Policies for Currency De-Dollarization: A Laboratory Study*

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Abstract

The mass adoption of a foreign currency (say the Dollar) often occurs amid economic crises. Interestingly, often this dollarization persists even after the economy has returned to macroeconomic stability. This is particularly relevant to central banks as dollarization can limit its policy effectiveness; yet, there is insufficient research on the relative impact of de-dollarization policies. We extend existing theory (based on Matsuyama et al. (1993)) and device a laboratory experiment to study the impact of different policies on the degree of currency dollarization, measured by the acceptance rate of foreign currency. Our experiment explores the impact of the following policies or environmental factors: (1) A tax on holdings of foreign currency; (2) A tax on domestic transactions in foreign currency; (3) Information on the likelihood of acceptance of the foreign currency in the local economy; (4) Money supply; (5) Differential storage costs for foreign currency. In this version we present the results of a pilot study.

Keywords: Bimonetary Economy, Dollarization, Central Bank, Monetary Policy, Experiment, Money.

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*The views expressed in this paper are our own and do not necessarily reflect those of the Central Reserve Bank of Peru. All errors are our own.

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1 Introduction

The coexistence of two currencies in an economy opens important challenges to central banking. Empirical evidence, mainly in emerging countries, shows that the mass adoption of alternative currencies arises when the local currency loses one or more of its functions. This occurs typically after fiscal and monetary disequilibrium that severely interfere with the functions of deposit of value and medium of exchange. (Yeyati and Ize, 2005). Interestingly, in many countries, the coexistence of two currencies persists even after the economy has returned to macroeconomic stability –i.e., when the local currency has recovered its fundamental attributes. This can be observed in several Latin American economies, where currency, price and financial dollarization are still prevalent (Yeyati and Ize, 2005; Colacelli and Blackburn, 2009).

Dollarization is particularly relevant to monetary policy, as it limits the role of the central bank as a lender of last resort and generates significant vulnerabilities to financial stability as well as to the payment system as a whole. Dollarization reduces the effectiveness of monetary policy in episodes of international turbulence that affect the domestic value of the foreign currency. To reduce vulnerability to external shocks, often Central Banks implement de-dollarization policies. However, there is insufficient research and evidence on which of the available policy options are more effective and efficient.

In this paper we use laboratory experiments to study the impact of different environmental factors and several policies on dollarization. In particular, our work focuses on exploring the transactional role of money in a bimonetary economy; and we study how a set of policies affect the acceptance rate of foreign currency in an experimental environment based on the model of Matsuyama et al. (1993). We study the following policies or environmental factors: (1) A tax on holdings of foreign currency; (2) A tax on domestic transactions in foreign currency; (3) Information about how likely is the acceptance of the foreign currency in the local economy; (4) Money supply; (5) Heterogeneous money storage costs (higher relative cost of mantaining foreign currency).

The rest of the document is organized as follows. Section 2 presents the related literature. Section 3 presents the model and its predictions. Section 4 describes the experimental design as well as hypotheses and the laboratory procedures. Section 5 presents the results a pilot test. Finally, section 6 discusses the limitations of our experiment and proposes future extensions.

2 Related Literature

Two branches of literature on the behavior of different currencies in an economy are relevant to our work: the theoretical work on search and matching models, and the research on monetary economics using laboratory experiments.

An important body of theoretical literature in macroeconomics uses search and matching models to study the main functions of money, and, in particular, the role of money as a medium of exchange. In a seminal paper, Kiyotaki and Wright (1993), present a theoretical search model in the money market. The model is based on a barter economy where exchange is conditional to the "double coincidence" of needs between agents. Money emerges, endogenously, as a mean of payment to increase the frequency of the exchange.

Interestingly, the authors do extend the model to analyze equilibria with multiple currencies finding that the universal circulation of currencies depends on the degree of relative liquidity in the economies. This extension consists on a search model in a economy with two currencies with different intrinsic properties: yields and relative amounts on the economy. The equilibrium of dual regime shows that the relative money supply has an important role on money holdings, greater than their returns.

Matsuyama et al. (1993) introduced a search and matching model with two economies and two currencies. In this setting, the currencies "compete" for the medium of exchange function. In these setting, the authors characterize the multiple equilibria, as a function of the fundamental parameters, such as the relative size of the economies and their trade integration degree.

Lagos and Wright (2005) developed a search model with a role for monetary policy interventions. The gap between theory and applications arises from the assumptions in the characteristics of money. For example, it is usually assumed that there is a fixed amount of money and that transactions are made in indivisible amounts. Consequently, the authors relaxed these assumptions to approach reality and explore new equilibria.

Also, Craig and Waller (2000) provided a variety of models to explore the circulation of two currencies in different environments. The theoretical predictions were compared with empirical data from emerging European economies. They find that before the lack of a developed financial system, two currencies can be used rationally as part of agents' strategies to hedge against the loss of value of the local currency.

These studies shed light to the growing research agenda regarding bimonetary systems and the connection between the results of monetary search models with policy making. This objective can serve as a basis for the application of alternatives methods

such as laboratory experiments.

On the experimental front, in the last decade, a growing body of research has focused on macroeconomics and monetary policy, testing the main assumptions and predictions of a wide range of theoretical models.

In an important and early study, Duffy and Ochs (2002) designed an experiment to evaluate the theoretical predictions of Kiyotaki and Wright (1993). Specifically, they studied how agents trade when a fraction of these have a token without intrinsic value, and each agent faces storage costs. Their results show that the token acquired value endogenously as means of exchange. This occurs especially in cases where it reduces costs of transaction. However, exchange is usually rejected when storage costs are high even though the theoretical model predicts that trading is still optimal. This work highlights interesting behavioral deviations from theoretical predictions and how those deviations interact with key policy factors.

More closely related to this paper, there is a newer body of experimental research about competing currencies. Jiang and Zhang (2018), for example, conduct an experiment based on the model of Matsuyama et al. (1993) to study the formation of currency circulation patterns and equilibrium selection. Their results suggest that changes in the relative size of the two economies do impact the acceptance of the foreign currency. They also find that there is a regime of universal circulation. Finally, the authors introduce an additional treatment to assess the role of the state as a participant in the exchange. In this setting, the government (represented by a *robot*) has a unique trading rule: Accept only the local currency. The results suggest that introducing this coordinating entity does influence the equilibrium of currency circulation.

Rietz (2017) studied the acceptance rates of a *cryptocurrency* when an official currency circulates in the economy. The author follows the approach used by Kiyotaki and Wright (1993) and Soller Curtis and Waller (2000) in their stability analysis of bimonetary systems. While the theoretical results predict the stability of two systems (local circulation and universal circulation), the experimental results show that usually there is an equilibrium with partial acceptance of the *cryptocurrency*. Taken together, this body of research highlights the fact that experiments can help answer important questions on (1) which equilibrium is more likely to emerge when the models predict multiple equilibrium and (2) which policies can impact currency adoption.

3 Theoretical Framework

The experimental design is based on the Matsuyama et al. (1993) search and matching model. This environment is useful to explore the transactional role of money in the presence of multiple currencies. In this context, the circulation patterns of each currency are endogenously determined by two fundamental factors: the relative size of the trading economies and the degree of trade integration. However, the model can be extended to include the role of a government that implements policies to promote the circulation of the domestic currency. In the following subsections, we develop the theoretical model and present its main predictions.

3.1 The Model

Time is discrete and agents are infinitely lived. There are two economies: Blue (B) and Red (R); and the mass of agents in each of them has measure n_i , where $i \in \{B, R\}$. All agents have an intertemporal discount factor equal to $\beta = \frac{1}{1+r} \in (0, 1)$, where r is the discount rate.

Economies are characterized by a matching technology that depends on the size of their populations, n_B and n_R , and the degree of trade integration, $\rho \in [0, 1]$. This technology determines the probability, α_{ij}, that an agent from economy i meets an agent from economy j. In general, this probability is given by equation (1).

$$\alpha_{ij} = \begin{cases} \frac{n_i}{n_i+n_j} + \frac{(1-\rho)n_j}{n_i+n_j} & , i = j \\ \frac{\rho n_j}{n_i+n_j} & , i \neq j \end{cases} \tag{1}$$

However, under the symmetry assumption, $n_B = n_R$, the matching function simplifies to equation (2). It should be noted that the trade integration parameter, ρ, increases the probability of meeting an agent from a different economy. Namely, when the two economies are perfectly integrated ($\rho = 1$), meeting a local agent becomes as likely as meeting a foreigner. In contrast, when the economies are closed ($\rho = 0$), trade is only feasible between agents of the same nationality.

$$\alpha_{ij} = \begin{cases} \frac{(2-\rho)}{2} & , i = j \\ \frac{\rho}{2} & , i \neq j \end{cases} \tag{2}$$

There are three objects in the model: a consumption good and two intrinsically worthless tokens. Each agent can costlessly produce a variety of the consumption good.

Nevertheless, agents only consume the varieties that others produce, which provides a flow utility of $u > 0$. After consumption, agents engage in production to restore their inventories. The absence of double coincidence of needs eliminates the existence of barter and the lack of record-keeping makes collective cooperation unsustainable.

Tokens are used solely as a medium of exchange. These are useless for production and do not provide utility to their holders. In this sense, both currencies represent fiat money. However, these differ in the origin of their issuance. The blue token is the local currency of economy B and, similarly, the red token is the local currency of economy R.

In each economy, i, a fraction $M_i \in (0, 1)$ of agents is initially endowed with a local token. The remaining fraction, $1 - M_i$, is endowed with a unit of the consumption good. Hence, in the first period, there are $n_i M_i$ buyers and $n_i(1 - M_i)$ sellers in the economy. Henceforth, we will assume that the per-capita supply of tokens will remain constant. Furthermore, currency exchange between agents will not be allowed.

The market generates a welfare improving trade opportunity whenever a token-holder (buyer) is matched with a good-holder (seller). In that case, both agents must decide, simultaneously, whether to make the exchange. Trade occurs only when there is mutual agreement, in which case agents swap inventories and roles are reversed. That is, the buyer consumes the good, for which she gains utility flow $u > 0$, and produces a unit of the consumption good immediately after. Thus, she begins the next period as a seller. Analogously, the seller receives a token and starts the subsequent period as a buyer. As a direct consequence of the trading rules, agents will never hold more than one object at a time.

In each period, the state of both economies is completely determined by the distribution of tokens among agents. In each economy, i, there will be a fraction of agents, m_{iB}, with a blue token; a fraction, m_{iR}, with a red token; and a fraction m_{i0} with a consumption good. Since agents can only hold one object at a time, equation (3) is always satisfied.

$$m_{iB} + m_{iR} + m_{i0} = 1 \tag{3}$$

Additionally, the total supply of currency i must equal its demand. That is, equation (4) must hold.

$$n_i M_i = n_i m_{ii} + n_j m_{ji} \tag{4}$$

The pure-strategy equilibria of this model are symmetric and stationary. This implies that, in each economy, all agents will follow the same strategy (trading rule) and the distribution of tokens will remain constant over time. Moreover, due to the sym-

metry in the size of the economies and, consequently, in the matching probabilities, equilibria will also be symmetric between economies.

$$M_i = m_{ii} + m_{ji} \tag{5}$$

In every equilibirum, a buyer who is matched with a seller will always want to trade. Similarly, it will be assumed that all sellers will accept to trade in exchange for a local currency. In this sense, equilibria will differ in the acceptance of the foreign currency. The dummy variable λ_i is defined as $\lambda_i = 1$ if the foreign currency is accepted in economy i, and 0 otherwise. Also, given the symmetry between economies, it will occur that $\lambda_B = \lambda_R$. Consequently, only two regimes of circulation may emerge in the equilibria of the model: (i) the universal circulation regime and (ii) the local circulation regime. In the first, both currencies circulate in both economies ($\lambda_B = \lambda_R = 1$); while in the second, each currency only circulates in its economy of origin ($\lambda_B = \lambda_R = 0$).

When two agents of different nationalities are matched, the stationary conditions for the distribution of tokens are given by (6) and (7). Condition (6) indicates that the outflow of currency i from economy j equals the inflow of currency i to economy j. Similarly, condition (7) shows that the inflow of currency j to economy i equals the outflow of currency j from economy i. It should be noted that these conditions of stationarity are sufficient, since trade between agents of the same nationality does not alter the aggregate distribution of the economy.

$$m_{i0}m_{ji} = m_{ii}m_{j0}\lambda_j \tag{6}$$

$$m_{i0}m_{jj}\lambda_i = m_{ij}m_{j0} \tag{7}$$

The value functions of the agents from economy $i \in \{B, R\}$ are represented by V_{ik}, where $k \in \{0, B, R\}$ represents the object that the agent owns. In this way, V_{i0} represents the expected lifetime utility of a seller from economy i. The value flow of this agent is expressed in equation (8) and comprises two terms. The first one is the product of (i) the probability of being matched with a buyer, local or foreign, who owns a local currency and (ii) the resulting trade surplus. Analogously, the second term is the product of (i) the probability of meeting a buyer, local or foreign, who owns a foreign currency and (ii) the corresponding trade surplus.

$$rV_{i0} = (\alpha_{ii} m_{ii} + \alpha_{ij} m_{ji}) (V_{ii} - V_{i0}) + (\alpha_{ii} m_{ij} + \alpha_{ij} m_{jj}) \lambda_i (V_{ij} - V_{i0}) \tag{8}$$

Similarly, equation (9) represents the value flow of a buyer of economy i who holds a local currency. In this context, governments might have available policy options that impact the circulation of the domestic currency by increasing the foreign currency rejection rates. A policy that introduces heterogeneous storage costs on the tokens can serve such a purpose. Specifically, an agent from economy i incurs in tax cost c_i for storing a local token and c_j for storing a foreign currency. That is, if one has a unit of local currency and the exchange is not carried out, this agent incurs in a storage cost c_i.

$$rV_{ii} = (\alpha_{ii} m_{i0} + \alpha_{ij} m_{j0} \lambda_j) (u + V_{i0} - V_{ii}) - (1 - \alpha_{ii} m_{i0} - \alpha_{ij} m_{j0} \lambda_j) c_i \tag{9}$$

On the other hand, equation (10) represents the flow of value associated with a buyer of economy i that owns a foreign currency. Unlike the previous case, the storage cost is given by c_j.

$$rV_{ij} = (\alpha_{ii} m_{i0} \lambda_i + \alpha_{ij} m_{j0}) (u + V_{i0} - V_{ij}) - (1 - \alpha_{ii} m_{i0} \lambda_i - \alpha_{ij} m_{j0}) c_j \tag{10}$$

The exchange ultimately depends on the decision of the seller, since the buyer will always be willing to hand over the currency he owns in exchange for the consumption good. Consequently, the acceptance of the foreign currency is determined, endogenously, by the incentive compatibility restriction faced by a seller in the economy i. This is presented in equation (11) and shows that the foreign currency will be accepted conditional on the relative values of holding the token or the object.

$$\lambda_i = \begin{cases} 1 & \text{if } V_{ij} > V_{i0} \\ [0,1] & \text{if } V_{ij} = V_{i0} \\ 0 & \text{if } V_{ij} < V_{i0} \end{cases} \tag{11}$$

3.2 Theoretical Predictions

A circulation regime is a symmetrical and stationary equilibrium that satisfies the conditions (6) - (11). Due to the assumption of symmetry in the relative size of the economies, only two of them can emerge endogenously: the universal circulation regime and the regime of local circulation.

Universal Circulation Regime

This regime emerges when the sellers of both economies accept the foreign currency exchange, $\lambda_B = \lambda_R = 1$. In this equilibrium, value flows can express as (12) - (14).

$$rV_{i0} = (\alpha_{ii} m_{ii} + \alpha_{ij} m_{ji}) (V_{ii} - V_{i0}) + (\alpha_{ii} m_{ij} + \alpha_{ij} m_{jj}) (V_{ij} - V_{i0}) \tag{12}$$

$$rV_{ii} = (\alpha_{ii} m_{i0} + \alpha_{ij} m_{j0}) (u + V_{i0} - V_{ii}) - (1 - \alpha_{ii} m_{i0} - \alpha_{ij} m_{j0}) c_i \tag{13}$$

$$rV_{ij} = (\alpha_{ii} m_{i0} + \alpha_{ij} m_{j0}) (u + V_{i0} - V_{ij}) - (1 - \alpha_{ii} m_{i0} - \alpha_{ij} m_{j0}) c_j \tag{14}$$

Additionally, since the local currency is always accepted in equilibrium, the existence of this regime implies that $V_{ii} = V_{ij}$. That is, agents are indifferent between accepting a local currency and a foreign currency. This can only happen if the costs of storage are identical; so that $c_i = c_j$. If this condition is met, it will always happen that $V_{i0} < V_{ii} = V_{ij}$, so this would always be an equilibrium.

Local Circulation Regime

This regime arises when the sellers of both economies reject the currency foreign exchange $\lambda_B = \lambda_R = 0$. This implies that, in each economy, only the local currency circulates. Moreover, since currency markets are cleared according to the condition (5), this means that $M_B = m_{BB}$, $M_R = m_{RR}$ and$m_{BR} = m_{RB} = 0$. With this, the value streams are simplified to (15) - (17).

$$rV_{i0} = \alpha_{ii} M_i (V_{ii} - V_{i0}) \tag{15}$$

$$rV_{ii} = \alpha_{ii}(1 - M_i) (u + V_{i0} - V_{ii}) - [1 - \alpha_{ii} (1 - M_i)] c_i \tag{16}$$

$$rV_{ij} = \alpha_{ij} (1 - M_j) (u + V_{i0} - V_{ij}) - [1 - \alpha_{ij}(1 - M_j)] c_j \tag{17}$$

Now, it remains to verify that the incentive compatibility restriction is met, so that $V_{ij} < V_{i0}$. For this, the condition (18) must be met. Keeping other factors constant, this will happen if the probability of matching with a foreign agent,α_{ij}, is sufficiently

low.

$$\alpha_{ii}^2 M_i(1-M_i)u - \alpha_{ii}M_i(\alpha_{ii}M_i+\alpha_{ij})c_i > (r+\alpha_{ii})\left[\alpha_{ij}(1-M_j)u - \alpha_{ii}c_j - \alpha_{ij}M_j c_j\right] \quad (18)$$

Note: It should be noted that this theoretical framework will be extended to formalize the equilibria when countries' sizes are asymmetric and taxes on foreign currency transactions are incorporated. For example, let τ_S be the lump-sum tax levied on the seller for accepting a foreign token in a domestic transaction and, similarly, let τ_C be the tax charged to the consumer for handing over a foreign token to a local seller. Then, the value functions will be given by equations $(19) - (21)$.

$$rV_{i0} = (\alpha_{ii}m_{ii} + \alpha_{ij}m_{ji})(V_{ii} - V_{i0}) + \alpha_{ii}m_{ij}\lambda_i(V_{ij} - V_{i0} - \tau_S) + \alpha_{ij}m_{jj}\lambda_i(V_{ij} - V_{i0}) \quad (19)$$

$$rV_{ii} = (\alpha_{ii}m_{i0} + \alpha_{ij}m_{j0}\lambda_j)(u + V_{i0} - V_{ii}) \quad (20)$$

$$rV_{ij} = \alpha_{ii}m_{i0}\lambda_i(u + V_{i0} - V_{ij} - \tau_C) + \alpha_{ij}m_{j0}(u + V_{i0} - V_{ij}) \quad (21)$$

4 Experiment

4.1 Environment

The experiment consists of an exchange game in which the three objects from the theoretical model are traded: a consumer good, a blue token and a red token. Participants are divided into two groups: Blue (B) and Red (R).

In each group, half of the participants receive a domestic currency as an endowment initial and the remaining half receive a consumption good, so that $M_B = M_R = 0.5$. The first group represent the role of buyers; and the second represent the role of sellers.

Participants are randomly matched following a known distribution. The probabilities of pairing are determined by the technology described in (1), and varies with the degree of trade integration, ρ. If both parts match, buyers and sellers must decide,

privately and simultaneously, whether to make the exchange. After that, the answers are revealed and the exchange occurs only if there is a mutual agreement. Moreover, bartering between sellers and the exchange of currencies between consumers is prohibited. The game is repeated T periods with a discount factor β. The participants start the game with an endowment of W points and, in each exchange, the consumption grants u points. For our pilot sessions, described below, we use groups of size 16, T = 50, $\beta = 0.98$, an endowment, W, of 50 points, and a consumption service u of 20 points.

4.2 Treatment Design

Our study has a between-groups design where each group will be exposed to a single condition or treatment. Also, we will concentrate in studying the behavior of a single economy. For that purpose, we will automate the agents in the foreign economy making them use their optimal trading rule.

Baseline Condition

In the baseline condition (control) we will have two asymmetrically sized countries with imperfect trade integration. We will set countries' sizes such that the Blue economy is larger than the Red economy, $n_B > n_R$. Then, we will calibrate the integration level so that the probabilities of meeting a foreign participant are $\alpha_{BR} = 0.1$ and $\alpha_{RB} = 0.3$. In this condition, the storage costs of the tokens are null, $c_i = c_j = 0$.

Treatment 1

In this treatment we maintain the setting of the baseline condition but implement asymmetric storage costs of $c_i = 1$ and $c_j = 2$. That is, it is more costly to hold foreign currency.

Treatment 2

In this treatment we maintain the setting of the baseline condition but implement taxes to domestic transactions in foreign currency. In principle, the taxes will be set at $\tau_S = \tau_C = 1$ point. But the calibration of the actual tax level will be reached when we solve for the equilibria in the extended model presented above. In this condition, the storage costs of the tokes are null, $c_i = c_j = 0$.

Treatment 3

In this treatment we maintain the setting of the baseline condition but implement

a (robot) government who participates in trading withdrawing foreign currency in exchange for a unit of the good.

4.3 Metrics and Hypotheses

The main metric that we study in this paper is the **acceptance rate of the foreign currency.** At the individual level, this is defined as the binary decision to accept a foreign token in exchange for the consumption good. At the economy level, this metrics is defined simply as the percentage of citizens that accept the foreign currency. Another important metric associated with efficiency in this environment, is simply the percentage of participants decide to trade.

Theoretical predictions of the model presented earlier are used to form the following hypotheses about the experimental results.

Hypothesis I: The acceptance ratio of the consumption good remains constant throughout the control and treatment sessions. This is a rationality test for the participants, accepting the exchange is a strictly dominant strategy for buyers.

Hypothesis II: The acceptance rate of the local currency is higher than the acceptance ratio of the foreign currency, and remains constant through the control sessions and treatment.

Hypothesis III: The introduction of heterogeneous storage costs, $c_j > c_i$, reduces the acceptance rate of foreign currency. Therefore, we observe convergence towards the equilibrium of local circulation.

Hypothesis IV: The introduction of taxes to domestic transactions in foreign currency, $\tau_S > 0$ and $\tau_C > 0$, reduces the acceptance rate of foreign currency. Therefore, we observe convergence towards the equilibrium of local circulation.

Hypothesis V: A government that operates under a trading rule that withdraws the foreign currency from the market is able to reduce its acceptance rate. Therefore, we observe convergence towards the equilibrium of local circulation.

5 Pilot Study

In September 2019, we conducted a pilot study with a subset of the treatments. In this pilot study, the **baseline condition** or control groups exhibited two countries with

perfect trade integration, $\rho = 1$, implying same probabilities for encountering a local or a foreign participant ($\alpha_{ii} = \alpha_{ij} = 0.5$). In addition, the storage costs were set to zero, $c_i = c_j = 0$. In this setting, the model predicts the equilibrium is characterized by the circulation circulation. We also implemented two treatments. In **Treatment 1**, we reduce the degree of trade integration to $\rho = 0.5$. In consequence, an agent is more likely to be paired with a local participant ($\alpha_{ii} = 0.75$) than with a foreign participant ($\alpha_{ij} = 0.25$). Token storage costs are homogeneous and equal to zero, $c_i = c_j = 0$. For this parameterization, there are multiple equilibria and both circulation regimes, universal and local, could emerge. In **Treatment 2**, the degree of trade integration is maintained at $\rho = 0.5$ but with we set different storage costs of $c_i = 1$ and $c_j = 2$. In this setting, the equilibrium is characterized by the local circulation regime.

5.1 Implementation

The pilot was conducted in the Experimental Economic Laboratory of the Pontifical Catholic University of Peru on September 9, 2019. We used a standard ORSEE server (Greiner, 2015) maintained by this University to recruit 16 undergraduate students. Upon arrival, each student was assigned a random number between 1 and 16 and seated on the computer with that number.

Although our proposed design id *between-group*, due to logistics and cost we implemented the pilot in a *within-group* fashion. That is, participants made decisions in all three of the conditions described above: the control and the two treatments (reduced trade integration and changed storage cost). Participants knew in advanced that the experiment had three blocks. Each of the three block (conditions) had 30 periods. The duration of the whole session was one and a half hours.

Participants received payments based on their performance and knew that only one randomly chosen block would be used for payment. The conversion rate was 0.03 soles per point obtained, which was public knowledge. Human subjects earned between 15 and 33 PEN (on average, 20 PEN). The software was mainly developed at the LEEPS Lab of the University of California at Santa Cruz using the oTree framework (Chen et al, 2013). The server was deployed on UCSC servers.

At the beginning of each session, we provided participants with printed instructions. Then, the participants read them, and waited to be instructed to start the interaction. The experimenters answered for any questions in private.

Each round consisted of two different screens: (i) individual information and the exchange decision, and (ii) the results of the round. Each of these screens were timed

out at 30 seconds. The first screen informed the participants about their own state, as well as the state of its counterpart. This included the group to which the players belonged (Blue or Red), the object carried by each one (blue coin, red coin or consumer currency), as well as their roles in the exchange (buyer or seller).

There is only one case in which trade exchange was possible: the encounter between a buyer and a seller. If this condition was met, each participant had the option of intending exchange simultaneously. In any other case, the following message was displayed: *You cannot exchange with your counterpart, since both are buyers (sellers).* Therefore, they did not have any option, and passed to the next screen of the game.

After all the participants in the group had played, a results screen was displayed showing: inventories, points obtained and the accumulated earnings. Once this screen passed, there was a new screen with the information corresponding to the new round. Subsequently, the exchange was decided and the process continued, successively, until completing the 30 rounds. At the end of each block, we delivered the instructions corresponding to next treatment. After we delivered the new instructions we verbally noted (highlighted) the change in the setting. At the end of the third block, we made cash payments following standard procedures of privacy.

5.2 Results

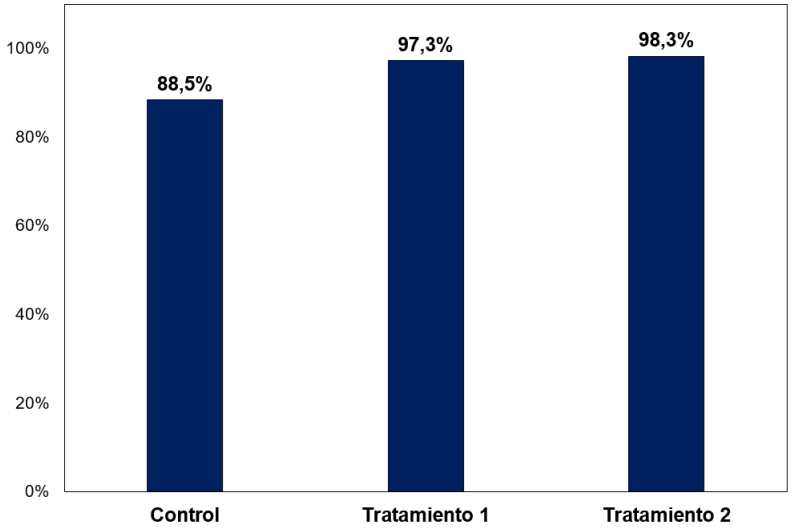
We focus this preliminary analysis on the acceptance ratios of the consumer good and the currencies. These are presented, by control and treatment groups, in Figures 1 and 2. We dropped information from round 1-4 of each block, not to focus on the learning stage of subjects' behavior in our environment.[1]

Figure 1 shows the acceptance rate of the consumer good throughout the three sessions. This ratio is calculated as the number of times that buyers accepted the consumption good over the total number of times in which the exchange was possible. The results show high acceptance of this good by consumers in all the sessions. The fact that rates are increasing, probably reflects the learning effect of the participants, given that a *within-group* experiment was performed.

These findings coincide with the hypothesis that the consumption good should always be accepted (it is rational -in fact a dominant strategy- that all buyers choose to accept the consumption good), regardless the treatment. Estimates are presented with three different probabilistic models: the linear probability model, probit and logit. We use dummy treatment variables to assess whether these have any effect on the rates of

[1] Indeed, more erratic behavior in the first four periods.

Figure 1: Acceptance rate of the consumption good



acceptance of the coins. In addition, the variable referring to the period number takes into account the effect of learning.

Tabla 1
Acceptance rate of the consumption good

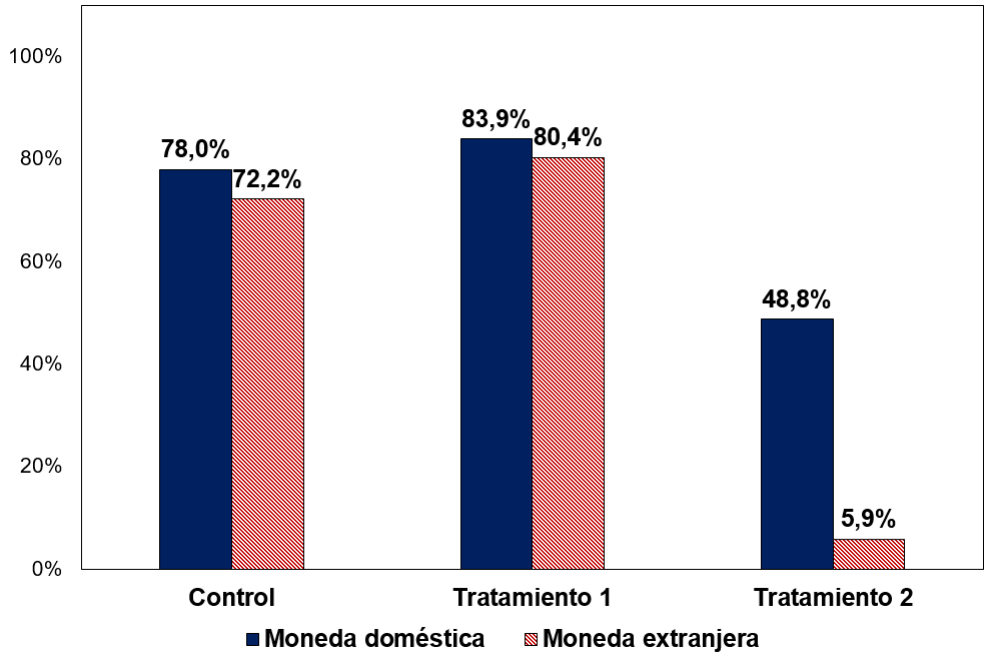
	(1) MPL	(2) Probit	(3) Logit
Treatment 1	-0.033	-0.573	-1.208
	(0.0493)	(0.544)	(1.172)
Treatment 2	-0.152	-1.748*	-3.658
	(0.0941)	(1.029)	(2.235)
Period	0.004**	0.047***	0.099***
	(0.002)	(0.018)	(0.038)
Constant	0.801***	0.360	0.289
	(0.056)	(0.364)	(0.696)
Observations	334	334	334

Standard errors in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

In all three models, we observe that the game period is the variable with significant and positive effect on the probability of accepting the consumption good. The

Figure 2: Coin Acceptance Ratio



Treatment variables, although they are negative, have no statistical significance in explaining the rate of acceptance of the good. In this way, Table 1 corroborates the first hypothesis.

On the other hand, Figure 2 presents the acceptance rates of local and foreign currencies by sellers in control sessions and treatments.

Figure 2 shows that the acceptance rate of domestic currency is greater than the acceptance of foreign currency throughout the three sessions. While in the control group and the first treatment the differences are smaller, there is a greater gap in the second treatment. Most of this significant fall is due to the lower acceptance of foreign currency. This would be experimental evidence in favor of the hypothesis that the acceptance rate of the local currency is higher than that of the foreign when storage costs are higher for foreign currency.

Table 2 presents the effects of the treatments and the number of rounds played on the acceptance of the domestic currency. The results provide mild evidence that the first treatment has a positive effect on the probability of accepting the local currency, while the second and the number of periods have no significant effects. Further, Figure 2 shows that the foreign currency continues circulating despite changes in the matching probability. Even the acceptance rate is similar to that registered in the control session.

These findings allow to reject the Hypothesis III. Theory predicts that a decline in trade integration would make pressure towards the a local circulation regime. However,

the preliminary evidence suggests that, in the absence of costs of storage, economies tend to a equilibrium of universal circulation. While the experimental results are not predicted by the theoretical model, Jiang and Zhang (2018) find similar results.

Hypothesis IV is tested by the regressions presented in Table 3. The second treatment is the one that shows the highest degree of statistical significance and has a high negative effect on the probability of accepting foreign currency. These findings complement the descriptive statistics in Figure 2: the acceptance of the currency foreign decreases because of differentiated costs. Agents would not have incentives to accept the foreign currency because they would incur higher costs relative to the currency local. In this way, theoretically and experimentally, economies would converge to a regime of local circulation.

Table 2
Acceptance rate of local currency

	(1) MPL	(2) Probit	(3) Logit
Treatment 1	0.258*	0.822*	1.383*
	(0.136)	(0.446)	(0.745)
Treatment 2	0.152	0.511	0.891
	(0.286)	(0.842)	(1.395)
Period	-0.008	-0.023	-0.038
	(0.005)	(0.014)	(0.024)
Constant	0.931***	1.218***	2.038***
	(0.116)	(0.369)	(0.647)
Observations	190	190	190

Standard errors in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Table 3

Acceptance rate of foreign currency

	(1) MPL	(2) Probit	(3) Logit
Treatment 1	-0.142	-0.539	-1.014
	(0.146)	(0.545)	(0.925)
Treatment 2	-1.082***	-3.656***	-6.565***
	(0.261)	(1.116)	(2.086)
Period	0.007	0.026	0.049
	(0.005)	(0.017)	(0.031)
Constant	0.581***	0.108	0.047
	(0.119)	(0.383)	(0.669)
Observations	144	144	144

Standard errors in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

6 Final Remarks

Our main preliminary result is that, in line with theoretical predictions, a policy that increases the storage costs of money can influence the currency acceptance decisions. However, we also document some interesting discrepancies between the theoretical and experimental results on the circulation of foreign currency with partial integration.

Hence, we propose to extend the experimental design and the theoretical framework to focus in the circulation of foreign currency among agents of the same economy. This happens, for example, in Latin American economies and it is called *transactional dollarization*. Interetingly, this type of dollarizatio has not been as researched as *financial dollarization*.

Additionally, we aim to complement the theoretical and experimental framework to include effects on the welfare of the economy. In the experiment documented above, it is shown that the introduction of differentiated costs generate a system of local circulation. However, the implications on welfare are not well defined, and, we will include that aspect in future versions.

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7 Appendices

7.1 Pilot Instructions

You are about to participate in an economic experiment. From now on, you must be careful With the decisions you make. Your choices and those of the other participants of the experiment They will determine your earnings. Therefore, it is important that you focus on understanding the instructions tion The earnings will be proportional to the points you accumulate throughout the experiment. TO its term, the accumulated points will be transformed into soles (S /) at conversion rate 1 point = S / 0.03. The earnings could amount to S / 50.00, depending mainly on of your performance. Payments will be made in cash at the end of the experiment. It is important that you do not communicate in any way with the other participants of the experiment. If you have questions or need assistance, please raise your hand so that An experimenter helps you. Any violation of this rule will cause you to be removed of the experiment and lose the right to receive your payment. Next, we will present the game instructions.

General instructions: Session 1

- The session consists of **50 periods** . The total number of participants is 16.
- In the first period, all participants will be assigned to one of the following **groups: Red or Blue** . Participants will remain in the same group for the whole session The size of each group will be 8 participants and these will be selected **randomly**
- The experiment consists of an **exchange game**. There are three different objects that can be exchanged with other participants to accumulate **points: tokens red, blue chips and a consumer good** . These objects differ in **points** They grant.
- The chips, regardless of their color, award **0 points**. However, the participants Cipants earn **20 points if they receive a consumer good** from another participant. Is that is, the consumer good generates point gain only if it is obtained as a result of an exchange.
- In the first period, 4 members of the **red group** will be randomly selected to receive a **red token** . The remaining 4 members will receive a consumer good. Similarly, 4 members of the **blue group** will be randomly selected to receive a **blue token** . The remaining 4 members will receive a **consumer good**.

Your group / Your group counterpart	**Red**	**Blue**
Red	50%	50%
Blue	50%	50%

- The consumer good is homogeneous in both groups.
- Participants who have a card will assume the role of **buyers**, and those who possess a consumer good will assume the role of **sellers**.

Experiment Development

- At the beginning of each period, you will be reminded of the group you belong to and the object you can sees (red card, blue card or consumer card). Then, you will be randomly matched with another participant of the experiment, who can be a member of the **red group or the blue group**. In the same way, your counterpart can be a **buyer or seller**.
- The **match** will present an **exchange opportunity** if the couple is made up of a **buyer and a seller**. In any other case, the interchange Bio will not be possible. In this sense, you will not be able to exchange tokens, even if they are of different colors; nor consumer goods in the barter mode.
- It should be noted that all participants start with a **50-point** endowment.

Pairing

- The table shown below summarizes the matching probabilities that they will govern in each period of this session.
- After pairing, you will be provided with the following information about your counter- part: the group to which it belongs (Red or Blue) and the object it possesses (red token, token blue or consumer). You will not receive additional information about your counterpart, nor will you they will give you results from previous rounds that involve other participants.

Exchange

- After the pairing, you will know if you have been presented with an exchange opportunity.

- If so, you will be asked, privately, if you want to exchange objects With your counterpart. You will have to select one of the following options: **“Yes” or "No"**.All exchanges will be **one by one**, which implies that you cannot Exchange fractions of an object.
- The answers will be revealed simultaneously after both members of the couple have selected their responses privately. The exchange happens, only, if both said they agree.
- If there is no exchange opportunity, you will be informed about it and you must Continue to the next period.
- Remember that the only way to get points is to acquire a consumer good as a result a successful exchange, which may take more than one period.

Possible results in a period

- If the exchange takes place, the result will be that:
  - You will earn 20 points if you receive a consumer good from your counterpart.
  - You will earn 0 points if you receive a red or blue chip from your counterpart.
  - In the next period, you will have the initial object of your counterpart, and vice versa.
- If the exchange does not take place, either because no mutual agreement was reached or because the opportunity was not presented, the result will be that:
  - You will earn 0 points, regardless of the object you are going to store.
  - In the following period, you will keep the same object with which you started the current period.

You are about to participate in an economic experiment. From now on, you must be careful with the decisions you make. Your choices and those of the other participants of the experiment They will determine your earnings. Therefore, it is important that you focus on understanding the instructions.

The earnings will be proportional to the **points** you accumulate throughout the experiment. To its term, the accumulated points will be transformed into soles (S/) at conversion rate 1 point = S / 0.03. The earnings could amount to S / 50.00, depending mainly on of your performance. Payments will be made in cash at the end of the experiment.

It is important that you do not communicate in any way with the other participants of the experiment. If you have questions or need assistance, please raise your hand so that An experimenter helps you. Any violation of this rule will cause you to be removed of the experiment and lose the right to receive your payment.

Next, we will present the game instructions.

General instructions: Session 2

- The session consists of **50 periods**. The total number of participants is 16.
- In the first period, all participants will be assigned to one of the following **groups: red or blue** . Participants will remain in the same group for the whole session The size of each group will be 8 participants and these will be selected **randomly**
- The experiment consists of an **exchange game** . There are three different objects that can be exchanged with other participants to accumulate **points: tokens red, blue chips and a consumer good**. These objects differ in points They grant.
- The chips, regardless of their color, award **0 points** . However, the participants earn **20 points if they receive a consumer good** from another participant. Is that is, the consumer good generates point gain only if it is obtained as a result of an exchange.
- In the first period, 4 members of the **Red group** will be randomly selected to receive a **red token** . The remaining 4 members will receive a consumer good.

Your group / Your group counterpart	**Red**	**Blue**
Red	75%	25%
Blue	25%	75%

Similarly, 4 members of the **Blue group** will be randomly selected to receive a **blue token**. The remaining 4 members will receive a consumer good.

- The consumer good is **homogeneous** in both groups.
- Participants who have a card will assume the role of **buyers**, and those who possess a consumer good will assume the role of **sellers**.

Experiment Development

- At the beginning of each period, you will be reminded of the group you belong to and the object you can sees (red card, blue card or consumer card). Then, you will be randomly matched with another participant of the experiment, who can be a member of the **red group or the blue group** . In the same way, your counterpart can be a **buyer or seller**.
- The **match** will present an **exchange opportunity** if the couple is made up of a buyer and a seller. In any other case, the interchange will not be possible. In this sense, you will not be able to exchange tokens, even if they are of different colors; nor consumer goods in the **barter mode**.
- It should be noted that all participants start with a 50-point endowment.

Pairing

- The table shown below summarizes the matching probabilities that they will govern in each period of this session.
- After pairing, you will be provided with the following information about your counter- part: the group to which it belongs (Red or Blue) and the object it possesses (red token, token blue or consumer). You will not receive additional information about your counterpart, nor will you they will give you results from previous rounds that involve other participants.

Exchange

- After the pairing, you will know if you have been presented with an exchange opportunity.
- If so, you will be asked, privately, if you want to exchange objects With your counterpart. You will have to select one of the following options: “Yes” or "No" . All exchanges will be one by one, which implies that you cannot

  Exchange fractions of an object
- The answers will be revealed simultaneously after both members of the couple have selected their responses privately. The exchange happens, only, if both said they agree.
- If there is no exchange opportunity, you will be informed about it and you must continue to the next period.
- Remember that the only way to get points is to acquire a consumer good as a result a successful exchange, which may take more than one period.

Possible results in a period

- If the exchange takes place, the result will be that:
  - You will earn 20 points if you receive a consumer good from your counterpart.
  - You will earn 0 points if you receive a red or blue chip from your counterpart.
  - In the next period, you will have the initial object of your counterpart, and vice versa.
- If the exchange does not take place, either because no mutual agreement was reached or because the opportunity was not presented, the result will be that:
  - You will earn 0 points, regardless of the object you are going to store.
  - In the following period, you will keep the same object with which you started the current period.

You are about to participate in an economic experiment. From now on, you must be careful With the decisions you make. Your choices and those of the other participants of the experiment They will determine your earnings. Therefore, it is important that you focus on understanding the instructions.

The earnings will be proportional to the points you accumulate throughout the experiment. TO its term, the accumulated points will be transformed into soles (S /) at conversion rate 1 point = S / 0.03. The earnings could amount to S / 50.00, depending mainly on of your performance. Payments will be made in cash at the end of the experiment.

It is important that you do not communicate in any way with the other participants of the experiment. If you have questions or need assistance, please raise your hand so that An experimenter helps you. Any violation of this rule will cause you to be removed of the experiment and lose the right to receive your payment.
Next, we will present the game instructions.

General instructions: Session 3

- The session consists of 50 periods. The total number of participants is 16.
- In the first period, all participants will be assigned to one of the following Groups: Red or Blue. Participants will remain in the same group for the whole session The size of each group will be 8 participants and these will be selected randomly
- The experiment consists of an exchange game. There are three different objects that can be exchanged with other participants to accumulate points: tokens red, blue chips and a consumer good. These objects differ in points They grant.
- Storing chips is expensive, so a penalty is incurred by keeping them. The cost of storing a card of the same color of your group is of 1 point per period. In contrast, the cost of storing a tab The other color is 2 points per period. As in the previous sessions, the participants earn 20 points if they receive a consumer good from another participant. That is, the consumer good generates points gain only if it is obtained as a result of an exchange.
- In the first period, 4 members of the Red group will be randomly selected to receive a red token. The remaining 4 members will receive a consumer good. Similarly, 4 members of the Blue group will be randomly selected to receive a blue token. The remaining 4 members will receive a consumer good.

Your group / Your group counterpart	**Red**	**Blue**
Red	75%	25%
Blue	25%	75%

- The consumer good is homogeneous in both groups.
- Participants who have a card will assume the role of buyers, and those who possess a consumer good will assume the role of sellers.

Experiment Development

- At the beginning of each period, you will be reminded of the group you belong to and the object you can sees (red card, blue card or consumer card). Then, you will be randomly matched with another participant of the experiment, who can be a member of the Red group or the Blue group. In the same way, your counterpart can be a buyer or seller.
- The match will present an exchange opportunity if the couple is made up of a buyer and a seller. In any other case, the interchange will not be possible. In this sense, you will not be able to exchange tokens, even if they are of different colors; nor consumer goods in the barter mode. It should be noted that all participants start with a 50-point endowment.

Pairing

- The table shown below summarizes the matching probabilities that they will govern in each period of this session.
- After pairing, you will be provided with the following information about your counter- part: the group to which it belongs (Red or Blue) and the object it possesses (red token, token blue or consumer). You will not receive additional information about your counterpart, nor will you they will give you results from previous rounds that involve other participants.

Exchange

- After the pairing, you will know if you have been presented with an exchange opportunity.

- If so, you will be asked, privately, if you want to exchange objects With your counterpart. You will have to select one of the following options: “Yes” or "No" . All exchanges will be one by one, which implies that you cannot Exchange fractions of an object.
- The answers will be revealed simultaneously after both members of the couple have selected their responses privately. The exchange happens, only, if both said they agree.
- If there is no exchange opportunity, you will be informed about it and you must Continue to the next period.
- Remember that the only way to get points is to acquire a consumer good as a result a successful exchange, which may take more than one period.

Possible results in a period

- If the exchange takes place, the result will be that:
  - You will earn 20 points if you receive a consumer good from your counterpart.
  - You will lose 1 point if you receive a card of the same color from your group, for concept of storage cost charged in advance.
  - You will lose 2 points if you receive a chip of a different color from your group, for the cost of storage charged in advance.
  - In the next period, you will have the initial object of your counterpart, and vice versa.
- If the exchange does not materialize, either because no mutual agreement was reached or because the opportunity did not present itself, the result will be that:
  - You will earn 0 points if you own a consumer good.
  - You will lose 1 point if you have a card of the same color as your group.
  - You will lose 2 points if you have a chip of a different color from your group.
  - In the following period, you will keep the same object with which you started the current period.

7.2. Screens shown in the game Figure 3: Exchange screen Figure 4: Results screen