Dual-Currency Economies as Multiple-Payment Systems

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Introduction

The phrase "multiple payment systems" typically brings to mind objects such as checks, credit cards, debit cards and, more recently, "smart" cards. However, many countries throughout history have used more than one currency at a time. In fact, although we tend to forget it, the use of multiple currencies as media of exchange in the United States was common into the 1930s. Until their abolition in 1935, privately issued banknotes were commonly used simultaneously with government-fiat and commodity-backed money. During its bimetallism period, the United States used two different government-issued commodity monies: gold and silver coins. More recently, we observe two-currency payment systems in developing and transitional economies, in which many modern payment systems are unavailable. Nevertheless, citizens may adopt a dual-payment system by using the dollar in addition to their own locally issued fiat currency as a medium of exchange, store of value, and unit of account. Indeed, this practice concerns the Federal Reserve System because a large amount of U.S. currency is being shipped overseas, partly to finance multiple-payment options (see Porter and Judson [1996]).

What is particularly fascinating is that people's use of a foreign currency in addition to their own government's fiat currency arises spontaneously (in response to market desires) rather than by government edict. Hence, governments' traditional reasons for circulating fiat currency (legal restrictions, use of fiat currency to discharge tax liabilities) fail to explain why a country's citizens would adopt fiat currency issued by a foreign sovereign as a medium of exchange. Consequently, to understand how a foreign currency comes to circulate in the domestic economy, one must model the private decision to accept foreign currency in exchange for goods and services. This is especially important for policymakers who wish to "drive out" a foreign currency or increase the acceptability of the domestic one. To do so, they must understand the foreign currency's fundamental benefits and costs.

In this article, we discuss recent research on dual-currency economies, focusing on monetary search models. Search models have special applicability to dual-currency economies because they explicitly model economic agents' decisions to accept a fiat currency in trade. They also yield insights concerning what the local government can do to alter the acceptability of the foreign relative to the domestic currency. The rest of this article is structured as follows: In section I, we present a simple one-country, two-currency search model of money to illustrate the acceptability of multiple currencies. Section II surveys the findings of dual-currency models from the search-theory literature. In section III, we use our simple model to study the policies used by one country, Ukraine, to increase the acceptability of a newly issued domestic currency and eliminate the acceptability of the dollar as a medium of exchange.

I. A Simple Dual-Currency Model

The fundamental purpose of search-theoretic models is to describe the trading frictions that produce the intrinsically useless object called money. The key friction in these models is the absence of a double coincidence of wants, which implies that bilateral trade (barter) is not possible and thus some payment system is needed before trade can occur. A dual-currency economy simply allows more than one object to serve as a medium of exchange. Several models of the type considered here appear in Aiyagari, Wallace, and Wright (1996), Li and Wright (1998) and Wallace (1998).

Preferences

Agents in this economy consume and produce goods and services but cannot produce their desired consumption good; hence, they must trade in order to consume. There are $k > 3$ types of goods in the economy distributed along the unit circle. Goods are divisible and nonstorable (services). An agent who produces good i desires good $i+1$ for consumption; consequently, a double coincidence of wants is not possible between a given pair of agents. The probability of a single coincidence of wants is given by $x = 1/k$. Agents receive utility from consumption $u(q)$, where q is the quantity of their consumption good and $u'(q) > 0$, $u''(q) < 0$ and $u(0) = 0$. Agents' disutility from production is given by $c(q)$, with $c'(q) > 0$, $c''(q) \geq 0$ and, $c(0) = 0$. It is also assumed that $u'(0) - c'(0) > 0$, and that there is some value of $\bar{q}$ such that $u(\bar{q}) - c(\bar{q}) = 0$. The number of agents in the economy is normalized to 1.

Agents do not trade in centralized markets but rather search for suitable trading partners. Individuals meet at random with probability α and meet only one person at a given point in time.[1] It is typically assumed that trading histories are private information, which makes trade credit impossible. Hence, some other payment mechanism is necessary for trade. That mechanism is money.

Money

Besides production goods, another type of good exists in this economy—money. While most search models study fiat currency, which is intrinsically worthless (that is, it provides no utility) but is costless to carry around, other models assume that money generates some basic cost (such as storage or transportation) or benefit (for example, aesthetic beauty), independent of its use as a medium of exchange. To capture all of these possibilities, we assume that a holder of currency i incurs a per-period holding cost (benefit) of $t_i > 0$ (< 0). For $t_i = 0$, the currency is truly a costless fiat currency.

Unlike a consumption good, money is durable. For analytical reasons, we assume that money is indivisible and agents can carry only one unit at a time.[2] We also assume that agents cannot produce until they have consumed.[3] As a result of this assumption, there are only two possible trading states for agents in this economy: They hold either 0 units of money (sellers) or 1 unit of money (buyers). Let M denote the proportion of agents in the economy who hold money, and $m_0 = 1 - M$ denote the proportion of sellers. Since we have two currencies, let m_1 denote the proportion of agents in the economy holding currency 1, and let m_2 denote the proportion holding currency 2. It then follows that $M = m_1 + m_2$ and that $m_0 + m_1 + m_2 = 1$.

1 This is modeled more formally and precisely by saying that meetings occur according to a Poisson process with arrival rate α.

2 This is typically done to avoid having to solve for the steady-state distribution of money holdings and trading prices.

3 This eliminates transactions in which money trades for money plus some goods. Aiyagari, Wallace, and Wright (1996) analyze a model in which these types are allowed.

Bargaining

We consider equilibria in which a money holder meets a seller who produces the money holder's preferred good. We assume that in such a meeting the buyer makes a take-it-or-leave-it offer which entails specifying an amount of the good for the unit of currency. The seller must decide whether to accept this offer or go on. This is true for either currency. Furthermore, if the offer is accepted, the money holder must judge it worthwhile to give up the unit of currency for the consumption good.

Returns to Search

Given the structure above, we can write down the steady-state returns to searching for both buyer and seller:

(1) $rV_2 = \alpha x m_0 \Pi_0^2 \max[u(q_2) + V_0 - V_2, 0] - t_2,$

(2) $rV_1 = \alpha x m_0 \Pi_0^1 \max[u(q_1) + V_0 - V_1, 0] - t_1,$

and

(3) $$rV_0 = \alpha x m_1 \max_{\pi_0^1} \pi_0^1[-c(q_1) + V_1 - V_0] + \alpha x m_2 \max_{\pi_0^2} \pi_0^2[-c(q_2) + V_2 - V_0],$$

where $i = 0$ denotes sellers, $i = 1$ denotes holders of currency 1, and $i = 2$ denotes holders of currency 2. V_i denotes the value function for a trader of type i and measures the expected present discounted value of utility from trading in the future, given that the current trading position is i. The parameter r is the real interest rate, q_i is the quantity of goods given up by a seller for currency i, and t_i is the per-period cost associated with holding currency i. In addition, the parameter Π_0^i, $i = 1, 2$ denotes the probability (as perceived by the buyer) that a seller will accept currency i in return for goods. The parameter π_0^i captures the seller's decision to accept or reject an offer to trade his good for currency i. If $\pi_0^i = 1$, the currency is accepted by the seller as payment; if $\pi_0^i = 0$, the seller chooses not to accept the currency. In a Nash equilibrium with identical sellers, $\pi_0^i = \Pi_0^i$, for $i = 1, 2$.

The right sides of equations (1) and (2) denote the expected return from trading. This is the probability of a buyer meeting a seller who has his desired consumption good, times the utility from consuming q_i, minus the cost of switching from a buyer to a seller $(V_0 - V_i)$. If this payoff is positive or zero, the buyer makes the trade; if it is negative, he does not. No other match of agents yields a payoff, since money holders who meet money holders do not trade currencies and because trading currency 1 for currency 2 plus some goods is ruled out by assumption. For the sellers, equation (3) is the expected return from producing q_i for a unit of currency i and then reversing roles. If this payoff is positive or zero, the seller chooses $\pi_0^i = 1$; if the payoff is negative, the seller does not accept the currency and sets $\pi_0^i = 0$. If the seller is indifferent as to accepting the money or rejecting the offer of money for goods, $0 < \pi_0^i < 1$; in other words, the seller flips a coin to decide whether to accept the currency. In the latter case, we say that a currency is only *partially* acceptable in trade.

Given our bargaining assumptions, the buyer's offer leaves the seller indifferent as to accepting the offer or walking away. Since the payoff is non-negative, the seller accepts the offer.[4] Thus, the equilibrium offer satisfies

(4) $V_1 = c(q_1) + V_0$

and

(5) $V_2 = c(q_2) + V_0.$

Furthermore, for the offer to be acceptable to the buyer as well, it must be the case that

(6) $u(q_1) + V_0 \geq V_1$

and

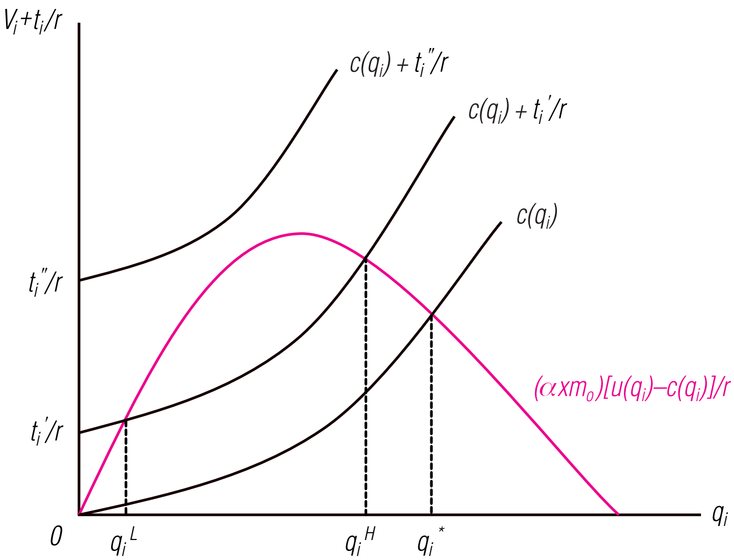
(7) $u(q_2) + V_0 \geq V_2.$

Hence, (6) and (7) are the buyer's incentive-compatibility constraints. Combining (4)–(7) implies that bargains acceptable to both sides must satisfy $u(q_i) - c(q_i) \geq 0$ for $i = 1, 2$.

4 In this case, the seller could choose any value of $0 \geq \pi_0^i \geq 1$, since he is indifferent. However, the buyer can always decide to accept a slightly smaller quantity of goods in return for the currency. This would make it rational for the seller to set $\pi_0^i = 1$, since he receives a positive surplus from trading.

FIGURE 1

Possible Monetary Equilibria



SOURCE: Authors' calculations.

A Dual-Currency Equilibrium

Consider the equilibrium in which both currencies are fully acceptable, $\pi_0^i = \Pi_0^i = 1$, for $i = 1, 2$. This corresponds to a dual-currency economy. Under full acceptability and buyer-take-all bargaining, equations (3)–(5) imply that $V_0 = 0$. In short, since buyers extract all the surplus from trade, the value of being a seller is zero.[5] All that remains is to determine the quantities q_1 and q_2 that can then be used to solve for V_1 and V_2 through equations (4)–(5). Substituting (4)–(5) into (1)–(2) for V_1 and V_2, with $V_0 = 0$, yields

$$(8) \quad c(q_2) + t_2/r = \alpha x m_0 [u(q_2) - c(q_2)]/r$$

and

$$(9) \quad c(q_1) + t_1/r = \alpha x m_0 [u(q_1) - c(q_1)]/r.$$

Equations (8)–(9) yield two independent equations in two unknowns, q_1 and q_2. If (8) and (9) have a solution, (q_1^*, q_2^*), in which the equations' right side is positive, then we have a steady-state equilibrium that satisfies the buyer's incentive-compatibility constraints.

Since (8) and (9) are functionally the same equation, we can illustrate the solution to both with figure 1. The right side of (8) and (9) is the expected present discounted value of the surplus from trading minus the holding cost and, given our assumptions on the utility and cost functions, is the hump-shaped curve in figure 1. The left side of (8) and (9) is an upward-sloping function in q with an intercept of t_i/r, which depends on the time cost of holding money of type i, t_i, normalized by the interest rate, r. For $t_1 = t_2 = 0$, it is relatively easy to show that a nonzero solution to (8) and (9) exists, is unique, and satisfies the buyer's incentive-compatibility constraints. The values of (q_1^*, q_2^*) that solve this equation will be a function of the parameters governing the trading environment and the preferences of the individual agent. The decision to accept a currency is endogenous and also a function of these fundamentals; we do not impose the currency's use from outside the model. Hence, we are able to derive the existence of a dual-currency equilibrium for an optimizing model of exchange in which the acceptability of the currencies is endogenously determined.

For the case of $t_1, t_2 > 0$, we will have either two solutions to each equation, (q_i^L, q_i^H), or no solution.[6] In this situation, holding money is costly, so a seller must be compensated for giving up his good to accept money and incur this holding cost. If the cost of holding money is sufficiently low, then there are a low and a high equilibrium. Again, if $t_1 = t_2$, the two solutions are the same for both currencies, since they are indistinguishable. As this cost increases, the low and high equilibrium values converge until, for sufficiently high costs, no equilibrium exists. In short, sellers demand such a high payoff to overcome the holding cost of money when becoming buyers that no trade exists, which is incentive-compatible for current buyers. Figure 1 shows how a single-currency equilibrium arises. If t_1 is sufficiently small and t_2 is sufficiently large, then private agents will use currency 1 but not currency 2 to trade, and vice versa. Thus, if the government can manipulate these two holding costs, it can alter the acceptability of each currency relative to the other.

5 If we assumed an alternative bargaining structure, such as Nash bargaining, V_0 would be greater than zero but it would be harder to derive the equilibrium quantities traded.

6 On the other hand, if holding a unit of money provides a net benefit in and of itself, $t_i < 0$, then if a monetary equilibrium exists, it will be unique. This would be shown in figure 1 by shifting $c(q_i)$ down to reflect a negative intercept. As a result, the two curves would intersect once in the positive quadrant, if at all.

We will return to this idea in section III to discuss a case in which one government accomplished this feat by altering the relative transaction costs to "de-dollarize" its economy.

Implications of the Model

Several important aspects of the model are worth mentioning. First, for $t_1, t_2 > 0$, there are multiple monetary equilibria. This common feature of search models illustrates the importance of focusing on the dynamics of the model to determine which equilibria are stable and which unstable. However, it is possible to Pareto-rank the two equilibria—q_i^H yields the higher equilibrium value of V_i. Since production is costly, sellers will be willing to incur the greater disutility of producing q_i^H only if the unit of currency they receive in return is more highly valued. As a result, unless $V_i(q^H) > V_i(q^L)$, it would not be rational to produce q^H rather than q^L.

Second, the currency values are independent of one another, that is, q_1 does not depend on q_2, and vice versa. In general, we would expect economic fundamentals that change the value of one currency to change the value of the other currency as well. For example, if the holding cost of one currency increases, we might expect to see currency substitution to occur as people move from the high-cost currency to the other one. Portfolio reallocation of this type does not happen here.

Third, the only difference between the two currencies' values results from the ad hoc cost/benefit ratio of holding the currencies. In the case where $t_1 = t_2$, it is also true that $q_1 = q_2$, since (8) and (9) are identical. This means that the two currencies are identical. If that is so, why use more than one? The use of two different currencies suggests that there is a fundamental difference between them; the model above suggests that the difference is related to the holding costs or benefits of each currency rather than the trading environment.

Fourth, currency trades do not occur in the model because of the one-unit-of-money inventory restriction.[7] Consequently, no nominal exchange rate exists in the model. Nevertheless, an implicit real exchange rate exists, given by the ratio of q_1/q_2. However, it will differ from 1 only if $t_1 \neq t_2$. In short, the real exchange rate depends on costs that are determined outside the model rather than on the trading environment or on preferences.

Fifth, the relative amounts of the two currencies in the economy, m_1 and m_2, do not influence the equilibrium quantities of goods. This is a result of the buyer-take-all assumption. The values m_1 and m_2 appear in the returns to search only for the seller, rV_0. But with the buyer-take-all condition, $V_0 = 0$ for all values of m_1 and m_2. Consequently, the actual stocks of each currency are irrelevant for determining their equilibrium values. This result would change if we adopted a more general bargaining structure such that both parties gain from trade.

Sixth, the closed-economy assumption used here is plausible for two domestic currencies. However, in most dual economies today, one of the currencies is foreign. Hence, the model ignores the fact that the foreign currency enters the economy in some fashion and also leaves the economy through purchases of imported goods. Therefore, the model is clearly missing an important feature of dual-currency economies, namely, trading interactions with other economies. To address this issue, one needs a two-country, two-currency model of money.

Finally, in the current set-up, it is difficult to see exactly how government policy can affect the equilibrium values of q_1 and q_2, since they depend only on the fundamentals of the trading environment and on preferences. Unless one argues (as we did above) that the government can alter the fundamental costs of holding the two currencies, a more elaborate formulation is needed to capture fully the government's role in the search model.

As the foregoing discussion points out, the simple model outlined above is lacking in many dimensions, despite its appealing features for endogenously determining the acceptability of fiat currencies. In the next section, we review the literature to show how the simple search model described here can be amended to include more interesting and realistic features of dual-currency economies.

7 There are equilibria in this model in which a unit of currency 1 trades for a unit of currency 2 plus some amount of goods and vice versa. However, these trades cannot occur if we assume that consumption must precede production, since they require the currency-2 money trader to produce twice before consuming.

II. Research on Dual-Currency Search Models

One-Country, Two-Currency Models

Indivisible Goods

In their first paper on search models of money, Kiyotaki and Wright (1989) look at the possibility of two commodity monies circulating in a closed economy. In this model, agents produce an indivisible good and then carry it with them in search of trading partners. As a result, there are real storage and transportation costs associated with goods production. Kiyotaki and Wright then ask whether one or more of the commodities will be accepted by traders who do not want the good for consumption purposes. They show that in certain equilibria, one of the goods uniquely serves as commodity money (the low-storage-cost good); in other equilibria, two of the goods circulate as money (the two lowest-cost goods). The authors explore whether a good that is useless to all traders but has zero storage costs can circulate as money—a true fiat currency. They show that there are equilibria in which both the commodity money and fiat money circulate. Thus, this was the first search model that looked at dual-currency issues.

In a 1993 paper, the same authors present a more elegant description of the indivisible-good-and-money search model and its solution. They explore the coexistence of two fiat currencies that have different dividends or storage costs, similar to t_1 and t_2 in the model described in section I. They show that there are equilibria in which both currencies circulate. Similar equilibria are derived in Aiyagari and Wallace (1992). One interesting feature of Kiyotaki and Wright's results is that even if the two currencies have identical storage costs ($t_1 = t_2$ in the model above), they may have different acceptabilities and thus different expected exchange values. Kiyotaki and Wright show that an equilibrium exists in which one currency is fully acceptable ($\Pi_0^1 = 1$) while the other is only partially acceptable ($0 < \Pi_0^2 < 1$). Since it is less widely accepted, the value of holding it is lower. This is an appealing finding for those of the developing and transitional economies where the foreign currency is not universally accepted in exchange. Thus, the dual-currency equilibria with different acceptabilities mimic a real-world feature of dual-currency economies.

Divisible Goods

Kiyotaki and Wright's finding that two identical currencies can have different trading values is puzzling, given our model showing that if $t_1 = t_2$, the two currencies will have the same equilibrium exchange value. What is the reason for these contradictory results? The different exchange values result from having a partially acceptable currency, which in turn results from the use of mixed strategies when goods are indivisible. Mixed strategies come into play when sellers are indifferent as to accepting or rejecting money in exchange for an indivisible unit of the good. Shi (1995) and Trejos and Wright (1995a) demonstrate that when goods are divisible, the buyer can always offer to take an infinitesimally smaller amount of the good to ensure that the seller is not indifferent and trade occurs. Since the seller will always accept such an offer, partial acceptability never occurs. Thus, while introduction of divisible goods into the standard search models was a great step forward in understanding exchange, it eliminated an empirically relevant equilibrium, namely, the partial acceptability of one of the currencies. Amending the search model to generate partial acceptability (when only some sellers accept the foreign currency all of the time) remains to be done.

Another feature of the equilibrium derived in the model in section I is that if $t_1 = t_2$, both currencies circulate at par. How can we generate different trading values of the currencies in the model above? Aiyagari, Wallace, and Wright (1996) show that there are more equilibria in our simple model than we discuss: An equilibrium exists in which one currency is perceived to have more value than the other. In pairings of currency-1 and currency-2 money traders, currencies are exchanged and the holder of the less valuable currency (the seller) also gives up some goods. To see this, suppose agents believe for some reason that currency 2 is more valuable than currency 1. One can think of these equilibria as ones in which the seller "gives change"—trades some of the good for the currency but also gives the buyer change (the seller's currency). This version of the model would alter equations (1)–(3) as follows (setting $V_0 = 0$ and $\Pi_0^1 = \Pi_0^2 = 1$, for $i = 1, 2$.):

$$(10)\quad rV_2 = \alpha x m_0[u(q_2) - V_2] - t_2 + \alpha x m_1[u(q_{12}) + V_1 - V_2],$$

$$(11)\quad rV_1 = \alpha x m_0[u(q_1) - V_1] - t_1 + \alpha x m_2[-c(q_{12}) + V_2 - V_1],$$

and

$$(12)\quad rV_0 = 0,$$

where q_{12} is the quantity of goods given up by a currency 1 holder in addition to his unit of currency 1 in return for a unit of currency 2. Assuming that the currency 2 holder makes a take-it-or-leave-it offer to the currency 1 holder, the bargaining conditions for q_1, q_2, and q_{12} are

$$(13)\quad V_1 = c(q_1),$$

$$(14)\quad V_2 = c(q_2),$$

$$(15)\quad V_2 - V_1 = c(q_{12}),$$

and

$$(16)\quad V_2 - V_1 \leq u(q_{12}),$$

where (16) is the incentive-compatibility constraint for the currency 2 holder in a "making change" trade. Equations (15)–(16) imply $u(q_{12}) \geq c(q_{12})$. Substituting (13)–(15) into (10)–(11) and then subtracting (10) from (11), with $t_1 = t_2$, yields

$$(17)\quad c(q_2) + t_2/r = \{\alpha x m_0[u(q_2) - c(q_2)] + \alpha x m_1[u(q_{12}) - c(q_{12})]\}/r,$$

$$(18)\quad c(q_1) + t_1/r = \alpha x m_0[u(q_1) - c(q_1)]/r,$$

and

$$(19)\quad c(q_{12}) = \{\alpha x m_0[u(q_2) - u(q_1)] + \alpha x m_1[u(q_{12}) - c(q_{12})]\}/(r + \alpha x m_1).$$

Equation (18) is the same as equation (9), so the solution for q_1 is the same as before. However, it is clear from (17) that, since the last term must be positive for "making change" trades to occur, $q_2 > q_1$ if a monetary equilibrium exists. Finally, $q_2 > q_1$ implies that (19) yields a positive value for q_{12} (under appropriate parameter values).

The point of this example is that even though the two currencies are fundamentally the same, as long as traders believe that one of the two is more valuable, it will be in equilibrium, and currency 2 will trade for currency 1 if the currency 1 trader gives a "side payment" of q_{12}. One last point is that, in this example, the quantity q_2 coming out of (17) depends on q_{12}, while the value of q_{12} that solves (19) depends on both q_1 and q_2. Thus, unlike the equilibrium studied in section I, the values of the two currencies in this equilibrium are interdependent.

Shi (1995) proposes an alternative method for generating different trading values for fundamentally equivalent currencies. He assumes that different currencies are associated with different bargaining arrangements. For one currency, the bargaining rule is buyer take all, with the seller getting zero surplus from the trade; the other currency trades under a Nash bargaining rule in which the surplus of trade is split between the buyer and seller. In short, Shi assumes that the bargaining conditions in (4)–(5) now look like

$$(4')\quad V_1 = c(q_1) + V_0$$

and

$$(5')\quad V_2 > c(q_2) + V_0\,.$$

Under this formulation, sellers expect to receive a positive surplus if they trade for currency 2, but no surplus when they trade for currency 1. Shi then shows that both currencies can circulate in trade but with different trading values, since sellers view the two currencies differently. However, it is not clear why traders would adopt different bargaining strategies based solely on the currency's national origin.

Gresham's Law

The one-country, two-currency framework has also been used to study Gresham's Law, which posits that "bad money drives out good." Velde, Weber, and Wright (1999) use a search model to study this long-standing issue. Their framework features a commodity money that yields a dividend to its holder; good money generates a higher dividend than bad. In the model above, this would correspond to currency 1 being the good one and currency 2 being the bad one by setting t_1, $t_2 < 0$ and $t_1 < t_2$. Velde, Weber, and Wright assume that some sellers have imperfect information and cannot determine which currency they are trading for. This creates a "lemons" problem—uninformed sellers are not willing to produce a sufficient amount of the commodity for the good money, since they are afraid of getting the bad money in return. The authors show that under some parameters, holders of the good money will not trade with these uninformed sellers, who undervalue the good currency. In this sense, Gresham's Law holds, since only the bad money circulates in trade.

Private versus Public Currency

As we mentioned earlier, the coexistence of privately issued bank notes and government-issued currency ("outside" money) has a long history in the United States. However, in the typical search model, no individual can unilaterally issue his own commodity-backed currency, since it would have to be redeemable at some point—an impossibility if all trading histories are private information. Cavalcanti and Wallace (1999) loosen this assumption and allow the trading histories of a subset of agents to be public information. These agents can then effectively function as banks and thus issue commodity-backed banknotes. Calvalcanti and Wallace show that banknotes and government-issued currency can coexist if the supply of outside money is sufficiently scarce.

Government Policy

Although the government is implicitly present in the search models as the creator of fiat currency, a prototypical search model lacks an active government and so has very little analysis of government policy.[8] Incorporating government into search models typically means assuming that the government is a subset of agents in the economy who adopt various strategies for trading when matched with private agents. With regard to government policy in dual-currency economies, Curtis and Waller (2000) argue that a policy in developing and transitional economies commonly makes the foreign currency illegal for internal trade. To give this illegality any meaning, however, the government must enforce the policy. Curtis and Waller adopt Li's (1995) approach, assuming that when government agents meet private agents who hold foreign currency 1, they either confiscate the currency or impose a fine.[9] Li assumes that a proportion g of the agents in the economy are government agents, with $g = g_0 + g_1$, where g_0 is the proportion of government agents without a unit of currency 1 and g_1 is the proportion of government agents holding a unit of the foreign currency 1. Upon meeting a holder of currency 1, government agents without a unit of currency confiscate the currency and use it to buy goods from sellers according to a take-it-or-leave-it offer. In addition, the government imposes a fine on using the foreign currency which corresponds to having $t_1 > 0$ and $t_2 = 0$. Under this set of assumptions, the returns to search equations (1) and (2) become

$$(20) \quad rV_2 = \alpha x m_0 [u(q_2) - V_2]$$

and

$$(21) \quad rV_1 = \alpha x m_0 [u(q_1) - V_1] - g_0 [V_1 - V_0 - t_1].$$

The second term in (21) is the expected cost to a holder of currency 1 of having the currency confiscated by the government agent and paying the fine. Curtis and Waller show that in some variants of the model, increased enforcement of currency restrictions lowers the trading value of the foreign currency and can drive it out of the economy while strengthening the value of the domestic currency. In figure 1, this would correspond to increasing t_1 to the point where currency 1 is not accepted.

Li and Wright (1998) take a different approach to studying policy. They too assume that government agents produce goods for money, but rather than accepting a currency according to optimizing behavior, they base acceptance on an exogenously determined trading rule. They examine a dual-currency economy to see whether a government strategy of "accept domestic currency, reject foreign currency" can drive the foreign currency out of circulation. The model presented in section I can be amended to illustrate this argument. Let currency 1 be the foreign currency. Let g be the proportion of government agents in the economy, with $g = g_0 + g_2$, where g_0 is the proportion of government sellers in the economy and g_2 is the proportion of government agents holding a unit of the domestic currency 2. The adding-up constraint requires that $1 = m_0 + m_1 + m_2 + g$, which implies $m_0 = 1 - m_1 - m_2 - g$. Government buyers make take-it-or-leave-it offers to sellers and accept such offers of currency 2 but not currency 1. The returns to search for holders of currency 1 and currency 2,

8 Ritter (1995) explicitly models the government as a subset of private agents who get together and issue currency and adopt the strategy that they will always accept the currency in trade. However, it is hard to distinguish a government from a private bank in his model. Dual currencies would reflect currencies issued by competing private banks or by competing governments, either state or local.

9 In single-currency models, confiscation by the government is considered equivalent to an inflation tax.

given earlier in equations (1) and (2), are now given by

$$(20') \quad rV_2 = \alpha x m_0[u(q_2) - V_2] - t_2 + \alpha x g_0[u(q_{g2}) - V_2]$$

and

$$(21') \quad rV_1 = \alpha x\,(1 - m_1 - m_2 - g)[\,u\,(q_1) - V_1] - t_1,$$

where q_{g2} is the quantity of goods a government agent gives up for a unit of currency 2. From these two equations we see that as g increases, all else being equal, the value of holding currency 1 falls, while the corresponding increase in g increases V_2 through the increase in g_0. Thus, Li and Wright show that if government is a large enough subset of the population, its transaction strategy will succeed in driving the foreign currency out of circulation.

Velde, Weber, and Wright (1999) adopt a different approach to modeling government policy in their study of Gresham's Law. They have the government adopt a debasement policy whereby private agents can bring in the high-value commodity money and convert it to the low-value commodity money. The private agent gets some of the surplus commodity from reminting for consumption purposes, and the government gets some of the commodity as seigniorage revenue. For certain parameterizations of their model, all holders of the good money will choose to remint their coins; thus, government seigniorage policy is capable of driving out one of the currencies.

Multiple Money Holdings

All the models described so far share one key assumption—the restriction that agents cannot hold more than one unit of money. Allowing agents to hold more implies that the proportion of agents holding a certain quantity of money is not constant, since people buy their way into and sell their way out of a level of money holdings. Permitting agents to hold multiple units requires solving for a steady-state distribution of money holdings in addition to all the quantities traded between a large (possibly infinite) number of traders who enter into bargaining with differing levels of money holdings. While research has begun to move in this direction for one-country, one-currency models (see Molico [1998], Camera and Corbae [1999], and Green and Zhou [1998]), very little has been done for *two*-currency, multiple-money holding search models. An exception is the work of Craig and Waller (1999), which examines how agents choose to hold *portfolios* of currencies and how the government's "inflation tax" policies affect the values of these portfolios. That model merges the inflation-tax model of Li (1995) with the multiple-units-of-money model of Camera and Corbae (1999). Although we do obtain some analytical results, in general the model must be solved using numerical methods. We find equilibria that mimic the simple model above: If the currencies are fundamentally equivalent (no inflation tax), then similar portfolios will have similar value in trade. Furthermore, when the currencies are fundamentally different because of their inflation-tax risk, we find parameterizations in which currency trades for currency plus goods in equilibrium (the Aiyagari, Wallace, and Wright [1996] result for portfolios or currencies). We also find parameterizations in which currency trades for currency. This latter result is interesting in that currency-for-currency trades occur when a single coincidence of wants does not arise; hence, there are pure financial trades in the model. Also, the existence of currency trades creates an explicit nominal and real exchange rate.[10] A typical dual-currency search model has an implicit endogenous real exchange rate but no endogenous nominal exchange rate.

Two-Country, Two-Currency Models

Until now, all of the models discussed were closed-economy models with multiple media of exchange. In addition to two-currency, one-country models, a fair amount of research has tried to capture the open-economy aspects of dual-currency models.

The earliest two-country, two-currency search model that we know of is Matsuyama, Kiyotaki, and Matsui (1993). Their paper uses the simple indivisible-commodity, indivisible-money model of Kiyotaki and Wright (1993), but designates agents as coming from different countries. These agents are randomly paired with agents from their own country and the other country and then decide to trade or not. A key issue is whether one or both currencies will be acceptable in international pairings of

■ **10** There is actually a distribution of nominal and real exchange rates, since individual pairs of traders can specify different quantities of goods and currencies to be exchanged, depending on the portfolio composition of the buyer and seller. This is equivalent to the price distributions obtained by Camera and Corbae (1999).

traders. Furthermore, the authors consider conditions under which the foreign currency will be used as a medium of exchange between two domestic traders. In this model, no currency exchange occurs, despite its international flavor; due to the indivisibilities of goods and money, the implied real exchange rate is 1.

Zhou (1997) amends the Matsuyama, Kiyotaki, and Matsui model to generate currency exchange. He assumes that some home agents desire home goods produced by home agents, while others desire goods produced by foreign agents. However, agents' preferences are subject to random shocks, which means they may switch from home goods to foreign goods or vice versa. In this set-up, home-goods producers who prefer to consume other home goods never accept foreign currency from foreign buyers. However, home-goods producers who want to consume foreign goods will accept foreign currency to pay for that consumption. Consequently, at any point in time, there are buyers of country 1 with country-2 currency and vice versa. At each point, some of these traders receive a shock that reverses their consumption preferences so that they now want to consume home goods. But home-goods sellers will not accept the foreign currency and the buyer does not want to use it to buy foreign goods. Consequently, buyers are stuck with the foreign currency unless they are paired with a foreign agent who is holding the home currency and has also experienced a preference reversal. As a result, in each period there is some currency exchange between country-1 buyers holding currency 2 and country-2 buyers holding currency 1. Although Zhou generates currency exchange in this model, the nominal exchange is always 1:1 because of the restriction that agents can hold only one unit of either currency.

Trejos and Wright (1995b, 1996) extend the model of Matsuyama, Kiyotaki, and Matsui by allowing for divisible goods. They derive conditions under which a) both currencies are national; b) there is one national and one international currency; and c) both currencies are international. Furthermore, they show that the currencies will have different trade values depending on several factors such as the probability of meeting someone from one's own versus the other country, the relative quantities of the two currencies in circulation, and whether the transaction occurs between two traders from the same country or traders from two different countries. They show that if the economies are symmetric and both currencies circulate internationally, then they have equal trading value. This is similar to the findings of the model in section I. Trejos and Wright also incorporate different government policies following the method of Li (1995) to see whether wildly different government inflation policies can either drive out the foreign currency for internal trades or cause it to be used for internal trade. In this set-up, each government's agents confiscate their own currency from traders they meet, regardless of their nationalities.

III. A Case Study of Government Policy in a Dual-Currency Regime

In this section, we describe a government's confrontation with the problem of making its new fiat currency, the *hryvna*, acceptable in a dollarized economy. The government also wanted to de-dollarize the economy in order to secure more seigniorage revenues. The country is Ukraine, which introduced the hryvna as part of its 1994 currency reform.

After the ruble zone collapsed, Ukraine issued its own currency, which was a coupon (although it behaved exactly like explicit fiat currency). Seigniorage considerations led to a rapid increase in the issue of these coupons, which produced hyperinflation of 10,000 percent in 1994. The result was massive currency substitution by Ukrainian citizens and the dollarization of the nation's economy. After stabilizing inflation by restraining the issuance of coupons, the government faced the challenge of issuing a new fiat currency—the hryvna—and inducing Ukrainian citizens to use it rather than dollars. Made cautious by the previous hyperinflation, however, citizens seemed reluctant to give up their dollars for hryvnas.

This situation can be described by our model in section I. Let currency 1 be the dollar and currency 2 be the hryvna. We showed that if t_1 was sufficiently low and t_2 sufficiently high, the dollar would be acceptable in trade but the hryvna would not be. This is, in some sense, similar to the situation that confronted Ukraine's central bank when it introduced its new currency.

Given the analysis in our model, how could the central bank reverse this situation? It had to figure out a way to lower the holding cost of the hryvna and raise that of the dollar as a medium of exchange. Raising the costs of using the dollar was easy—make it illegal and enforce the laws strictly enough to drive it out of the economy. This is the result Curtis and

Waller (2000) report for currency restrictions. How could the government lower the cost of using the hryvna? Since it had generated hyperinflation very recently, its promises to keep inflation low were probably not credible. With this in mind, we can think of the holding cost as the utility loss arising from the risk of devaluation through hyperinflation. Since the threat of another hyperinflation was very real, sellers demanded such a high premium to accept the local currency that using it as a medium of exchange was not worthwhile. Unless the holding cost of the hryvna fell, the launch of the new currency would fail.

The government needed a commitment device to lower the cost of using the hryvna yet make it easy to switch back to dollars should inflation get out of control. The government decided to make it very easy to obtain a license to set up a currency-exchange booth. As a result, booths sprouted up all over (particularly in Kiev), with three dramatic effects on citizens' willingness to hold the local currency. The proliferation of exchange points made it easy to exchange the currency in a hurry; this minimized the nonpecuniary "shoe-leather" costs of converting the hryvna into dollars, thereby increasing the hryvna's liquidity. Second, competition among the multitude of currency exchanges lowered the buy–sell spread almost to zero, which made the pecuniary costs of currency conversion almost nil.[11] Finally, since all currency exchanges posted the exchange rate, they acted as an information loudspeaker regarding the behavior of current monetary policy. Simply by glancing in the windows as one walked around the city, it was very easy to see if the hryvna was depreciating as a result of loose monetary policy. In short, the presence of competitive currency exchanges dramatically lowered the cost of holding the new currency. By recognizing how the fundamentals of trading affected the acceptability of currencies, the Ukrainian government was able to launch a new currency and significantly reduce the dollarization of its economy.

IV. Concluding Thoughts

The purpose of this article is to examine how modern monetary theory aids our understanding of an old and venerable multiple-payments system—the dual-currency economy. Dual-currency economies persist today as a way to avoid devaluation of domestic currencies, unstable banking systems, and government restrictions on trade using other means of payment. Monetary search models are very useful for studying how currency acceptability arises endogenously in economies that lack more sophisticated payment systems. While search models' basic assumptions may not be consistent with modern financial systems, they provide fairly good descriptions of transitional and developing economies. In particular, the economies of the former Soviet Union are well described by the basic assumption of the search models—an absence of credit, a lack of smoothly functioning banking systems, reliance on currency as the sole medium of exchange, and primitive trading environments. Thus, the application of dual-currency search models to these economies should yield interesting case studies of monetary theory and will offer potentially helpful policy prescriptions for the beleaguered governments of these countries.

■ **11** In June 1998, the buy–sell spread in downtown Kiev was ½ cent per dollar exchanged, or 50 cents per $100. There were no fixed commissions on exchanges.

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