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Shuze Ding, Daniela Puzzello

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Legal Restrictions and International Currencies: An Experimental Approach

Shuze Ding* Daniela Puzzello†

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Abstract

This paper integrates theory and experiments to explore how policy rules related to government interventions can affect economic allocations and the international status of a currency. Using a two-country, two-currency search model, we study two types of government interventions: (1) legal restrictions impacting a seller's ability to accept a foreign currency, and (2) reductions to the cost a seller must pay to accept a foreign currency. The first intervention can be viewed as a way to capture a decrease in capital controls, while the second can be viewed as a way to explore the impact of reducing information costs associated with using a foreign currency. Our results indicate that abolishing legal restrictions that impact a seller's ability to accept a foreign currency can increase both quantities traded and the number of trades involving two types of currencies. Additionally, the international status of currencies is significantly enhanced when sellers face very low foreign currency acceptance costs.

keywords: search models of money, international economics, monetary experiment.
JEL code: C92, D83, F40, F41

* School of Finance, Nankai University, No.38 Tongyan Road, Jinnan District, Tianjin 300350, PR China (email:dingshuze@nankai.edu.cn).

† Department of Economics, Indiana University, 100 S. Woodlawn Ave., Bloomington, IN 47405 (email:dpuzzell@indiana.edu). The authors gratefully acknowledge the support of The International Foundation for Research in Experimental Economics (IFREE) and the Fundamental Research Funds for the Central Universities (No. 998-63192136).

1 Introduction

Historically, government agencies have adopted a wide range of policies to achieve various monetary goals. These goals have included stabilizing the value of a domestic currency, introducing a new currency, or promoting a currency's domestic circulation or its international status (see discussions in Wallace (1983), Li and Wright (1998), Craig and Waller (2000), Camera et al. (2004), Craig and Waller (2004) and Goldberg (2012)). For example, in the 1990s, the Ukrainian government employed a combination of policies that decreased the cost of adopting the domestic currency as a medium of exchange while increasing the cost of accepting U.S. dollars. These policies helped introduce a new domestic currency and reduce the dollarization of the Ukrainian economy (see Craig and Waller (2000) for more details). China has also been actively promoting the international status of renminbi by imposing or lifting various restrictions on currency utilization (e.g., Park (2016)). More recently, the emergence of cryptocurrencies has attracted renewed attention to issues associated with currency competition. Ultimately, whether such policies succeed in affecting the targeted economic outcomes as intended, depends on the decisions of private citizens and firms living in the countries potentially impacted by the policy of interest.

The aforementioned policies and other comparable policies, provide some of the motivation behind this paper. However, our primary goal is not to provide policy lessons. Instead, we aim to better understand factors that facilitate or hinder coordination around the use of multiple currencies. To this end, our study integrates monetary theory and experiments to explore how government interventions affect economic allocations and the international status of a currency. More specifically, the theory and experimental setting are designed to address the following questions: How is the value of a foreign currency determined by individuals trading in the laboratory market setting? How do policies that affect the legality and the cost of accepting a foreign currency impact trade patterns and the adoption of these currencies?

The model used for examining currency exchange is based on the search-theoretic approach proposed by Lagos and Wright (2005) and Zhang (2014). One advantage of this approach is that it is micro-founded, i.e., explicit about features that give endogenous value to fiat moneys. In the model provided by Zhang (2014), transaction patterns are endogenous, so it is possible to determine in equilibrium which currencies are adopted and at which prices. Thus, it is possible to study how government policies may affect currency acceptance decisions of private

citizens and currencies' circulation patterns. Because the model is micro-founded, it is also amenable to laboratory implementation (see also Duffy and Puzzello (2014a,b), Jiang and Zhang (2018), or Rietz (2019))). Another advantage of this model is that it provides a tractable framework, despite the assumption of divisible currencies and goods, as it builds on the model originally proposed by Lagos and Wright (2005). As a result, this framework allows one to evaluate the impact of government policies on both the extensive and intensive trade margins, and thus provide a more accurate assessment of these policies.

The empirical literature on currency competition is limited, in part due to the lack of micro-level data. Another reason is that field data faces causal identification challenges (e.g., Colacelli and Blackburn (2009)). The experimental approach allows us to have greater control over the decision-making environment, to isolate factors affecting the decision to accept a particular currency, and to make direct observations about trading behavior. That is, we view the experimental method as a complementary tool to other empirical methods, and we use it to obtain insights that are difficult, if not impossible, to obtain using field data (see Smith (1994) for reasons to conduct experiments or Duffy (2016) for arguments in support of experimental methods in international economics and macroeconomics). For example, we focus on an environment with trading complementarities, e.g., an environment in which the currency sellers accept depends on the currency buyers carry, and vice versa. Such complementarities give rise to coordination issues with multiple equilibria. The laboratory setting can provide useful insights on factors affecting equilibrium selection.

In the search-theoretic model used in this paper, there are two countries with different population sizes, which include buyers and sellers.[1] In each period, agents trade in a decentralized market and a centralized market. Interactions in the decentralized market generate gains from trade, while the centralized market allows agents to rebalance their money holdings. In the decentralized market, sellers choose which currency to accept, before being randomly paired with a domestic or foreign buyer. There is an information cost for accepting foreign currency, which could correspond, e.g., to the costs associated with installing verification technologies or dealing with foreign exchange traders.

[1] We chose a framework with two countries as examining the legal restrictions hypothesis is more natural when framed in terms of currencies associated with distinct groups (e.g., when national identity is part of the legal restrictions view).

The international status of currencies is determined endogenously by sellers' decisions. Sellers in both countries decide whether to accept a particular foreign currency as payment. A currency is deemed "international" if it is accepted by sellers in both countries, while it is "national" if it is accepted only by domestic sellers. In the centralized market, a general good is traded in terms of both currencies. In this setting, government interventions (such as legal restrictions that allow only the use of the domestic currency in the decentralized market, or a change in the cost that sellers must pay to accept the foreign currency) can affect currency acceptance decisions and international status.

To examine how currency interventions affect market allocations, the laboratory market setting includes the examination of four treatment conditions. In the Baseline treatment, a subset of sellers in both countries can only accept the domestic currency. This treatment is designed to capture legal restrictions (see also Wallace (1983)). Unconstrained sellers can choose to accept foreign currency, but incur a cost for doing so. The Baseline treatment allows two monetary equilibria that depend on the agents' beliefs: one in which one currency is domestic and the other currency is international, and one in which both currencies are international.[2] In the NoRestriction treatment, sellers in both countries are allowed to choose which currency to adopt as well as whether to accept both currencies. This treatment corresponds to a *laissez-faire* regime characterized by free trade, no capital controls and market-determined exchange rates (see Kareken and Wallace (1981) and Aritovic (1996)). This treatment allows only one equilibrium, where both currencies are international. In the LowCost and VeryLowCost treatments, the cost of accepting foreign currency is decreased to progressively lower levels. These treatments also allow only one equilibrium in which both currencies are international.

Overall, we find evidence in support of a currency regime shift only when foreign currency acceptance costs are sufficiently low. Indeed, when those costs are very low, the acceptance and usage of foreign currencies increase significantly. While we do not find strong evidence that legal restrictions are successful in determining a regime shift, it is evident that economic allocations are affected by legal restrictions. Specifically, traded quantities and trade proposals involving both types of currencies are significantly larger in the NoRestriction treatment than in the Baseline treatment. In sum, legal restrictions have an impact on the intensive and extensive margins, and

[2] The fixed costs of accepting foreign currency for unconstrained sellers are set so that the currency regime where both currencies are national is not an equilibrium.

thus affect economic allocations. Still, to boost the international status of a currency, sellers must face a considerably low foreign-currency acceptance cost. Section 2 summarizes related literature and our contribution to the literature. Sections 3 describes the model environment. Section 4 provides details of the experimental design and procedures, while Section 5 presents the experimental results. Section 6 discusses why we did not observe strong evidence in support of a currency regime shift in the NoRestriction and LowCost treatments. Section 7 concludes the paper.

2 Literature Review

As mentioned in the introduction, our theoretical framework is based on Lagos and Wright (2005) and Zhang (2014). In this section, we primarily review experimental implementations of micro-founded models of money that are closest to ours (we refer the reader to Zhang (2014) for a more exhaustive review of international currency models).

The closest paper to our study is Jiang and Zhang (2018). This paper, written simultaneously with ours, also uses a micro-founded model to understand the emergence of different currency regimes. We consider the authors' contribution complementary to ours, as they use an approach based on the model proposed by Matsuyama et al. (1993), with indivisible goods and indivisible money. As a result, while there is some overlap, the two studies also focus on different questions. Jiang and Zhang (2018) study how economic integration and legal restrictions affect the selection of international currency regimes. They find that foreign currency acceptance rates are not significantly affected by the degree of country integration. They also study the effect of legal restrictions on foreign currency acceptance decisions by introducing "computerized subjects" or "robots" who can only accept the domestic currency. They find that foreign currency rejection rates significantly increase with the presence of legal restrictions. Jiang and Zhang (2018) do not focus on how changes in foreign currency acceptance costs may affect currency regimes. Importantly, we adopt a different approach. We use *divisible* money and goods. The reason is that, in addition to currency adoption, it is also possible to study how government interventions affect quantities traded, prices and exchange rates. As a result, we can focus on the impact of government interventions on both the intensive and extensive margins. Our approach with divisible money and goods can be further adapted to study the impact of monetary policy on the international status of a currency and exchange rates fluctuations, which we leave for further

research.[3] Rietz (2019) studies an environment with two currencies and *one* country. His study is based on a model proposed by Kiyotaki and Wright (1993) and Craig and Waller (2000), which uses indivisible money and indivisible goods (see also Lester et al. (2012) for a one-country model with multiple currencies where money and goods are both divisible.) The model explores whether the existence of barter affects the secondary currency acceptance rate. Rietz (2019) shows that secondary currency is accepted at a higher rate when barter is not possible. Rietz (2019) studies an environment with one country, where the primary currency is automatically accepted, and allows subjects to decide whether to accept the secondary currency. In our paper, currency acceptance decisions are embedded in an international economics context and both currencies could be accepted or rejected by subjects.

Arifovic (1996) studies exchange rates' behavior in a version of the overlapping generations model provided by Kareken and Wallace (1981). In this model, exchange rates are indeterminate since the demand of individual fiat currencies is not well defined under flexible exchange rates and without legal restrictions. Arifovic (1996) finds that exchange rates fluctuate over time and that the genetic algorithm is good at capturing these fluctuations. Our paper considers frameworks with and without exchange rates indeterminacy, thus allowing us to compare exchange rates behavior across different environments. Exchange rates fluctuate and exhibit similar volatility in all environments, regardless of whether there is indeterminacy (see Appendix B).

Our paper implements a micro-founded monetary model with divisible goods and divisible monies. While other studies have implemented similar frameworks, they have focused on different questions. Duffy and Puzzello (2014b) implement a simplified version of the Lagos and Wright (2005) model to study whether fiat money is empirically essential. They find that fiat money is welfare-improving. Camera and Casari (2014) study questions that are similar to Duffy and Puzzello (2014b) but based on a decentralized matching model. Davis et al. (2019) study fiat money in finite horizon environments where monetary exchange may or may not be supported in equilibrium. They find that production is higher in environments with fiat money, regardless of whether monetary exchange is an equilibrium. Duffy and Puzzello (2014a) test propositions about

[3] See Zhang (2014) and Liu and Shi (2010) for welfare analyses of monetary policies in open-economy search models with multiple currencies. See Head and Shi (2003) for a study of how different money growth rates may affect nominal exchange rates fluctuations.

the essentiality and neutrality of money, while Duffy and Puzzello (2017) and Jiang et al. (2019) explore optimality of inflationary and deflationary monetary policies in a laboratory environment based on Lagos and Wright (2005). Camera et al. (2003) compares the economic allocations with fiat money as a medium of exchange, as well as with an additional asset. McCabe (1989), Lim et al. (1994), Marimon and Sunder (1993) and Marimon and Sunder (1994) use overlapping generation models to study monetary economics questions in laboratory environments where money serves as a store of value. Other laboratory experiments where commodity money serves as a medium of exchange, such as Brown (1996) and Duffy and Ochs (1999), are based on the first generation monetary search model of Kiyotaki and Wright (1989) with indivisible money and indivisible goods. Duffy and Ochs (2002) also explore equilibrium selection in a similar environment with fiat money. Noussair et al. (2007) conduct experiments with three countries and three currencies to study general equilibrium predictions and properties of the equilibration process; however, they implement cash-in-advance constraints, and do not focus on currencies' competition.

3 Environment and Equilibria

The basic setup of the model is based on Zhang (2014). We utilize the search-theoretic approach proposed by Zhang (2014), as it provides a micro-founded model that is explicit about features that give value to fiat monies. As the model is micro-founded, it is also amenable to laboratory implementations (see also Duffy and Ochs (1999), Duffy and Ochs (2002), Duffy and Puzzello (2014a,b), Jiang and Zhang (2018), Jiang et al. (2019), Kamiya et al. (2019) or Rietz (2019) for implementations of micro-founded monetary models). Further, despite the assumption of divisible currencies and goods, it provides a tractable framework, as it builds on the model originally proposed by Lagos and Wright (2005). We chose to work with divisible currencies and goods. This choice allows us to explore the impact of government interventions on the intensive margin, i.e., quantities produced and consumed in each pair, as well as prices and exchange rates.[4]

We depart from Zhang (2014) by assuming that the economy is populated by finitely many agents. We also replace the Kalai bargaining with a random take-it-or-leave-it (TIOLI) bargaining

[4] Another desirable feature of using an approach with divisible currencies and goods is that it allows us to study the impact of monetary policy on the international status of a currency, which is left for further research.

protocol, where the buyer or the seller is selected to make a take-it-or-leave-it proposal with some probability. These departures allow for the experimental implementation of the model.[5]

There are two countries, Country 1 and 2, with populations $2N_1$ and $2N_2$, respectively. Each country issues its own currency, denoted by Currency 1 and Currency 2. All agents in Country s ($s=1,2$) are equally divided into sellers and buyers. That is, the number of buyers and the number of sellers in Country s is given by N_s. Sellers are then further divided into *private sellers* and *government sellers*. We denote by $g_s N_s \in \mathbb{N}_+$ of N_s the number of government sellers in Country s. Government sellers can only accept domestic currency in exchange.[6] While private sellers have the option of accepting both currencies, private sellers from Country s incur a fixed flow cost κ_s to recognize and accept foreign currency.[7]

Time is discrete and agents live forever with a discount factor $\beta \in (0,1)$. In each time period t, there are two subperiods with different market structures. In the first subperiod, a special good is traded in the Decentralized Market (DM). Each private seller from either country (Country 1 or 2) chooses whether to accept the foreign currency as payment before being randomly matched with a buyer from Country 1 or Country 2. In each pair, the seller can produce q units of the special good and sell them to the buyer after negotiating the terms of trade with the random TIOLI bargaining rule. In the second subperiod, all agents from both countries are brought into the centralized market (CM), where they produce and consume a general good. Denote the consumption in the CM as X and the production in the CM as Y. While consumption goods in

[5] The specific choice of Kalai bargaining is not critical for the theory. The crucial feature of the trading protocol is that sellers should receive some surplus. We chose the random TIOLI as it satisfies this requirement, it is amenable to experimental implementation and easy to explain to subjects.

[6] See Li and Wright (1998) and Waller and Curtis (2003) for a similar assumption in the context of one-country and two-country models, respectively. See Curtis and Waller (2000) for a study of enforcement issues associated with legal restrictions.

[7] For different interpretations of this cost, see footnote 10 in Zhang (2014). Some examples include costs associated with the installation of new technology, with learning how to use foreign currencies, etc. Legal restrictions and imperfect recognizability of currencies break the nominal exchange rate indeterminacy result, as currencies are not necessarily perfect substitutes. For an alternative approach with counterfeiting frictions, see Goms-Porqueras et al. (2017).

the DM and the CM are nonstorable, currencies are storable.[8] Both goods and currencies are divisible.

The preferences of buyers and sellers in a period are given by:

$$U^B = u(q) + U(X) - Y$$

$$U^S = -c(q) + U(X) - Y,$$

where $u(\cdot)$ and $c(\cdot)$ denote the utility and the cost functions in the DM, respectively, and $U(\cdot)$ denotes the utility function in the CM. For tractability, the cost function in the CM is linear. The utility function and cost functions in the DM satisfy the following properties: $u' > 0, u'' < 0, c' > 0, c'' > 0, u(0) = c(0) = c'(0) = 0$, and $u'(0) = \infty$. Thus, there exists a $q^* \in (0, \infty)$ such that $u'(q^*) = c'(q^*)$. Note that the quantity q^* maximizes surplus in a pair and provides the first-best allocation. The utility function in CM satisfies $U' > 0, U'' \leq 0$ and there exists a $X^* \in (0, \infty)$ such that $U'(X^*) = 1$.

The matching rule determines the matching probabilities in the DM of each time period. At the beginning of the DM, $\alpha_s N_s \in \mathbb{N}_+$ sellers in country s are matched with foreign buyers. This implies that $\alpha_s N_s$ buyers in Country s will be matched with foreign sellers, as no agent remains unmatched. Therefore, the total number of international trade meetings is given by $\alpha_1 N_1 + \alpha_2 N_2$. Each row of Table 1 provides the matching probabilities associated with different meetings for a buyer or a seller in Country 1 or Country 2.

Table 1: Matching Probabilities in the DM by Role and Country

Role **Buyers**	Government Seller from Country 1	Private Seller from Country 1	Government Seller from Country 2	Private Seller from Country 2
Buyer from Country 1	$g_1(1-\alpha_1)$	$(1-g_1)(1-\alpha_1)$	$g_2\alpha_1$	$(1-g_2)\alpha_1$
Buyer from Country 2	$g_1\alpha_2$	$(1-g_1)\alpha_2$	$g_2(1-\alpha_2)$	$(1-g_2)(1-\alpha_2)$
Sellers	Buyer from Country 1		Buyer from Country 2	

[8] Specialization in consumption and production in the DM generates gains from trade, while periodic access to the CM, in conjunction with quasilinear preferences, achieves tractability.

Sellers from Country 1	$1-\alpha_1$	α_1
Sellers from Country 2	α_2	$1-\alpha_2$

The intrinsically worthless currency s issued by the government in Country s is perfectly divisible and storable. The monetary policy in country s at time t is given by $\gamma_{s,t} \equiv \frac{M_{s,t+1}}{M_{s,t}}$, where $M_{s,t}$ and $M_{s,t+1}$ denote the supply of currency s at time t and $t+1$, respectively. We set $\gamma_{s,t} = 1$, i.e., the money supply in both countries is kept constant.

A currency regime is an ordered pair that describes the international status of the two currencies. There are two possibilities for the international status of a currency when both currencies are valued: I or N. Status I means that the currency is an *international* currency, and it is accepted in both countries; Status N means that currency s is a *national* currency and it is only accepted in Country s. There are four possible currency regimes: (I,I), (N,I), (I,N) and (N,N), where the first letter denotes the international status of Currency 1, and the second denotes that of Currency 2. The international status of a currency is determined by private sellers' foreign currency acceptance decisions. For example, if private sellers in Country 1 accept foreign currency, then Currency 2 is accepted in both countries; thus, Currency 2 is an international currency. If private sellers in Country 1 do not accept foreign currency, then Currency 2 is a national currency.

As in Zhang (2014), there exist multiple monetary equilibria depending on fundamentals, as well as expectations regarding other agents' behavior. Specifically, multiplicity of equilibria is a result of complementarities between buyers and sellers' decisions: which currencies sellers accept depends on which currencies buyers carry, and which currencies buyers carry depend on which currencies sellers accept. If a currency is more widely accepted by sellers, then it is more liquid and buyers have a stronger incentive to hold it. In turn, if buyers hold more of a currency, sellers have a stronger incentive to accept it. Thus, the value of a currency is affected by buyers and sellers' decisions. Fundamentals also play an important role. For example, if information costs are sufficiently high, then the cost to accept foreign currencies is too high relative to the expected additional benefit. As a result, only national currencies circulate in the domestic economy. In the next section, we characterize equilibrium currency regimes for the parameterizations associated with our experimental design.

4 Experimental Design and Procedures

4.1 Parameterization and Theoretical Predictions

The main goal of our paper is to study how economic allocations and international currency regimes are affected by government interventions. The interventions we consider are legal restrictions and fixed costs associated with the use of foreign currencies.

To capture these government interventions, the main treatment variables of our study are: (1) legal restrictions, modeled as restrictions on sellers' foreign currency acceptance decisions (the g parameter in the model); and (2) the fixed costs government sellers pay to accept foreign currency (the κ parameter in the model). That is, the first intervention imposes a *direct* constraint on sellers' acceptance decisions, while the second restriction affects the cost of dealing with foreign currency, thus *indirectly* affecting sellers' foreign-currency acceptance decisions.

We consider four treatments: **Baseline**, **NoRestriction**, **LowCost**, and **VeryLowCost**.[9] In the Baseline treatment, there are Constrained Sellers (government sellers) in both countries.[10] These sellers can only accept domestic currency. In the NoRestriction treatment, we eliminate this restriction so that all sellers are Unconstrained Sellers (private sellers) who can potentially accept both currencies. In this way, we capture a laissez-faire regime. In the LowCost and VeryLowCost treatment, there are some Constrained Sellers, as in the Baseline treatment; however, the fixed costs of accepting foreign currency for Unconstrained Sellers are lower than in the Baseline treatment. Next, we provide more details on the parameterization. The population sizes of Country 1 and Country 2 are equal to $2N_1 = 4$ and $2N_2 = 6$, respectively. In the **Baseline** treatment we set $g_1 = \frac{1}{2}$ and $g_2 = \frac{1}{3}$, i.e., half (one third) of the sellers in Country 1 (Country 2) are Constrained Sellers. In the **NoRestriction** treatment, we set $g_1 = 0$ and $g_2 = 0$. That is, in the Baseline, LowCost, and VeryLowCost treatments, there is one Constrained Seller and one Unconstrained Seller in Country 1, and one Constrained Seller and two Unconstrained Sellers in Country 2. In the

[9] We thank the editor and anonymous reviewers for suggesting that we conduct sessions in the VeryLowCost treatment.

[10] In the experiment we adopted a neutral terminology. For example, we replaced government and private sellers with Constrained Sellers and Unconstrained Sellers. Similarly, we replaced terms like "country" and "currency" with "group" and "token," respectively.

NoRestriction treatment where $g_1 = g_2 = 0$, however, all sellers in both countries are Unconstrained Sellers.

In both the Baseline and NoRestriction treatments, the flow cost of accepting foreign currency for unconstrained sellers in Country 1 is equal to $\kappa_1 = 2$, while the flow cost of accepting foreign currency for unconstrained sellers in Country 2 is equal to $\kappa_2 = 4$. To study the impact of a government's intervention that lowers the cost of dealing with the foreign currency, the fixed cost for unconstrained sellers in Country 2 is reduced from $\kappa_2 = 4$ to $\kappa_2 = 2$ in the **LowCost** treatment. The fixed costs are lowered to $\kappa_1 = \kappa_2 = 0.01$ in the **VeryLowCost** treatment. All other parameters are common to all treatments.

Regarding the matching rule, we set $\alpha_1 = \frac{1}{2}$ and $\alpha_2 = \frac{1}{3}$, which implies that one of the two sellers from Country 1 and one of the three sellers from Country 2 will be paired with a buyer from the "foreign" country. In sum, the five pairs formed by ten subjects are given by: one intra-country pair from Country 1, two intra-country pairs from Country 2, and two inter-country pairs.

We set $\theta = 0.5$, i.e., within each pair in the DM, one subject (either the buyer or the seller) is chosen with equal probability to make a trade proposal.

In the DM, the points gained from consuming q units of the special good are given by $u(q) = 24\sqrt{q}$. The points lost from producing q units of the special good are given by $c(q) = 2q$. Recall that the first best quantity q^* is the quantity satisfying $u'(q^*) = c'(q^*)$, therefore $q^* = 36$. In the CM, the points gained from consuming the general good are simply $U(X) = X$, and the points lost from producing Y units of the general good are equal to Y. The continuation probability after each period is $\beta = 0.75$.

Finally, we set $\gamma_1 = \gamma_2 = 1$, i.e., there is no active monetary policy: the total supply of Currency 1 is equal to 200, and the total supply of Currency 2 is equal to 300.[11]

If we focus on monetary equilibria where both currencies are valued, the theoretical predictions associated with this set of parameters are shown in Table 2 (See Appendix A for more details). Note that there are two equilibria in the Baseline treatment: currency regime (I,I) and

[11] In the experiment, we use the term token rather than currency.

(N,I). That is, depending on the equilibrium, Currency 1 is either international or domestic, while Currency 2 is always an international currency. There are multiple equilibria, as the currency regime supported in equilibrium depends on the beliefs of buyers and sellers. When sellers decide whether to accept a foreign currency, they face a trade-off between the fixed cost and the potential benefit of achieving a higher expected surplus associated with accepting both currencies. If buyers believe that unconstrained sellers accept both currencies, the amount of real money holdings they bring is such that the sellers expected surplus from accepting foreign currencies is sufficiently high that it is optimal to accept foreign currencies. Then, the currency regime (I,I) is an equilibrium. On the other hand, if buyers believe that sellers in Country 2 only accept Currency 2, then Currency 1 is less liquid and the real amount of Currency 1 they bring is lower. It follows that the expected surplus of sellers in Country 2 from accepting foreign currency in addition to domestic currency is too low relative to the cost. As a result, they are better off not accepting Currency 1. In this case, regime (N,I) prevails.[12] That is, buyers and sellers face a coordination game, whose outcome determines whether Currency 1 is international or domestic.

In the NoRestriction, LowCost, and VeryLowCost treatments, there exists only the monetary equilibrium (I,I), where both currencies serve as international currencies. The intuition for this result is that in the LowCost and VeryLowCost treatments, the fixed costs are now sufficiently low to make it optimal to accept both currencies also for sellers in Country 2. Basically, the expected surplus sellers obtain by accepting both currencies, net of the cost, is higher than the expected surplus they would obtain if they accepted only domestic currency. Thus, (I,I) is the only currency regime. In the NoRestriction treatment, if buyers believe that sellers accept both currencies, and since all sellers are unconstrained, currencies are more liquid. Thus, buyers' real money holdings are higher relative to the Baseline environment. Therefore, sellers' expected surplus is again sufficiently high to support (I,I) as an equilibrium regime. In the NoRestriction treatment, (N,I) is no longer an equilibrium as both currencies are valued only if they are perfect substitutes, which is not possible in this regime.[13]

[12] The fixed cost for sellers in Country 1 is sufficiently low so that it is always optimal to accept Currency 2.

[13] If Currency 1 is not accepted by sellers in Country 2, this implies that buyers' marginal benefit of holding Currency 1 is strictly lower than holding Currency 2. This holds true, as bringing more Currency 1 can only increase their benefit when they trade with sellers in Country 1. Bringing more Currency 2, however, can increase their benefit when they trade with sellers from both countries (and money supply is constant in both countries, so that the

Note that the average quantity produced is higher in the monetary equilibrium where both currencies are accepted. This also implies that welfare is higher when both currencies are accepted. The highest welfare is achieved under the NoRestriction treatment, as shown in the seventh row of Table 2. Aggregate surplus from trade in DM as a measure of welfare provides an ordinal ranking of the different treatments. To quantify how much better off consumers would be in the different treatments, we followed the approach used in the macroeconomics literature to compute the welfare gain or cost of government interventions. Specifically, $1-\Delta_s$ measures how much the buyers in Country s would be willing to give up in terms of consumption to be in the (I,I) equilibrium of LowCost, VeryLowCost or NoRestriction treatments. The size of welfare benefits to be obtained by the policies we consider depend on which equilibrium is selected as a reference point in the Baseline treatment. For example, if (I,I) is selected as a reference point in the Baseline treatment, then consumers would not be willing to give up consumption to decrease the cost of accepting foreign currency for sellers in Country 2. On the other hand, if (N,I) is selected in the Baseline treatment, then consumers would be willing to give up at least 3% of their consumption to decrease the foreign-currency acceptance cost for sellers in Country 2. However, no matter which equilibrium is selected in the Baseline treatment, consumers are better off if legal restrictions are eliminated. Specifically, buyers in Country 1 (Country 2) would be willing to give up 8.70% (7.72%) of their consumption to be in the (I,I) equilibrium of the NoRestriction rather than in the (N,I) equilibrium of the Baseline treatment. Similarly, buyers in Country 1 (Country 2) would be willing to give up 5.13% (4.25%) of their consumption to be in the (I,I) equilibrium of NoRestriction rather than in the (I,I) equilibrium of Baseline. We designed our experiment to obtain large welfare differences across equilibria.[14]

Table 2: Parameters and Theoretical Predictions across Treatments

Treatment	Baseline	NoRestriction	LowCost	VeryLowCost

opportunity cost of holding Currency 1 is the same as Currency 2). Then, no one would accept or hold Currency 1, and as a result, it would not be valued. However, while (N,I) cannot be a monetary equilibrium where both currencies are valued, there are equilibria where only one of the currencies is valued or none is valued.

[14] These costs are quite large, e.g., relative to the welfare costs of inflation evaluated in other microfounded models of money, see Lagos and Wright (2005). See Appendix A for details on the computation of welfare costs for our environment.

g_1	$\frac{1}{2}$		0	$\frac{1}{2}$	$\frac{1}{2}$
g_2	$\frac{1}{3}$		0	$\frac{1}{3}$	$\frac{1}{3}$
κ_1	2		2	2	0.01
κ_2	4		4	2	0.01
Monetary Eq.	(N,I)	(I,I)	(I,I)	(I,I)	(I,I)
Average DM Quantity	4.97	5.68	7.07	5.68	5.68
Aggregate Welfare	17.27	17.77	19.43	18.17	18.77
Consumption Equivalent Welfare					
1- Δ_1, versus Baseline (N,I)	0	3.83%	8.70%	3.83%	3.83%
1- Δ_2, versus Baseline (N,I)	0	3.04%	7.72%	3.04%	3.04%
1- Δ_1, versus Baseline (I,I)	-	0	5.13%	0	0
1- Δ_2, versus Baseline (I,I)	-	0	4.85%	0	0

4.2 Experimental Procedures

The experiment was computerized using the z-Tree software (Fischbacher, 2007). Subjects were undergraduate students at Indiana University who were recruited using the Online Recruitment System for Economic Experiment (ORSEE) developed by Greiner (2015). Subjects had no prior experience with the game considered in the paper. Each session consisted of 10 subjects who were given written instructions (see Appendix C for the instructions). Subjects were then given roughly 20 minutes to read the instructions on their own. The *instructions' summary*, however, was read aloud by the experimenter, in an effort to make the instructions common knowledge. After the summary instructions were read, subjects were given another 20 minutes to answer a number of quiz questions to test their understanding of the game. After all subjects correctly answered all quiz questions, the experiment began.

At the beginning of each experimental session, subjects were randomly divided into two groups: Four subjects were assigned to Country 1 and six subjects were assigned to Country 2.[15] Subjects in each country were then equally divided into Buyers and Sellers. In the NoRestriction treatment, all sellers were assigned the role of Unconstrained Sellers. In the Baseline and LowCost

[15] In the experiment, we used the neutral term "Group" instead of "Country."

treatments, one seller in Country 1 and one seller in Country 2 were assigned the role of Constrained Seller, while the remaining sellers were assigned the role of Unconstrained Sellers.

Each session consisted of several sequences, and a sequence consisted of an indefinite number of periods. Each period consisted of two rounds: a decentralized market round and a centralized market round. At the end of each period, the sequence continued with probability 0.75 . Specifically, when a period ended, a random number was drawn from the set {1,2,3,4}: if the number drawn was 1 or 2 or 3, the sequence continued with another two-round period. If the number drawn was 4, the sequence ended.[16] Once a sequence ended, a new sequence began depending on the time available. Subjects' roles alternated across sequences, so that if a subject had a buyer's role in a sequence, he would be a seller in the next sequence. This minimized the realization of unequal payoffs (as theoretically buyers' payoffs are higher than sellers' payoffs) and exposed subjects to both roles.

At the beginning of each sequence, all Buyers in Country 1 were endowed with 55 units of Currency 1 and 45 units of Currency 2, and Buyers in Country 2 were endowed with 30 units of Currency 1 and 70 units of Currency 2. Additionally, at the beginning of each sequence, all Buyers were endowed with 10 points and all sellers were endowed with 50 points, to lower the likelihood that a subject would end up with a negative point balance. Sellers received a higher endowment to equalize expected earnings within a sequence.

Subjects earned points by engaging in consumption or production in a period. Within a period, there were two rounds for subjects to play. The first round captured the Decentralized Meeting (DM) environment. At the beginning of the DM, Unconstrained Sellers decided whether to pay a flow cost for the option to accept foreign currency. The flow cost varied depending on the treatment. In the Baseline and NoRestriction treatments, the flow costs for Unconstrained Sellers

[16] We follow the interpretation of discount factor as probability of continuation (e.g., Mailatha and Samuelson (2006)). The use of random termination to implement indefinite horizons in the laboratory started with Roth and Murnighan (1978) and is now common in experimental economics. Alternative approaches include finite horizon economies with final round coordination games or uncertainty in the trading position that bypass backward induction's arguments (see, e.g., Cooper and Kühn (2014), Fréchette and Yuksel (2017) and Davis et al. (2019)). Here, we decided to follow the standard method used in experimental economics, as current experimental evidence indicates that behavior is consistent with the presence of dynamic incentive only with methods using random termination, see Fréchette and Yuksel (2017). Further, the environments studied in Davis et al. (2019) are not currently suitable to address the questions we tackle in this paper.

from Country 1 and Country 2 were set to $\kappa_1 = 2$ and $\kappa_2 = 4$, respectively. In the LowCost treatment, these costs were equal to $\kappa_1 = \kappa_2 = 2$. In the VeryLowCost treatment, these costs were equal to $\kappa_1 = \kappa_2 = 0.01$.

Each buyer was randomly paired with a seller, as described in Table 1. Specifically, one buyer in Country 1 was randomly paired with a seller in Country 2, while the other buyer was randomly paired with a seller in Country 1. Similarly, one buyer in Country 2 was randomly paired with a seller in Country 1, while the other two buyers were randomly paired with two sellers in Country 2. Thus, the number of inter-country pairs was equal to two, while the number of intra-country pairs was equal to three.

Within each pair, the Buyer or the Seller was selected with equal probability to make a proposal including the amount of the special good q, to be produced by the Seller and consumed by the Buyer, and amounts d_1 of Currency 1 and d_2 of Currency 2 (if any), to be transferred from the Buyer to the Seller. Before making the proposal, subjects were informed of both their own and their partners current currency balances. Subjects were instructed that the amount of money offered could not exceed the Buyer's current currency holdings. The subject who received the proposal decided whether to accept or reject the trade proposal. If the proposal was accepted, the buyer would gain $u(q) = 24\sqrt{q}$ points and the seller would lose $c(q) = 2q$ points. These functions were presented to subjects in a payoff table showing how a certain quantity of the special good translated into a positive number of "points" in the case of consumption or a negative number of points in the case of production (subjects were instructed in how to use that table to calculate their earnings). The proposed amounts d_1 of Currency 1 and d_2 of Currency 2 were transferred from the Buyer to the Seller. If the proposal was rejected, currency holdings and points balances remained unchanged.

The second round captures the Centralized Meeting (CM) environment. The market mechanism used for the CM was a market game as in Duffy and Puzzello (2014b), modified to take into account the presence of two currencies and thus two trading posts. All subjects first chose whether to produce-and-sell or buy-and-consume. Subjects who chose to be sellers in the CM were asked to state a quantity Y_s of the general good that they were willing to produce and sell for Currency s; subjects who chose to be buyers in the CM were asked to state the bid in terms of

Currency s, B_s, they were willing to use to buy and consume units of the general good. Each buyer's bid of Currency s, B_s, could not exceed their available balance of Currency s. Under this market game, in each trading post market $s = A, B$, the price in terms of Currency s was determined by the following formula:

$$P_s = \frac{Sum\ of\ Bids\ B_s}{Sum\ of\ Quantity\ Y_s}.$$

Then all transactions in terms of Currency s were carried out at this price P_s. We set $P_s = 0$ if either the Sum of Bids B_s or the Sum of Quantity Y_s were equal to zero, and no trade took place.

The payoffs for the CM round were determined as follows. Given the price P_s, the sellers producing Y_s units of the general good gained $P_s Y_s$ amount of Currency s but they incurred the production cost of Y_s points, and the buyers of Y_s' units of general good gave up $P_s Y_s'$ of their available money balances, but received Y_s' points in exchange. Points were added or subtracted to subjects' point totals. At the end of the period, the sequence continued with probability 0.75, as described above. If a sequence continued, subjects could carry over their currency balances to the next period. If a sequence ended, currency balances could not be carried over to the next sequence and they were reset at the beginning of the next sequence. Figure 1 illustrates the timing of events in a typical period in a sequence.

Figure 1: Timing of Events in a Typical Period in a Sequence

Additionally, while points were converted to US dollars, currencies in the experiment (tokens) were never converted into US dollars, so as to capture the fact that fiat money is an intrinsically worthless and inconvertible object. At the end of a session, cash payments were calculated by converting the points accumulated across all sequences into US dollars at a preannounced conversion rate. Subjects earned about $31.5 on average and sessions lasted about 135 minutes.[17]

[17] Subjects were recruited for 150 minutes.

5 Experimental Results

The experimental sessions were conducted from May 2016 to November 2019 in the IELab at Indiana University.[18] We conducted five sessions in each treatment, aside from the VeryLowCost treatment, which consisted of four sessions. Table 3 provides some basic session information. As indicated in Table 3, subjects participated on average in 4.2 sequences and 15.3 periods, each one consisting of a DM and CM market. Our experimental results are summarized as a list of findings associated with the theoretical predictions.[19]

Table 3: Characteristics of Experimental Sessions

Session no., Treatment	No. of Sequences	No. of Periods	Average Payment to Subject
1, Baseline	4	12	37.2
2, Baseline	4	17	30.2
3, Baseline	3	13	28.3
4, Baseline	4	15	30.7
5, Baseline	4	19	31.6
6, NoRestriction	4	14	35.1
7, NoRestriction	6	20	41.3
8, NoRestriction	4	13	28.1
9, NoRestriction	4	15	27.5
10, NoRestriction	4	11	23.4
11, LowCost	3	17	32.4
12, LowCost	3	15	25.5
13, LowCost	4	16	29.3
14, LowCost	5	13	34.1
15, LowCost	5	14	28.5
16, VeryLowCost	7	18	43.0

[18] Most of our experimental sessions were conducted from May 2016 to September 2017. We conducted four new sessions of the VeryLowCost treatment in November 2019 following the suggestion of anonymous reviewers.

[19] As in other experiments in monetary economics (e.g., Bernasconi and Kirchkamp (2000), Duffy and Puzzello (2014a, 2014b, 2017), Jiang and Zhang (2018)) we used theory to explore directional hypotheses. The reason is that we believe they are a more reasonable benchmark. While we find some support for the directional hypotheses, perhaps not surprisingly, point predictions are not supported, e.g., see Appendix B for more details.

17, VeryLowCost	3	16	25.2
18, VeryLowCost	4	15	33.1
19, VeryLowCost	5	16	33.4
Average	4.2	15.3	31.5

There is dependence at the subject-level and session-level in the panel data from our experiment. To address this issue, we use two-way clustering regressions that cluster both at the individual and session levels. Therefore, for regressions with continuous dependent variables, such as traded quantity and welfare per period, the regression analysis provides standard errors clustered both at the individual and session levels.[20] However this estimation approach is not available with probit models for binary dependent variables, such as foreign currency acceptance or proposal acceptance decisions. For these regressions we estimate random-effects multilevel models where we can take into account dependence both at the subject and session levels (see Moffatt (2015)).[21] We provide robustness checks in Appendix B.

We start by observing that subjects valued both currencies and used them in exchange. More than 97.8% of accepted proposals involved positive amounts of currencies in all sessions. Offer acceptance rates are positive, around 62.2%, as shown in Table 4. These rates are consistent with Duffy and Puzzello (2014b), who also find support for monetary equilibria.

Table 4: Offer Acceptance Rates and Accepted Quantities in DM, by Session and Treatment

Session no., Treatment	Offer accept rate	Accepted Quantities
1,Baseline	61.5	4.41
2,Baseline	57.1	9.00
3,Baseline	56.3	6.51
4,Baseline	71.2	6.22
5,Baseline	63.2	5.11
Average for Baseline	61.8	6.29
6,NoRestriction	61.2	8.88
7,NoRestriction	66.3	10.26

[20] We use the *ivreg2* package in Stata, as it allows us to cluster at both individual and session levels.

[21] We use the *gllamm* package in Stata. This package allows to estimate multi-level models.

8,NoRestriction	66.7	6.70
9,NoRestriction	59.7	7.51
10,NoRestriction	60.4	5.93
Average for NR	63.0	8.12
11,LowCost	65.4	7.04
12,LowCost	60.3	4.88
13,LowCost	65.3	4.12
14,LowCost	63.1	10.32
15,LowCost	60.6	3.90
Average for LC	63.1	6.03
16,VeryLowCost	65.5	7.29
17,VeryLowCost	53.3	5.15
18,VeryLowCost	64.8	6.93
19,VeryLowCost	59.7	9.81
Average for VLC	60.1	7.33

We next provide evidence that legal restrictions have an impact on the intensive margin, namely, on quantities traded.

FINDING 1: Quantities traded are higher in the NoRestriction treatment than in the Baseline treatment. Quantities proposed by buyers are higher than quantities proposed by sellers.

Support for Finding 1 is shown in the third column of Table 4 and Figure 2 that report average amounts traded of the decentralized good by sessions and by treatment, respectively. The average quantity produced of the decentralized good is roughly 30% (34%, 11%) larger in the NoRestriction treatment than in the Baseline (LowCost, VeryLowCost) treatments. This result is qualitatively consistent with the theoretical predictions. Using a one-sided, non-parametric, Wilcoxon Mann-Whitney test on the five session-level average traded quantities, we can reject the null hypothesis of no difference in traded quantities between the Baseline treatment and the NoRestriction treatment in favor of the alternative that the traded quantities are higher in the NoRestriction treatment than in the Baseline ($p=0.087$).

The regression results in Table 5 provide more details on factors affecting traded

quantities.[22] We report treatment effects without controls in Column (1), while results for the specification with additional control variables is reported in column (2). The independent variables consist of: (1) *Baseline* (/ *NR* / *LC* / *VLC*), a dummy variable taking value of 1 if the treatment is Baseline(/NoRestriction/LowCost/VeryLowCost) (2) d_1 and d_2, the amounts of Currency 1 and Currency 2 transferred from the Buyer to the Seller; (3) *Buyerprop*, a dummy variable that takes value 1 if the trade proposal is made by a Buyer; and (4) *Period*, the period number in a sequence. The regression results reported in Table 5 show that quantities traded in the NoRestriction treatment are significantly higher than in the Baseline, while quantities traded in the LowCost and VeryLowCost treatments are not significantly different from the Baseline treatment.[23] The regression results reported in Table 4 also show that traded quantities are increasing in the amount of currencies transferred and, conditional on exchange quantities proposed by buyers are significantly higher than those proposed by sellers. These findings are consistent with the qualitative theoretical predictions based on the take-it-or-leave-it bargaining rules, which predict that quantities proposed by buyers are higher than quantities proposed by sellers.

Furthermore, the theoretical predictions imply larger absolute differences across treatments for quantities proposed by buyers than by sellers (e.g., see Table 12 in Appendix A). Indeed, the regression analysis reported in Table 6 indicates that, when the buyer makes the trade proposal, quantities traded in the NoRestriction treatment are significantly higher than in the Baseline treatment. Likewise, when the seller makes the proposal, quantities traded tend to be higher in the NoRestriction treatment than in the Baseline, but this result is not significant. These results are also supported by a one-sided Mann-Whitney non-parametric test with session as the unit of observation (p-value of NoRestriction vs. Baseline is $p = 0.038$ when only using the trades proposed by buyers, and $p = 0.377$ when we use trades proposed by sellers). There are no other significant differences across treatments.

Figure 2: Average Traded Quantity in DM, by Treatment

[22] Standard errors are clustered both at the individual and session levels.

[23] There are no other significant differences across treatments, except that quantity traded is marginally significantly higher in the NoRestriction treatment than in the LowCost treatment in the first specification, p-value=0.097.

Table 5: Regression Analysis of Traded Quantities

	(1)	(2)
	Traded Quantity	Traded Quantity
NR	1.828*	1.659*
	(0.996)	(0.972)
LC	−0.254	−0.0503
	(1.232)	(1.200)
VLC	1.036	0.787
	(1.013)	(0.865)
d1		0.121***
		(0.0275)
d2		0.134***
		(0.0167)
Buyerprop		1.167***
		(0.396)
Period		−0.296**
		(0.131)
Constant	6.290***	3.863***
	(0.683)	(0.853)
Observations	829	829
R^2	0.016	0.173

Standard errors in parentheses are clustered at the subject and session level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Regression Analysis of Traded Quantities, by Role

	(1)	(2)	(3)	(4)
	Quantity proposed by Buyers		Quantity proposed by Sellers	
NR	2.557***	2.484**	1.253	1.175
	(0.836)	(1.033)	(1.424)	(1.309)
LC	0.702	1.004	−0.811	-0.620
	(1.120)	(1.250)	(1.310)	(1.316)

VLC	1.228	1.042	0.530	0.729
	(1.117)	(0.725)	(0.978)	(1.061)
d1		0.124***		0.120***
		(0.0435)		(0.0380)
d2		0.167***		0.106***
		(0.0273)		(0.0191)
Period		−0.768***		−0.0481
		(0.184)		(0.173)
Constant	6.676***	5.214***	6.061***	3.843***
	(0.439)	(0.983)	(0.903)	(1.033)
Observations	352	352	477	477
R^2	0.018	0.272	0.014	0.106

Standard errors in parentheses are clustered at the subject and session level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We now focus on the impact of government policies on the extensive margin.

FINDING 2: Buyers' proposals are more likely to be accepted in the NoRestriction treatment. The lower the proposed quantity, and the higher the proposed currency transfer, the more likely Buyers' proposals are to be accepted by Sellers.

To further analyze the proposal acceptance decisions, we separated the proposals based on the proposer. While theory does not predict a treatment effect on the extensive margin, as shown in the second column of Table 7, we find that buyers' proposals are more likely to be accepted in the NoRestriction treatment than in Baseline. This appears to indicate that legal restrictions have an impact on the extensive margin, namely on the number of proposals accepted. Furthermore, the better the proposed terms of trade from the perspective of the receiver, the more likely it is that the proposal will be accepted. When the Buyer is the proposer, the Seller is less likely to accept as the quantity proposed increases and more likely to accept as the currency transferred in either type increases. When the Seller in the pair makes the proposal, the impact of the terms of trade on the acceptance probability are in a similar direction, but are either not significant or only marginally significant. There are no other significant differences across treatments. These findings are consistent with Duffy and Puzzello (2014b).

Table 7: Probit Regression Analysis of Proposal Acceptance Decision

	(1)	(2)	(3)	(4)
	Accept = 1, Reject = 0			
	Buyers' Proposals		Sellers' Proposals	
NR	0.121	0.375***	−0.00138	−0.193
	(0.0769)	(0.111)	(0.139)	(1.041)
LC	−0.0626	-0.0193	0.286*	0.531
	(0.104)	(0.231)	(0.158)	(0.600)
VLC	0.129	0.208	-0.0605	−0.154
	(0.120)	(0.163)	(0.213)	(0.944)
Quantity		−0.0925***		0.250
		(0.0200)		(0.619)
d1		0.0410***		−0.0265*
		(0.0135)		(0.0153)
d2		0.0253***		−0.0426
		(0.00852)		(0.109)
Period		0.229***		−0.185
		(0.0377)		(0.524)
Constant	-0.0279	0.682***	0.752***	1.634
	(0.0638)	(0.153)	(0.147)	(4.181)
Observations	691	691	641	641
log likelihood	-498.37	−445.85	−365.36	−329.98

Random effects at the subject and session level. Robust standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Next we discuss whether the international status of currencies was affected by government interventions. According to the theoretical predictions, currency regime (I,I) is the only equilibrium regime in the NoRestriction, LowCost, and VeryLowCost treatments, and thus Currency 1 should always be accepted by Unconstrained Sellers in Country 2. However, both (N,I) and (I,I) are equilibrium regimes in the Baseline treatment, so that Currency 1 may or may not be

accepted by Unconstrained Sellers in Country 2 in equilibrium. In what follows, we test whether government interventions increased the acceptance frequency of foreign currencies, and particularly Currency 1 by Unconstrained Sellers in Country 2.

FINDING 3: Unconstrained Sellers in both countries pay the cost to be able to accept foreign currency more frequently in the VeryLowCost treatment, suggesting a currency regime shift. Unconstrained Sellers in Country 1 pay the cost to accept foreign currency more frequently than Unconstrained Sellers in Country 2.

Unconstrained Sellers in both countries pay the cost to be able to accept foreign currency more frequently in the VeryLowCost treatment than in the Baseline treatment (see Figure 3 and Table 8), while foreign currency acceptance rates in the NoRestriction and LowCost treatments are similar to the Baseline treatment.[24] The results from the subject level and session-level random effects probit regression are provided in Table 9.[25] The regression results indicate that sellers' willingness to pay to accept foreign currency was not strongly affected by changes in legal restrictions or moderately lower acceptance costs. However, when the fixed costs are lowered to near zero in the VeryLowCost treatment, Unconstrained Sellers in both countries are much more likely to pay the cost to accept foreign currencies. As a result, the international status of both currencies is stronger than in the other three treatments (with p-values less than 1% in the first and third specifications and less than 5% in the second specification).[26] As subjects proceeded in the experimental session, they tended to be less willing to pay the cost to accept foreign currency as indicated by the negative coefficients for the variable *Period* , a variable capturing periods within

[24] The theoretical predictions for foreign currency acceptance decisions are 100% for Unconstrained Sellers in both countries in the NoRestriction, LowCost and VeryLowCost treatments, and for Unconstrained Sellers in Country 1 in the Baseline treatment. Regarding Unconstrained Sellers in Country 2 of the Baseline treatment, foreign currency acceptance rates could be either 100% or 0%, as Currency 1 is National or International depending on the monetary equilibrium.

[25] The random effects regression analysis for the multilevel model is estimated with the *gllamm* package in Stata with random effects at both the subject and session levels.

[26] Specifically, under the first specification, VeryLowCost vs. Baseline: p-value=0.002, VeryLowCost vs. NoRestriction: p-value=0.0015, VeryLowCost vs. LowCost: p-value=0.0015. Under the second specification, VeryLowCost vs. Baseline: p-value=0.018, VeryLowCost vs. NoRestriction: p-value=0.03, VeryLowCost vs. LowCost: p-value=0.011. Under the third specification, VeryLowCost vs. Baseline and VeryLowCost vs. NoRestriction: p-value < 0.001, VeryLowCost vs. LowCost: p-value=0.0021.

a sequence. The regression results also indicate that Unconstrained Sellers in Country 2 were less likely to pay the cost to accept foreign currencies than Unconstrained Sellers in Country 1. This is true in all four treatments, as indicated by the negative coefficient for variable *Country*2, which takes value 0 for Unconstrained Sellers from Country 1 and value 1 for Unconstrained Sellers from Country 2 (see Column (1) in Table 9). While this result is not consistent with the theory, it is consistent with the findings of Jiang and Zhang (2018). This effect may be attributed to the asymmetry in country sizes and the probability of matching a foreign buyer, which was higher for Unconstrained Sellers in Country 1. In our design, an Unconstrained Seller in Country 1 matches with a foreign Buyer with probability $\frac{1}{2}$, while this probability is smaller and equal to $\frac{1}{3}$ for an Unconstrained Seller in Country 2. Therefore, an Unconstrained Seller in Country 1 meets a foreign buyer more frequently than an Unconstrained Seller in Country 2.

Table 8: Foreign Currency Acceptance Decision by Unconstrained Sellers (in Percentage)

Countries, Treatment	1st half	2nd half	overall
Country 1, Baseline	60.98	35.14	48.72
Country 2, Baseline	36	19.75	27.56
Country 1, NoRestriction	60.53	44.29	52.74
Country 2, NoRestriction	40.57	23.89	31.96
Country 1, LowCost	48.72	36.11	42.67
Country 2, LowCost	36.49	25.00	30.67
Country 1, VeryLowCost	84.85	90.63	87.69
Country 2, VeryLowCost	67.69	56.92	62.31

Figure 3: Foreign Currency Acceptance Decisions by Unconstrained Sellers

Table 9: Probit Regression Analysis of Foreign Currency Acceptance Decisions

	(1)	(2)	(3)
		Country 1	Country 2
NR	0.193	−0.000766	0.271
	(0.192)	(0.526)	(0.264)
LC	−0.0564	−0.0912	0.0767

	(0.219)	(0.356)	(0.397)
VLC	1.328***	2.336**	1.124***
	(0.419)	(0.987)	(0.311)
Period	−0.163***	−0.234***	−0.144***
	(0.0265)	(0.0810)	(0.0262)
Country2	−0.644**		
	(0.258)		
Constant	0.384**	0.491**	-0.339
	(0.155)	(0.227)	(0.248)
Observations	1019	364	655
log likelihood	−595.24	−199.26	-392.04

Random effects at subject and session level. Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

FINDING 4: There are more proposals involving both types of currencies in the NoRestriction and VeryLowCost treatments than in the Baseline and LowCost treatments.

Support for Finding 4 is provided in Table 10. We find similar results regardless of whether we use all proposals or only accepted proposals. The results from the probit regression reported in Table 9 show that the probability of proposals involving both types of currencies is significantly higher in the NoRestriction and VeryLowCost treatments than in the Baseline treatment. These results also hold relative to the LowCost treatment (column (1): NoRestriction vs. LowCost p-value < 0.001, VeryLowCost vs. LowCost p-value=0.0053; column (2): NoRestriction and VeryLowCost vs. LowCost p-value < 0.001). There are no other significant differences across treatments. This result provides further evidence that subjects were more likely to coordinate on the usage of both currencies in the absence of legal restrictions or when foreign currency acceptance costs were very low.

Table 10: Probit Regression Analysis of Proposals with Both Types of Currencies

	(1)	(2)
	Both Currencies Used=1, Otherwise=0	
	Accepted Proposals	All Proposals

NR	0.758***	0.749***
	(0.116)	(0.115)
LC	−0.0194	0.0893
	(0.0763)	(0.120)
VLC	0.548***	0.682***
	(0.191)	(0.156)
Period	−0.110***	−0.131***
	(0.0330)	(0.0286)
Buyerprop	0.0912	−0.00642
	(0.143)	(0.117)
Constant	−0.646***	−0.738***
	(0.124)	(0.127)
Observations	829	1332
log likelihood	−501.93	−741.17

Random effects at the subject and session level. Robust standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In sum, we find that traded quantities and trades involving both types of currencies are higher when there are no legal restrictions. However, we find strong evidence in support of a currency regime where both currencies are international only when the fixed costs associated with the usage of foreign currency are considerably low (see Section 6 for a more detailed discussion).

While allocations are affected by government interventions, the difference in welfare per period, calculated as the sum of total earnings in each period, is not statistically significant across treatments. The regression results reported in column 1 of Table 11 show that welfare levels achieved in the NoRestriction, LowCost and VeryLowCost treatments tend to be higher than in the Baseline, but there are no significant differences across treatments. Welfare decreases within a sequence, as indicated by the significant coefficient of the variable *Period*. However, Buyers earn significantly more than Sellers, which is consistent with the theoretical predictions. When we regress individual welfare by role, clustered at both subject and session levels, as reported in Columns 2 and 3 of Table 11, we find that buyers achieve a higher welfare and that sellers achieve a lower welfare in the NoRestriction treatment than in the Baseline. Additionally, sellers' welfare

is lower in NoRestriction treatment than in the LowCost treatment (p-value=0.024) and the VeryLowCost treatment (p-value=0.007), as they produce lower quantities in the latter treatments.

Table 11: Regression Analysis of Welfare

	(1)	(2)	(3)
	Average welfare per period	Buyer's welfare	Seller's welfare
NR	0.862	5.041**	−3.316***
	(0.847)	(2.511)	(1.038)
LC	0.391	0.684	0.0974
	(1.004)	(3.426)	(1.617)
VLC	1.017	2.647	−0.613
	(0.730)	(2.381)	(1.127)
Period	−1.508***	−4.949***	1.933***
	(0.203)	(0.595)	(0.227)
Country2		1.174	-0.0564
		(1.602)	(1.248)
Constant	15.95***	44.11***	-12.88***
	(0.719)	(2.530)	(1.223)
Observations	291	1455	1455
R^2	0.1994	0.0649	0.0371

Standard errors in parentheses are clustered at the session level for column 1.
Standard errors in parentheses are clustered at the subject and session level for column 2 and 3.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Further Discussion of Experimental Results

While some results are in line with theoretical predictions (e.g., we observe higher traded quantities and more proposals involving multiple currencies under NoRestriction), we failed to find strong evidence in support of a currency regime shift in both the NoRestriction and LowCost treatments. We found evidence in favor of a currency regime shift towards international currencies only in the VeryLowCost treatment. What prevented unconstrained sellers from paying the fixed costs to accept foreign currencies in the NoRestriction and LowCost treatments?

As shown in Appendix A.3, unconstrained sellers' foreign currency decision is determined by a cost-benefit analysis. The cost to be able to accept foreign currency is equal to κ_s for unconstrained sellers in Country s. This cost is constant over time, pre-announced, and immediately borne by a seller at the beginning of the DM. On the other hand, the benefit of accepting foreign currency is random and realized at the end of the CM market. The reason why unconstrained sellers may benefit from accepting both currencies is that their expected surplus is increasing in the traded quantity, and the latter is higher when both currencies are used. In the laboratory, the expected benefit from accepting both currencies was lower than predicted by theory for a number of reasons that we discuss below.

First, as reported in Table 4, about 62% (rather than 100%) of the proposals in all treatments are accepted, which lowers the expected benefits as some trades do not materialize. Indeed, Table 209 in Appendix B provides evidence that the probability of accepting foreign currency was negatively affected by the number of failed DM trades experienced in prior periods, as captured by the NoTrade variable. Specifically, there were instances where the sellers paid the cost, the DM proposal was rejected, and thus there was no gain in having paid the cost. As a result, sellers became less likely to incur the cost again.[27] Second, when sellers made the proposal, they produced more than predicted (see Table 19 in Appendix B), which also contributed to lowering the expected benefit. Finally, while sellers tended to rebalance money holdings, they were not spending in the CM all of the money earned in the DM, and thus were not earning as many points as predicted from CM consumption. We conjecture that the reason why they were not spending all of their money in the CM is that, if they spent it all, they were not sure to be able to obtain currencies in the next DM because of the rejection rates. Additionally, there was some uncertainty in the CM price that may have lead sellers to keep some money to avoid losing out on future favorable trading opportunities.

In sum, several factors contributed to decreasing the expected additional benefit of accepting foreign currency relative to its cost. When we lowered the cost to 0.01 in the VeryLowCost treatment, it became easier for subjects to understand that the expected benefit of accepting foreign currency exceeded its cost. As a result, they became more likely to accept it, which facilitated the emergence of a currency regime shift.

[27] We conjecture that this is also the primary reason why foreign currency acceptance rates are lower than 100% also in the VeryLowCost treatment.

7 Conclusion

This paper integrates theory and experiments to explore a two-country, two-currency economic system in a laboratory environment. We test how government interventions affect economic allocations and the international status of a currency. Specifically, we examine two types of governmental interventions: legal restrictions on the ability of sellers to accept foreign currency; and regulations on sellers' costs for accepting foreign currency. Based on the theoretical predictions, both interventions have the ability to alter currency regimes.

Overall, we do not find strong evidence that legal restrictions can successfully orchestrate a regime shift. Nonetheless, it is evident that legal restrictions can affect economic allocations. Specifically, and as predicted, traded quantities and trade proposals involving both types of currencies are significantly larger in the NoRestriction treatment than in the Baseline. We find evidence in support of a regime shift only when the fixed costs to accept foreign currencies are sufficiently low. Monetary policies have traditionally been considered an important tool to influence the international status of currencies. One promising potential extension of our study includes testing how different monetary policies, (e.g., via changes in the money supply) affect currency adoption and international currency regimes in laboratory experiments.

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- A two-country two-currency model where buyers and sellers coordinate on the use of domestic and foreign currency
- Integration of theory and experiments to study the impact of government interventions
- Abolishing legal restrictions increases quantities traded and number of trades involving two currencies
- International status of currencies is enhanced when sellers face very low foreign currency acceptance costs