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Why Do Different Countries Use Different Currencies?

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Abstract

During long periods of history, countries have pegged their currencies to an international standard (such as gold or the U.S. dollar), severely restricting their ability to create money and affect output, prices, or government revenue. Nevertheless, countries generally have maintained their own currencies. The paper presents a model where agents have heterogeneous preferences—that are private information—over goods of different national origin. In this environment, it may be optimal for countries to have different currencies; we also identify conditions where separate national currencies do *not* expand the set of optimal allocations. Implications for a currency union in Europe are discussed.

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SUMMARY

Why do different countries have different currencies? Traditional answers assume that governments can use their ability to create money to affect exchange rates, output, prices, or government revenue. Yet countries have found it generally in their interest to maintain different currencies even when their ability to create money, and in particular to create money at nationally differentiated growth rates, was severely limited—for example, during periods when currencies were pegged to the price of precious metals or exchange rates were fixed.

In this paper we show that it may be socially beneficial to have multiple national moneys, even when there are no possibilities for money creation. We construct a model of pairwise exchange in which the individuals' preferences, which are private information, depend on the goods' country of origin. We consider allocations achievable by society if there is a single global currency, or country-specific currencies. If there are multiple national moneys, they are substitutable prior to but not during a match of pairwise exchange.

A key result is that if agents' preferences are sufficiently heterogeneous over the different nationalities of goods, then the presence of different national moneys is socially beneficial. Multiple national moneys here allow the buyer to credibly signal his preferences to the seller because the buyer makes his decision about what currency to hold before he meets the seller; and production will be differentiated based on the nationality of the buyer. We also derive conditions under which separate national currencies do *not* expand the set of optimal allocations. Within the model, the planned European currency union can be interpreted as an optimal response to a decrease in the heterogeneity of preferences over national goods; alternatively, this can be viewed as a response to the harmonization of national quality standards and an improvement in cross-country contract enforceability.

I. INTRODUCTION

Why do different countries have different currencies? Traditional answers to this question assume that governments can use their ability to create money to affect exchange rates, output, prices or revenue. However, such explanations are difficult to reconcile with several empirical facts. For example, there have been long periods in history in which countries followed fixed exchange rate regimes or pegged their currencies to the price of gold or other precious metals. These episodes include, among others, the gold standard of the 19th and early 20th century as well as the post-war era of fixed exchange rates under the Bretton-Woods regime. In all of these cases, the ability of national authorities to create money, and in particular to create money at nationally differentiated growth rates, was extremely limited. Nonetheless, throughout these periods, countries generally found it in their interest to maintain different currencies.

In this paper, we show that it may be socially beneficial to have multiple national monies, even when there are no possibilities for money creation. We construct a model of pairwise exchange in which individuals' preferences over goods may depend on the goods' country of origin. Preferences are heterogeneous over individuals and are private information. Within this environment, we consider the allocations achievable by society if there is a single global currency, or country-specific currencies. If there are multiple national monies, we model them as being (at least somewhat) substitutable at a fixed exchange rate. However, within a match, the buyer has no currency substitution possibilities.

We use the approach of Kocherlakota and Wallace (1997) to analyze the efficient allocations of resources in this environment. We obtain three results. The main result is that if agents' preferences are sufficiently heterogeneous over the different nationalities of goods, then the presence of different national monies is socially beneficial. Intuitively, the presence of multiple national monies allows the buyer to credibly signal his preferences to the seller because the buyer makes his decision about what currency to hold before he meets the seller. As a result, production will be differentiated based on the nationality of a buyer; this possibility for differentiation in the production structure, which national currencies enhance, can be optimal because buyers value home and foreign goods differently.

We also show that the commonly observed home goods bias, where buyers tend to buy relatively smaller quantities of foreign goods and may be charged a higher price when carrying foreign money, is an integral part of any optimal allocation with multiple national monies. In fact, the implied difference in price between home and foreign currencies may exceed the costs of substituting between the two. Finally, we show that nationally distinct currencies only improve welfare for countries that engage in foreign trade.

We discuss the implications of our results for the debate about European currency union. In our model, the adoption of a currency union may be plausibly interpreted as an optimal response to a decrease in the heterogeneity of preferences over national goods. Alternatively, we can think of this decline in heterogeneity of "preferences" as representing a harmonization of national quality standards or an improvement in cross-country contract enforceability. However, the adoption of a currency union may also be optimal if the costs of substituting between currencies within a match fall.

There is, of course, a large literature on multiple currencies and currency unions. The aggregate models on optimum currency areas, building on Mundell's (1961) work, emphasize the role of goods and factor mobility as well as the types of shocks that may hit the different countries. However, the distinction between an optimum currency area and separate currency areas is fundamentally the same as that between fixed and flexible exchange rates. In contrast, the model presented in this paper identifies a potential role for separate national currencies even in circumstances where the exchange rate may not change over time.

The model presented in this paper is an extension of the literature of "deep" models of money. As far as we know, none of this literature considers models in which multiple monies are essential to achieving relatively efficient allocations of resources. In particular, while money itself is essential in the work of Matsuyama, Kiyotaki, and Matsui (1993), Trejos and Wright (1997), and Zhou (1997), having two monies does not lead to Pareto superior allocations.[2]

In the rest of the paper, we set up the environment in Section II. Following the definition of the social planner's problem in Section III, which describes efficient allocations of resources in the environment, the main results are derived in Section IV. We discuss some implications of our results for thinking about European currency union in Section V, and then conclude in Section VI.

II. THE ENVIRONMENT

A. Preferences and Frictions

Consider a random-matching model similar to the one in Trejos and Wright (1997). There are two countries, A and B, and three types i of agents in each country, with $i \in \{1,2,3\}$; there are equal measures of each type. In every period, agents find a match and an agent is matched with somebody from his own country with probability $p > \frac{1}{2}$.

Agents of type i produce type i goods at a cost of y_i in terms of the utility measure and get utility from consuming type (i+1) goods. A type i agent's momentary utility function is given by:

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[2]Townsend (1987) discusses an environment in which multiple tokens are an optimal recordkeeping technology. However, in that environment, agents are forced to give up resources in exchange for valueless tokens, and so the tokens cannot be viewed as equivalent to fiat money.

$$u(c_{i+1}) - y_i$$

where u is C^2, $u(0) = 0$, $u'(0) = \infty$, $u'(\infty) = 0$, $u' > 0$ and $u'' < 0$. All agents discount the future using a factor β, where $0 < \beta < 1$.

We assume that with probability $(1\text{-}\alpha)$, a type i agent in region A(B) receives zero utility from consuming goods produced by a type $(i+1)$ agent in region B(A).[3] This probability is meant to represent a variety of things. For example, it captures the notion that it may be more difficult to assess the quality of foreign goods, reflecting possibly different quality standards across countries and other informational constraints. It could also reflect that contract enforceability is often more difficult in cross-border trade.

There are three frictions in the environment.

Friction 1 (limited recordkeeping): money is the only type of recordkeeping possible.

Friction 2 (sequential individual rationality): within a match, individuals are always free to choose autarky instead of the allocation in that match.

Friction 3 (incomplete information about agent's nationality): in any match between a type i and a type $(i+1)$, the nationality of the type i is unobservable and the nationality of the type $(i+1)$ is observable.

The first two frictions result in a possible role for money in a random-matching environment and are standard in this literature. Taken together, the two frictions are sufficient to guarantee that an intrinsically useless token (currency) can allow society to obtain Pareto superior allocations (see Aiyagari and Wallace, 1991, and Kocherlakota, 1997). Friction 3 introduces a particular form of incomplete information into the model. In its absence, and given that agents prefer the same quantity of domestic goods over foreign ones, it is optimal for relatively low production to take place in cross-country matches, and relatively high production to take place in intra-country matches. But Friction 3 implies that it may be hard to implement differential production levels for cross-country and intra-country matches, because buyers in cross-country matches may claim to be whatever nationality gets them a lower price.

While Friction 3 refers to private information about the nationality of the buyer, the following results are quite general and apply also to several alternative interpretations of this friction. What really matters is that, given all of the observable characteristics of the buyer, the seller does not know whether the buyer prefers the seller's nationality of goods or not. Hence, when we talk about the nationality of the buyer (both in the statement of Friction 3 and later in the paper), it is important to keep in mind that we are, equivalently, referring to the nationality

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[3]See Zhou (1997) for a similar type of heterogeneity in preferences.

of the goods preferred by the buyer. There is also considerable empirical support for this notion that the nationality of traders, or goods, is important in trading outcomes.[4]

B. Alternative Currency Arrangements

In an environment characterized by the lack of a double coincidence of wants and by the sequential individual rationality constraint, a producer will only produce if he receives some promise of future benefits in exchange for producing today. This means that there must be some recordkeeping technology that keeps track of past production on the part of any agent. We consider two different recordkeeping technologies.

One Currency Case

The first type of recordkeeping technology is an indivisible token which does not enter individual preferences or production technologies. In any period, an agent can hold at most one token. As is familiar from the work of Trejos and Wright (1995) and Shi (1995), the existence of this token makes production possible despite the lack of a double coincidence of wants in any match: if an agent produces for some other individual who holds a token, then the token is transferred to the producer.

It may be helpful to illustrate the trading environment and the potential outcomes in this situation in more detail. First, note that since there is no double coincidence of wants and producing today will entail negative utility y_i for the producer, Friction 2 implies that agents will only produce today if they receive in return a claim on future consumption. With currency the only recordkeeping device (Friction 1), this implies that a necessary condition for an agent to engage in production is that the matched partner is in possession of a token. As a result, there will be no production in a match between agents of type i and type (i+1), if the potential buyer, agent i, holds no currency. Second, we shall restrict our analysis to those cases where agents hold at most one unit of currency, which is assumed to be indivisible. As a result, no production and trade will also take place in matches where both agents hold currency at the beginning of a period.

In this environment, potential trading situations are therefore confined to matches where one agent holds currency—the "potential buyer" in the table below—while his counterpart holds no currency—the "potential seller." In these situations, a sale may occur when a buyer of type i is matched with a seller of type i+1 (as indicated by a "✓" in the table). In all other situations, no production and trade will take place (indicated by "—" in the table). The following section will describe in more detail the social planner's problem in this environment.

[4] See the literature on home bias in trade and asset allocations; for example, Stockman and Tesar (1995).

Potential buyer	Potential Seller		
	1	2	3
1	—	✓	—
2	—	—	✓
3	✓	—	—

Two Currency Case

While the previous case allowed only for one type of token, or currency, we shall consider a second recordkeeping technology consisting of two distinct (say, red and blue) tokens. Again, it will be assumed that the tokens are indivisible, an agent can hold at most one token at any point in time (either a red or a blue one), and the tokens do not enter preferences or production technologies. However, an individual who has a red (blue) token can transform it into a blue (red) token, at a cost k. A crucial feature of this recordkeeping technology is that this transformation can only be done at the beginning of the period, before the individuals know with whom they will be matched.

III. Social Planner's Problems

In this section, we consider the problem of a social planner who seeks to determine an optimal allocation of resources, given the frictions described above. The problem is first described for the case of a single currency and is subsequently extended to the multiple currency case. We interpret this as analyzing the question: when are separate currencies better than a currency union?

A. Currency Union

Suppose the planner uses the first recordkeeping technology. Initially, a randomly selected half of the agents in the two-region economy is endowed with an indivisible token, and agents are assumed to be able to hold only a single token at a time. Consider the following type of trading mechanism. In a meeting between a type (i+1) person and a type i person carrying currency, the consumer announces his nationality. Given this announcement, the planner specifies whether the buyer should give his money to the seller and, if so, in exchange for how many units of the good. The Revelation Principle implies that, without loss of generality, we can restrict attention to mechanisms that induce truth-telling.

We restrict attention to stationary allocations that satisfy the sequential individual rationality constraints, and use the following notation. If a buyer announces that his nationality is different from that of the seller, we let $z_f \in \{0,1\}$ denote whether the buyer gives his money to the seller and y_f denotes the amount of goods produced by the seller should an exchange take place. If the buyer announces that his nationality is the same as that of the seller, we let z_d and y_d represent the corresponding quantities. The notation V_m represents the utility associated with having one unit of money, and V_0 represents the utility associated with having zero units of money.

The planner then solves the following maximization problem.[5]

PROBLEM 1 (One-currency problem):

$$\max_{\substack{z_d, z_f \in \{0,1\} \\ y_d, y_f}} \quad 0.5V_m + 0.5V_0$$

$$s.t.\ V_m = p[z_d\{u(y_d)/6 + \beta V_0/6\} + (1-z_d)\beta V_m/6 + 5\beta V_m/6]$$
$$+ (1-p)[z_f\{\alpha u(y_f)/6 + \beta V_0/6\} + (1-z_f)\beta V_m/6 + 5\beta V_m/6]$$

$$s.t.\ V_0 = p[z_d\{-y_d/6 + \beta V_m/6\} + (1-z_d)\beta V_0/6 + 5\beta V_0/6]$$
$$+ (1-p)[z_f\{-y_f/6 + \beta V_m/6\} + (1-z_f)\beta V_0/6 + 5\beta V_0/6]$$

$s.t.\ z_d(-y_d + \beta V_m) + (1-z_d)\beta V_0 \geq \beta V_0$: participation for seller when buyer announces domestic

$s.t.\ z_f(-y_f + \beta V_m) + (1-z_f)\beta V_0 \geq \beta V_0$: participation for seller when buyer announces foreign

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[5]As in Kocherlakota and Wallace (1997), we can motivate the planner's constraint set as consisting of the set of allocations that are stationary and symmetric equilibrium outcomes of a class of mechanisms. The class of mechanisms under consideration here include all mechanisms such that within a match, agents simultaneously announce their types and make an action choice; the mechanism then maps the pairs of announcements and action choices into an allocation of money and goods within the match. Because of the sequential individual rationality friction, the mechanisms are restricted to have the property that any agent can always choose an action that guarantees an autarky allocation of resources, regardless of the announcements and actions chosen by his trading partner.

$s.t.\ z_d[u(y_d) + \beta V_0] + (1-z_d)\beta V_m \geq z_f[u(y_f) + \beta V_0] + (1-z_f)\beta V_m$: truthtelling for domestic buyer

$s.t.\ z_d[u(y_d) + \beta V_0] + (1-z_d)\beta V_m \geq \beta V_m$: participation for domestic buyer

$s.t.\ z_f[\alpha u(y_f) + \beta V_0] + (1-z_f)\beta V_m \geq z_d[\alpha u(y_d) + \beta V_0] + (1-z_d)\beta V_m$: truthtelling for foreign buyer

$s.t.\ z_f[\alpha u(y_f) + \beta V_0] + (1-z_f)\beta V_m \geq \beta V_m$: participation for foreign buyer

$s.t.\ y_d, y_f \geq 0$

The first two constraints are essentially definitions of V_m and V_0, the utility associated with having and not-having currency at the beginning of the period. The next two constraints guarantee that the seller satisfies his sequential individual rationality constraint, regardless of what the buyer announces about his type. The final four constraints ensure that buyers announce the truth about their type, and also satisfy their sequential individual rationality constraints.[6]

Note that if $z_d = z_f = 1$, then y_d must equal y_f in order to satisfy the planner's constraint set. Intuitively, if there is always an exchange of the currency for goods in international as well as intra-national meetings, then the buyer must be indifferent between claiming to be a domestic and being a foreigner.

B. National Currencies

Next, we consider the social planner's problem when there are two colors of tokens that are substitutable at a fixed cost before matches take place. First, suppose the differently colored tokens are initially distributed symmetrically across the two countries and the three types of agents. This symmetric distribution across countries means that the color of the token carried by an individual reveals nothing about his preferences. Hence, given this initial distribution of tokens, any allocation that is achieved using a single currency can be achieved using two currencies: agents can simply ignore the color of the currencies and trade as if the two currencies were identical.

It follows that, given this initial distribution of tokens, there is necessarily no welfare loss associated with using multiple currencies. However, the question remains whether there is a welfare *gain* associated with using multiple currencies. To explore this, we assume that half

[6]We can guarantee existence of a solution to PROBLEM 1 (and the subsequent PROBLEMS 2, 3A, and 3B) by imposing an (irrelevant) upper bound $y_{\max}$ on the planner's choice of y_d and y_f, where $y_{\max}$ is sufficiently large that $u(y_{\max}) - y_{\max} < 0$.

of the agents in country A are initially endowed with only one type of currency (say, red tokens) and half of the agents in country B are initially endowed with another type of currency (say, blue tokens). Subsequently, we restrict our attention to allocations in which this distribution of currencies persists over time: should agents from country A (B) receive blue (red) tokens, they will always exchange them for red (blue) ones.[7] Because currency substitution can only take place before matches, and because currency-holding is so strongly associated with nationality, agents can use the multiple tokens to make credible (albeit costly) ex ante announcements of their nationality. It is the ex ante nature of their announcements (as opposed to the ex-post announcements made with one currency) that makes gains in welfare possible.

For a given individual, let V_d define the utility associated with holding one unit of "domestic" currency (the color of token that others of the same nationality are holding) and let V_f define the utility associated with holding the "foreign" currency. In any given allocation, no agent will actually have utility V_f, but we need to calculate it to make sure that agents do not want to switch currencies.

The social planner's problem is then:[8]

PROBLEM 2 (National currency problem):

$$\max_{\substack{z_d,\, z_f \in \{0,1\} \\ y_d,\, y_f}} \quad 0.5V_d + 0.5V_0$$

$$s.t.\ V_d = p[z_d\{u(y_d)/6 + \beta V_0/6\} + (1-z_d)\beta V_d/6 + 5\beta V_d/6]$$

$$+ (1-p)[z_f\{\alpha u(y_f)/6 + \beta V_0/6\} + (1-z_f)\beta V_d/6 + 5\beta V_d/6]$$

[7]We restrict our attention to deterministic allocations. Given this restriction, there are only two possible stationary distributions of tokens: one in which tokens are symmetrically distributed across both countries, and another in which all agents in a given country have the same color of token. This explains why we discuss here only two possible initial distributions of tokens.

[8]In PROBLEM 2, we do not allow for the possibility of within-match announcements of nationality. Since we focus on allocations such that agents of the same nationality always hold the same color of token, this restriction is without loss of generality.

$$s.t.\ V_0 = p[z_d\{-y_d/6 + \beta V_d/6\} + (1-z_d)\beta V_0/6 + 5\beta V_0/6]$$
$$+ (1-p)[z_f\{-y_f/6 + \beta(V_d-k)/6\} + (1-z_f)\beta V_0/6 + 5\beta V_0/6]$$

$$s.t.\ V_f = p[z_f\{u(y_f)/6 + \beta V_0/6\} + (1-z_f)\beta V_f)/6 + 5\beta V_f/6]$$
$$+ (1-p)[z_d\{\alpha u(y_d)/6 + \beta V_0/6\} + (1-z_d)\beta V_f/6 + 5\beta V_f/6]$$

$s.t.\ z_f(V_d - k - V_f) \geq 0$: currency-switching (seller)

$s.t.\ V_d \geq V_f - k$: currency-switching

$s.t.\ z_f[-y_f + \beta(V_d-k)] + (1-z_f)\beta V_0 \geq \beta V_0$: seller's participation when buyer has foreign currency

$s.t.\ z_d[-y_d+\beta V_d]+(1-z_d)\ \beta V_0 \geq \beta V_0$: seller's participation when buyer has domestic currency

$s.t.\ z_d[u(y_d) + \beta V_0] + \beta V_d(1-z_d) \geq \beta V_d$: buyer's participation when he has domestic currency

$s.t.\ z_f[u(y_f)\alpha + \beta V_0] + (1-z_f)\beta V_d \geq \beta V_d$: buyer's participation when he has foreign currency

$s.t.\ y_d, y_f \geq 0.$

The first three constraints serve to define V_d, V_0, and V_f. The "participation" constraints are the usual sequential individual rationality constraints that guarantee that the participants in a match prefer the allocation to autarky.

There are two "currency-switching" constraints. The first guarantees that if $z_f=1$ (so that sellers give up goods to those who have foreign currency), then the seller is willing to switch the foreign currency that he receives for domestic currency. If this constraint were not satisfied, then the tokens will eventually not be useful as signals of nationality, as they will, in the long run, be equally distributed across everyone in the population, regardless of their nationality. The second currency-switching constraint guarantees that anyone carrying domestic currency will be unwilling to switch to foreign currency. Together, these two constraints preserve the definition of what is meant by "domestic currency."

As discussed above, it is always possible to achieve as much societal welfare using two colors of tokens as with one color of token. Hence, the key question is whether multiple currencies are *essential* in the sense defined below.

Definition 1: Multiple currencies are *essential* if the maximized value of PROBLEM 1 is smaller than the maximized value of PROBLEM 2.

C. Simplified National Currency Problem

It is useful to simplify the planner's national-currency problem for the case in which currency substitution is costless ($k = 0$). We first restrict $z_d = 1$ *a priori*; later, we prove that this restriction is without loss of generality because it is always suboptimal to set $z_d = 0$.

Given that $z_d = 1$, the planner can solve the national-currency problem by solving each of the following two problems, and then choosing z_f based on which solution yields a higher utility value.

PROBLEM 3A (Foreign trade — $z_f = 1$):

$$\max_{y_d, y_f} \quad p[u(y_d) - y_d] + (1-p)[u(y_f)\alpha - y_f]$$

$$s.t. \quad y_d \geq y_f$$

$$s.t. \quad -y_d(1-2\beta/3) + \beta[p\{u(y_d) + y_d\}/6 + (1-p)\{\alpha u(y_f) + y_f\}/6] \geq 0$$

$$s.t. \quad -y_f(1-2\beta/3) + \beta[p\{u(y_d) + y_d\}/6 + (1-p)\{\alpha u(y_f) + y_f\}/6] \geq 0$$

$$s.t. \quad u(y_d)(1-2\beta/3) - \beta[p\{u(y_d) + y_d\}/6 + (1-p)\{\alpha u(y_f) + y_f\}/6] \geq 0$$

$$s.t. \quad \alpha u(y_f)(1-2\beta/3) - \beta[p\{u(y_d) + y_d\}/6 + (1-p)\{\alpha u(y_f) + y_f\}/6] \geq 0$$

$$s.t. \quad y_d, y_f \geq 0$$

We arrive at this constraint set and objective by substituting out for V_d, V_f, and V_0 in the planner's national-currency problem described in PROBLEM 2, and multiplying through the objective and the constraints by $(1-\beta)$.

Next, we apply the same substitutions to derive the following optimization problem for the case of no foreign trade, i.e., $z_f = 0$.

PROBLEM 3B (No foreign trade — $z_f = 0$):

$$\max_{y_d} \quad p[u(y_d) - y_d]$$

$$s.t.\ -y_d(1-2\beta/3) + \beta p\{u(y_d) + y_d\}/6 \geq 0$$

$$s.t.\ u(y_d)(1-2\beta/3) - \beta p\{u(y_d) + y_d\}/6 \geq 0$$

$$s.t.\ y_d \geq y_f$$

$$s.t.\ y_d, y_f \geq 0$$

We now prove that restricting z_d to equal one in the constraint set of PROBLEM 2 is without loss of generality.

Lemma 1: In the planner's national-currency problem, it is suboptimal to set z_d equal to 0.

Proof: First, note that if $\alpha = 1$, it is suboptimal to set $z_d = 0$, $z_f = 1$ and $y_f > 0$. If $k = 0$, then we can set $z_d = 1$ and $y_d = y_f$. This lies in the constraint set and makes everyone better off. On the other hand, if $k > 0$, then we can set $z_d = 1$, $z_f = 0$, and $y_d = y_f$. This makes everyone better off because they do not have to incur the currency substitution costs. Hence, if $z_d = 0$ is optimal, the maximal amount of utility is zero.

Now assume that $\alpha < 1$. Consider some allocation such that $z_d = 0$ and $z_f = 1$. Such an allocation can only be in the national-currency constraint set if $y_f = 0$ (because otherwise $V_d - V_f < 0$), which implies it provides zero utility to the planner.

Hence, in the national-currency problem, setting $z_d = 0$ is only optimal if zero is the highest utility level that the planner can attain.

Now consider any allocation in which $z_d = 1$. Set $z_f = 0$ and $y_f = 0$. Then, there exists $y_d > 0$ that satisfies the constraints in PROBLEM 3:

$$-y_d\ (1 - 2\beta/3) + \beta p\{u(y_d) + y_d\}/6 \geq 0$$

$$u(y_d)(1 - 2\beta/3) - \beta p\{u(y_d) + y_d\}/6 \geq 0.$$

The result is straightforward: increase y_d from zero; because $u'(0) = \infty$, this relaxes the seller's constraint. On the other hand, it relaxes the buyer's constraint as long as $1 - 2\beta/3 - \beta p/6 > 0$, which is true because $\beta < 1$ and $p < 1$.

Thus, by setting $z_d = 1$, it is always possible to find some allocation that gives positive utility to the planner; hence, $z_d = 0$ is always suboptimal. Δ

Intuitively, because $u'(0) = \infty$, it is always optimal to have some trade.

We conclude from Lemma 1 that if $k = 0$ and $0 < \beta < 1$, the constraint set of PROBLEM 3 is the same as the constraint set of PROBLEM 2, and so the solution to PROBLEM 3 is the solution to PROBLEM 2.

IV. RESULTS

In this section, we derive three results concerning the properties of optimal allocations. First, multiple currencies are only essential if sellers accept foreign currency. Second, if multiple currencies are essential, then it is efficient to have less production in cross-country matches than in domestic matches. Finally, multiple currencies are essential if the two countries are sufficiently distinct, in terms of α being sufficiently different from 1.

The first proposition demonstrates that if multiple currencies are essential, sellers must be willing to accept foreign currency.

Proposition 1: Suppose multiple currencies are essential. Then, in any solution to the national-currency problem, $z_f = 1$.

Proof: Suppose $z_f = 0$ in a solution to PROBLEM 2, and the value of PROBLEM 2 is strictly larger than the value of PROBLEM 1. Then, the solution to PROBLEM 2 cannot lie in the constraint set of PROBLEM 1. Why? The only possible reason is that the foreign buyer might want to pretend to be domestic:

$$\alpha\, u(y_d) + \beta V_0 > \beta V_m$$

a deviation which is not possible in PROBLEM 2 (recall that, from Lemma 1, we know that $z_d = 1$ in any solution to PROBLEM 2). But then it is possible to construct a welfare-improving allocation that satisfies the constraints of PROBLEM 1:

$$\hat{y}_d = y_d,\ \hat{y}_f = y_d,\ \hat{z}_f = 1,\ and\ \hat{z}_d = 1 .$$

It is clear that this new allocation improves societal welfare, because $\alpha u(y_d) > \beta(V_m - V_0) \geq y_d$. Hence, it is better to have production equal to y_d in cross-country matches as well as domestic matches.

But is this new allocation incentive-feasible? Clearly, truth-telling constraints are satisfied. Moreover, the new allocation implies a value for $(\hat{V}_m - \hat{V}_0)$ that is larger than $(V_m - V_0)$, so the seller's participation constraints are certainly satisfied.

All that is left is to show that the buyer's participation constraint is satisfied. We know that:

$$\alpha u(y_d) \geq \beta\,(V_m - V_0) = (\beta/6)[u(y_d) + y_d]/[1\text{-}2\beta p/3\text{-}(1\text{-}p)\beta]$$

We need to check if:

$$\alpha u(y_d) \geq \beta(\hat{V}_m - \hat{V}_0)$$
$$= \beta(1\text{-}2\beta/3)^{-1}\{p[u(y_d) + y_d]/6 + (1\text{-}p)[\alpha u(y_d) + y_d]/6\}$$

But this follows from simple algebra:

$$\alpha u(y_d)(1\text{-}2\beta/3) = \alpha u(y_d)(1\text{-}2\beta p/3)\text{-}(1\text{-}p)\beta\alpha u(y)+\beta(1\text{-}p)\alpha u(y)/3$$
$$\geq (\beta/6)\{p[u(y_d)+y_d]/6 + (1\text{-}p)\beta\alpha u(y_d)/3\}$$
$$> (\beta/6)\{p[u(y_d)+y_d]/6 + (1\text{-}p)\beta\alpha u(y_d)/6 + (1\text{-}p)y_d/6\}$$

since $\alpha u(y_d) > y_d$. Δ

Proposition 1 is equivalent to the statement that if $z_f = 0$, then it cannot be essential to have multiple currencies. Intuitively, whenever z_f equals zero in a solution to PROBLEM 2, the value of money in domestic trades exceeds a foreign buyer's valuation of y_d; otherwise, the planner would implement an exchange of one unit of money for y_d in cross-country meetings. Hence, there is no incentive with a single currency for the foreign buyer to pretend to be domestic, and the participation constraints of PROBLEM 1 are automatically satisfied. This implies that multiple monies cannot be essential.[9]

The main proposition describes a set of sufficient conditions for a society to use only one currency and a set of conditions for a society to use two currencies.

Proposition 2: Fix p. There is an open set $S \subset (0, 1) \times (0,1) \times [0, 1)$ and two continuous decreasing functions $\alpha^*(\beta, k) \geq \alpha_*(\beta, k)$ that satisfy the following two properties.

i. Multiple currencies are essential for the nonempty set of (α, β, k) such that $\alpha < \alpha_*(\beta, k)$ and (α, β, k) in S.

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[9]If $\alpha = 0$, then it is suboptimal in either PROBLEM 1 or PROBLEM 2 to set $z_f = 1$ (because setting $z_f = 1$ always violates a foreign buyer's participation constraint). The Theorem of the Maximum implies that $z_f = 0$ is optimal for α in a neighborhood around 0 as well.

ii. Multiple currencies are not essential for the nonempty set of (α, β, k) such that $\alpha > \alpha^*(\beta, k)$ and (α, β, k) in S.

Proof: Set $\beta = 1$, $\alpha = 1$ and $k = 0$ and consider PROBLEM 3 (the simplified national currency problem). The solution to PROBLEM 3A is to set $y_d = y_f = y^*$, where $u'(y^*) = 1$. Why? This maximizes the objective, assuming none of the constraints bind. Also, the buyer's participation constraint is satisfied because:

$$u(y^*) + V_0 - V_d = \{u(y^*) - y^*\}/6 > 0$$

and the seller's participation constraint is satisfied because:

$$-y^* + V_d - V_0 = \{u(y^*) - y^*\}/6 > 0$$

Obviously, this beats any possible solution to PROBLEM 3B.

The above analysis implies that if we pick $\hat{\beta}$ sufficiently close to 1 (keeping $\alpha = 1$ and $k = 0$), $y_d = y_f = y^*$ still solves PROBLEM 3A. It follows that for $\beta = \hat{\beta}$, $\alpha = 1$, and $k = 0$, $y_d = y_f = y^*$ solves PROBLEM 1 and PROBLEM 2. The Theorem of the Maximum then implies that there exists an open set S of exogenous parameters such that $\beta < 1$ and the participation constraints are slack both in the solution to PROBLEM 2 and in the solution to PROBLEM 1. Now, for any α, define $y^{**}(\alpha)$ and $y^{***}(\alpha)$ to satisfy:

$$y^{**}(\alpha) = u'^{-1}(1/\alpha)$$

$$pu'(y^{***}(\alpha)) + \alpha(1-p)u'(y^{***}(\alpha)) = 1$$

If (α, β, k) lie in S, in a solution to PROBLEM 1 we must have $y_d = y_f = y^{***}$; in a solution to PROBLEM 2 such that the seller's currency-switching constraint does not bind, $y_d = y^*$ and $y_f = y^{**}$.

Now, for any value of k and β, define $\alpha_*(\beta, k)$ to be the largest value of α that simultaneously satisfies:

$$\begin{aligned}(1-p)\{\alpha u(y^{**}(\alpha)) - y^{**}(\alpha)\} + p(u(y^*) - y^*) - (1-p)k \\ \geq (1-p)\alpha u(y^{***}(\alpha)) + pu(y^{***}(\alpha)) - y^{***}(\alpha)\end{aligned} \tag{*}$$

$$[p-(1-p)\alpha]\ \{u(y^*) - u(y^{**}(\alpha))\} \geq k(6 - 5\beta) \tag{**}$$

and let $\alpha^*(\beta, k)$ be the value of α such that (*) is satisfied with equality. (Note that if α satisfies (*) and (**), then any $\alpha' \leq \alpha$ also does.) Given that none of the participation constraints bind, (*) guarantees that the value of PROBLEM 2 is at least as large as the value of PROBLEM 1; (**) guarantees that the seller's currency-switching constraint is satisfied given that $y_d = y^*$ and $y_f = y^{**}(\alpha)$. Hence, if $\alpha < \alpha_*(\beta,k)$, multiple currencies are essential; if $\alpha > \alpha^*(\beta, k)$, they are not. Note that both functions are continuous and decreasing in k and in β, and that $\alpha^*(\beta, k) \geq \alpha_*(\beta, k)$.

It is only left to prove the nonemptiness of the two sets of exogenous parameters. First, take any $(\alpha, \beta, 0)$ in S, with $\alpha < 1$. Since $k = 0$, the solution to PROBLEM 2 involves setting $y_d = y^*$ and $y_f = y^{**}(\alpha)$ (because $k = 0$, the currency-switching constraint is automatically satisfied). This solution to PROBLEM 2 is strictly better than the solution to PROBLEM 1, because the optimal amount of trade is taking place in every match with money, and the amount of trade is lower in cross-country matches. Hence, the set of part (i) of the Proposition is nonempty.

Second, note that for β sufficiently close to 1, $\alpha = 1$, and k chosen so that (α, β, k) is in S, the solution to PROBLEM 1 is $y_d = y^* = y_f$. If $k > 0$, then the maximized value of PROBLEM 1 is strictly larger than the maximized value of PROBLEM 2. So, the set of part (ii) of the Proposition is nonempty. Δ

Proposition 2 shows that if economies are sufficiently integrated, in that agents are nearly indifferent between domestic and foreign goods, then there are no efficiency gains for society from having separate currencies. However, if agents' preferences are sufficiently heterogeneous, then it is essential to have multiple currencies.

The final proposition demonstrates that if multiple currencies are essential, then prices are higher for individuals who have foreign currencies than for individuals who have domestic currencies. Equivalently, production is smaller in exchanges involving foreign currencies than in exchanges involving domestic currencies.

Proposition 3: If multiple currencies are essential, then $y_d > y_f$ in any solution to the national-currency problem.

Proof: Suppose $y_d \leq y_f$ and $k > 0$. But $y_d \leq y_f$ implies that $V_d \leq V_f$, which is not incentive-compatible if $k > 0$.

If $k = 0$, then $y_d < y_f$ for the same reason as above. Suppose $y_d = y_f$. Since multiple currencies are essential, $z_f = 1$; also, from Lemma 1, $z_d = 1$. Then, clearly, $V_d = V_f = V_m$. The truth-telling constraints in PROBLEM 1 are satisfied, and so the solution to the national-currency problem satisfies the constraints of the one-currency problem. Hence, multiple currencies cannot be essential. Δ

Intuitively, multiple currencies are only essential if the planner wants to treat people who are carrying foreign currency differently from those who are carrying domestic currency. This "difference" means that those who have foreign currency get a different amount in exchange for their currency. Furthermore, in order to preserve the linkage between color of token and nationality, it must be true that people receive more from domestic matches than from foreign matches.

It is important to emphasize that, in an optimal allocation, the difference between y_d and y_f may exceed the cost k of substituting between currencies. For example, if $k = 0$, the proof of Proposition 2 makes clear that for $(\alpha, \beta, 0) \in S$, it is optimal to have two currencies and $y_d > y_f$ in an optimal allocation. In this sense, Proposition 3 implies that it may be optimal to see deviations from the law of one price beyond those attributable to transaction costs involved in exchanging currencies.

V. European Currency Union

The above analysis allows us to shed some light on the ongoing policy debate about an economic and monetary union (EMU) in Europe that would replace the national currencies of participating countries by a common currency, the euro. In particular, two issues can be addressed: first, why it may *not* have been optimal in the past to switch from separate national currencies to a common currency; and, second, what in the economic environment may have changed that could make such a switch optimal at this time or in the future. It should, however, be borne in mind that the above analysis abstracts from all issues related to money creation as well as non-economic political factors.

In terms of the prior analysis, there are at least three possible changes in the underlying economic environment that might lead a society to switch from having separate national currencies to a currency union. First, if the cost of converting a unit of foreign exchange, k, had increased over time, then currency substitution costs might have become too large to warrant the potential benefits of national currencies; it is then optimal to switch to a single currency system. However, it seems unlikely that this has played a role in the push towards EMU; most indicators suggest that the costs of substituting between currencies has, if anything, declined over time.

Another possibility is that the European economies are becoming more integrated. With the reduction in trade barriers, the harmonization of legal procedures and quality standards across the European Union (EU), the probability that there is a substantial utility difference between home and foreign goods has presumably declined over time in the EU. Indeed, the rapid expansion of intra-EU trade itself and, in particular, of intra-industry and horizontal trade, is a strong indication in this regard. In terms of the model, this would presumably be captured in a reduction of the probability $(1-\alpha)$ of an agent receiving zero utility from a foreign good. The benefits of having agents reveal their nationalities are therefore becoming smaller, and so is the need for multiple currencies.

A third possibility is only implicit in the above model. We assume throughout that it is impossible (that is, infinitely costly) for agents to substitute between currencies *after* they know with whom they are matched. Suppose, though, that it is possible for agents to substitute, after matching, between currencies at some cost κ, and that κ is falling over time. If κ gets small enough, then an allocation in which y_d is larger than y_f will cease to be (incentive)-feasible because agents will always switch to the domestic currency. Hence, small values of κ imply that it is optimal to use only one currency.

This last possibility is in some sense counter-intuitive. In particular, we generally think of declining cost as being a technological innovation that increases the opportunity set. But this is not necessarily the case for a decreases in κ. Low values of κ mean that is harder for agents to make credible, unchangeable, ex-ante announcements of their nationalities (and their preferences). Hence, the onset of a currency union could be an optimal response to either a change in the economic environment where it becomes more difficult to distinguish between different nationalities (if κ is falling over time) or an improvement in the economic environment where the distinction between different nationalities becomes less relevant (if α is rising over time).

VI. CONCLUSIONS

Currently, there is a large disparity in the modeling of environments with multiple currencies and the modeling of environments of single currencies. So-called "deep" models of money (Samuelson, 1958; Townsend, 1980; and Kiyotaki and Wright, 1991) place great emphasis on money's being actually useful to society in efficiently allocating resources. Yet, even the "deepest" models of international currencies do not motivate why there are different currencies.

The purpose of this paper is to take a first step towards correcting this disparity. The model in this paper develops an economic environment in which multiple national currencies may play an essential role in achieving an optimal allocation of resources. It is assumed that the buyer's valuation of different nationalities of goods is private information. In this environment, multiple currencies allow agents to make a credible announcement of how they evaluate goods from different countries before they are actually matched. The paper identifies the conditions under which this ability of agents to make a credible announcement before being matched allows world society to achieve a better allocation of resources.

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