorage, the effect of α on the relative price of foreign goods is ambiguous. If, at the initial equilibrium, $\psi^f = \psi$ the reduction in α increases q.

4. CONCLUSION

This paper has presented a framework in which the domestic effects and the international transmission of financial innovation in the presence of currency substitution can be examined. The analysis provides a number of insights. First, because of the nature of the cash-in-advance constraints faced by individuals, financial considerations are shown to affect the relative effective price of consumption goods and, hence, the equilibrium real exchange rate.

[19]Equation (33) is also valid when μ and μ^* are different from zero.

[20]The importance of currency substitution for the cross-border payment of seigniorage has been analyzed by Fisher (1982), who provides estimates of the size of these transfers for several groups of countries.

Second, analyzing the effects of financial innovation that changes the relative cost of transacting in one currency, it has been found that such innovation may lead to negative co-movements between the nominal and the real exchange rate. This negative co-movement is explained in terms of the effects of financial innovation on the relative demand for currencies, on one hand, and on the effective relative price of consumption goods, on the other hand.

Third, the international transmission, as well as the domestic effects, of financial innovation depends importantly on how it affects the cross-border transfers of seigniorage, which occur because of the presence of currency substitution, in addition to how it affects the equilibrium real exchange rate. In particular, it is shown that a change in the technological (or, regulatory) environment that reduces the cost of transacting in the foreign currency induces, provided the two countries are initially similar, a nominal appreciation and real depreciation of the domestic currency, and results in a net seigniorage inflow from the rest of the world.

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