On the Emergence of International Currencies:
An Experimental Approach*

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Abstract

We integrate theory and experimental evidence to study the emergence of different international monetary arrangements based on the circulation of two intrinsically worthless fiat currencies as media of exchange. Our framework is based on a two-country, two-currency search model where the value of each currency is jointly determined by private agents’ decisions and monetary policy formalized as changes in a country’s money growth rate. Results from the experiments indicate subjects coordinate on a regime where both currencies are accepted even when other regimes are theoretical possibilities. At the same time, we find the emergence of international currency depends on relative inflation rates where sellers tend to reject payment with a more inflationary foreign currency.

Keywords: international currency, monetary policy, inflation, experimental macroeconomics

JEL Classification: C92, D83, E40

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1 Introduction

The study of international currencies as media of exchange is a fundamental aspect of international economics with a long and diverse history. Prominent international currencies such as the gold coin of the Byzantine Empire, pound sterling in the 1900s, and more recently, the U.S. dollar, have risen and fallen in prominence over time Eichengreen (2020).\footnote{In this study, we emphasize the role of currencies as media of exchange in domestic and international transactions of goods. In addition to this role, it can also serve to invoice imports and exports, anchor the exchange rate, denominate international assets and liabilities, and facilitate inter-bank transactions. While much of the discussion on international currencies may center on some of these other roles, the model we use and experiment we design focuses specifically on an international currency’s role as a store of value and medium of exchange in cross-border goods transactions. In practice, however, many of these roles are complementary and the currencies used for pricing also tend to serve as means of payment. Goldberg (2011) provides evidence the U.S. dollar historically maintains a dominant role in all key functions.} It is important to emphasize that a currency’s standing as an international medium of exchange is influenced by both choices made by private citizens and governments. In particular, monetary policy plays a crucial role in policymakers’ ability to impact the global status of their currency. For instance, by lowering domestic inflation, monetary policy reduces the opportunity cost of using the domestic currency, providing both domestic and foreign citizens with more incentives to adopt and use it. In an open economy, citizens may opt to substitute to a less inflationary foreign currency such as the U.S. dollar, which is considered a more stable store of value. Understanding the factors influencing currency substitution is also of recent interest given the emergence of multiple cryptocurrencies that may compete with local currencies as a means of payment.

The goal of our study is to contribute to a more comprehensive understanding of the conditions under which different international monetary arrangements arise. In particular, we focus on how fundamentals like a country’s money growth rate affect coordination on the use of one or more currencies as media of exchange. Our main contribution is to integrate monetary theory with experimental evidence to study the conditions under which different international transaction patterns arise and investigate the dynamics of currency acceptance and use. Specifically, we design a laboratory experiment that implements an open-economy search model with microfoundations on the circulation of multiple currencies and a role for inflation in order to answer the following questions: First, how do fundamentals and policies affecting relative money growth rates affect the emergence of different monetary regimes? Second, what are the dynamics of currency adoption and use? Finally, given the presence of multiple equilibria, how does coordination on different currency regimes evolve over time?

We rely on experimental methods in this study for several important reasons. First, the model we are working with features microfoundations on the use of multiple currencies which means there are certain assumptions – e.g., random matching and bargaining – that may not be easily captured in naturally occurring field data. This makes it difficult to empirically assess some of the model’s aggregate predictions. Laboratory experiments instead can be used to evaluate both individual and aggregate outcomes since we generate data from an experiment designed to specifically implement the model. Second, our model admits multiple equilibria regarding the circulation of currencies...
and therefore is silent on which equilibrium individuals ultimately coordinate on. Laboratory methods provide a means for resolving equilibrium selection issues and is an important motivation for many other macroeconomic experiments. Third, isolating the main factors driving the use and acceptance of multiple currencies is challenging for several reasons that can be at least partially alleviated using experimental methods. Empirical findings on currency competition are limited due to the lack of micro-level field data. For instance, existing studies rely on rare natural experiments or survey evidence that are not incentivized and prone to measurement issues. Experimental methods allow us to directly observe currency use and acceptance over time instead of relying on proxies for these decisions. In addition, we can isolate the key factors influencing the use and acceptance of currencies by providing clean control of the laboratory environment. Finally, controlled monetary policy experiments in the field can be costly, infeasible, and unethical to implement. Experiments instead provide a systematic way to examine the effects of policy and collect data without causing harm to individuals or the economy. Overall, we view experimental methods as a useful complement to existing research that can offer insights into the effects of monetary policies on currency competition that are otherwise difficult to establish.

The theoretical framework for the experiment is based on a two-country, two-currency search model developed by Zhang (2014). Search-theoretic models are particularly useful at addressing international currency use, since they explicitly formalize the essential role of money in different transactions rather than assuming circulation patterns exogenously. In the model, each country issues one currency distributed lump-sum to domestic residents. Gains from trade between buyers and sellers can be facilitated with a portfolio of currencies. However, while sellers always accept domestic currency, they must incur a fixed cost in order to accept foreign currency. Since sellers’ acceptance decisions depend on buyers’ portfolio choices, and vice versa, complementarities in the trading environment lead to multiple steady-state equilibria where zero, one, or two international monies can emerge. For instance, when acceptance costs are sufficiently high, an equilibrium with two national currencies arises endogenously. Network externalities can also lead to coordination failures, with no guarantee that the socially efficient monetary system maximizing aggregate welfare is chosen.

By formalizing the role of currency in payments, the model provides a channel for monetary policy – through changes in a country’s money growth rate – to affect prices, trade, and wel-
fare. For instance, currency substitution occurs as an endogenous response to local inflation: as it becomes more costly to hold local money, agents start substituting with foreign currency such as dollars. This captures the phenomenon of dollarization common in many Latin American and eastern European economies. The theory also emphasizes an important influence on the choice of money as an international medium of exchange. Fundamentals like inflation, as well as expectations regarding other agents’ behavior, jointly determine this decision and thereby determine the circulation patterns that arise. Due to inertia, it may be difficult to dislodge an incumbent currency from its international role. At the same time, a change in inflation can permanently shift payment patterns. International currency use, therefore, reflects both fundamentals and history, consistent with what we observe in practice. While the strategic complementarities and multiple equilibria are intuitive at capturing international payment patterns, the theory is silent on which of many potential equilibria is more likely.

To better understand how relative money growth rates affect the emergence of different international currency regimes and address issues related to equilibrium selection, we design a laboratory experiment based on the model described above. The experiment involves human subjects making individual decisions over time in a similar manner as those in the theoretical model. In particular, subjects are divided into two countries, Red and Blue, and assigned roles as buyers or sellers. Subjects first interact all together in a centralized market where they receive lump-sum transfers of domestic tokens and trade a consumption good at an endogenous market price. The main role of this market is to allow subjects to rebalance their portfolios before proceeding to a decentralized market featuring pairwise meetings and bargaining between buyers and sellers across countries. In addition, prior to being matched, sellers can choose to accept foreign tokens at a fixed cost. Once matched, buyers and sellers bargain over the terms of trade. The key outcome variables are then prices, foreign currency acceptance, consumption, production, and welfare.

The main treatment variable in the experiment is the money growth rate of each country. In the Baseline treatment, the money growth rates of both countries are equal. In the HighBlue treatment, the Blue country’s money growth rate is set higher than the Red country’s. Furthermore, the Red country’s money growth rate is the same across the two treatments thereby facilitating comparisons at the treatment level. We parameterize the experiment so that four currency regimes are theoretically possible: an equilibrium with two national currencies, two equilibria with one international currency and one national currency, and finally an equilibrium with two international currencies.

Results from the experiments offer a detailed understanding of how different money growth rates across treatments and countries affect prices, inflation, foreign currency acceptance rates, output, and welfare. Overall, the behavior of prices and inflation align with theoretical predictions: inflation magnitudes from the experiments are close to theoretical predictions, and higher money growth generates higher inflation, consistent with the literature (see Section 2 for a more detailed discussion). Regarding equilibrium selection, we find broad support for an equilibrium where both currencies are everywhere accepted, i.e. a regime with two international currencies, even in
the treatment where one currency has a relatively higher money growth rate. However, sellers’ acceptance rates for the more inflationary currency is significantly lower than acceptance rates for the less inflationary currency. While we did not detect significant differences in welfare across treatments, we identified differences in the bargaining stage indicating subjects may find it more difficult to find mutually acceptable trades when using currencies with different inflation rates.

The remainder of the paper is organized as follows. Section 2 discusses related literature and clarifies our contribution. We introduce the theoretical framework in Section 3 that forms the basis for the experiments. Section 4 describes the experimental design and procedures, and Section 5 discusses the experimental results. We conclude in Section 6 with closing remarks and open questions for future research.

2 Related Literature

Our study broadly fits within a growing literature studying monetary economics and macroeconomics using experimental methods (see Duffy (2016, 2022) and Hommes (2021) for comprehensive surveys). More specifically, we contribute to two branches in this literature: experiments on multiple currencies as media of exchange using search-theoretic models and experiments on the real effects of inflationary monetary policies.

The closest paper to our study is Ding and Puzzello (2020) who also use experimental methods to implement the two-country, two-currency model of Zhang (2014) but with constant money supplies. The key contribution of the present paper relative to Ding and Puzzello (2020) is our introduction of active monetary policies through a constant money growth rule associated with each country’s currency. Importantly, our focus on how different money growth rates affect the international status of a currency is distinct and novel. The design of our experiment also differs along several key dimensions. First, we offer subjects a considerable amount of feedback on decisions particularly in the bargaining stage by introducing design aids in the experimental interface that allowed subjects to see the consequences of different actions before committing to a decision. Second, given the added complexity introduced with money injections over time, we streamlined other aspects of the design (e.g., keeping the rest of the environment symmetric across countries, removing legal restrictions on foreign currency). In terms of results, our findings on equilibrium selection are consistent with Ding and Puzzello (2020): both our studies find that subjects coordinate on an equilibrium where they tend to accept both currencies, despite treatment differences, indicating a regime with multiple currencies may be a more robust outcome than other ones. Since the two studies focus on different treatment variables – i.e., legal restrictions and costs of accepting foreign currency vs. money growth rates – our results on the effects of money growth are distinct and not directly comparable to Ding and Puzzello (2020). Overall, we view our studies as complementary that together offer a more nuanced understanding of the factors driving the rise and fall of international circulation patterns.

This paper also relates to experiments studying multiple currencies using earlier search-theoretic models with indivisible currencies and therefore no money growth.\footnote{Early contributions to the study of money as a medium of exchange using experimental methods include Brown (1996) and Duffy and Ochs (1999, 2002), which implement versions of the Kiyotaki and Wright (1989, 1993) model with indivisible commodity and fiat money, respectively. Duffy and Puzzello (2014b) pioneered the use of divisible money search models in the laboratory by comparing experimental environments based on Lagos and Wright (2005) and Aliprantis, Camera, and Puzzello (2007b) where money is and is not essential. Camera and Casari (2014) examine a related issue of coordination on monetary equilibria in a different framework featuring decentralized matching. Together, both studies find support that money acts as a coordination device even when it is not theoretically essential. More recently, Davis, Korenok, Norman, Sultanum, and Wright (2022) and Jiang, Norman, Puzzello, Sultanum, and Wright (2021) study whether fiat money is essential in finite horizon economies where monetary exchange may or may not be supported in equilibrium. Their findings show welfare is higher with money, even if monetary exchange is not an equilibrium.} Jiang and Zhang (2018) study currency competition by implementing a two-country, two-currency search model based on Matsuyama, Kiyotaki, and Matsui (1993) which has fixed prices and therefore exchange rates. In contrast, prices are endogenous in our study and key outcome variables we investigate in the experiments. Similar to us, they find subjects tend to coordinate on a regime where both currencies are everywhere accepted. Arrieta-Vidal, Florián, López, and Morales (2022) develop a similar experiment as Jiang and Zhang (2018) but with de-dollarization policies designed to reduce foreign currency acceptance and find such policies do promote the use of local currency. Rietz (2019) studies the effects of introducing a secondary currency in an experiment based on a two-currency version of Kiyotaki and Wright (1993). Relative to these studies, we introduce multiple divisible currencies and active monetary policies through changes in money growth rates. We therefore directly obtain observables from the laboratory such as prices and inflation that these studies abstract from by design.

There are also experimental studies with multiple assets or payment instruments using alternative monetary models. Arifovic (1996) studies the behavior of exchange rates in a two-currency overlapping generations model based on Kareken and Wallace (1981) where the nominal exchange rate is indeterminate. Exchange rates fluctuate over time in human subject experiments, which can be well captured using a genetic algorithm learning rule. Noussair, Plott, and Riezman (1997) also examine exchange rates in a two-currency cash-in-advance economy when subjects must carry foreign currency before purchasing foreign goods, therefore abstracting from currency choice and acceptance. While the exchange rate is also observable in our experiment, we abstract from a detailed analysis in this study and delegate a closer investigation in a companion paper. Camera, Noussair, and Tucker (2003) examine the use of assets dominated in rate-of-return in an experimental economy with a fiat currency and real asset. Arifovic, Duffy, and Jiang (2023) develop an experimental framework to understand the factors driving the adoption of a new payment method when there is an already existing payment method accepted by sellers. They find a low acceptance cost favors quick adoption of the new payment method, while sellers gradually learn to reject the new payment method with a sufficiently high fixed cost. In contrast with these studies, we focus on how inflation affects the use and acceptance of two intrinsically worthless currencies.

Finally, our study also contributes to a growing experimental literature studying the real effects of...
of inflationary monetary policies in search-theoretic models of money. Duffy and Puzzello (2022) implement a version of Lagos and Wright (2005) to study the real effects of deflationary policies and different implementations of the Friedman rule. They also consider an inflationary monetary policy in one treatment and find, in contrast with theory and our study, inflation leads to higher output and welfare. Jiang, Puzzello, and Zhang (2023) use a similar framework and focus on the effects of inflationary monetary policies and different money injection schemes. We implement a similar lump-sum transfer scheme to introduce increases in the money supply over time and similarly find the quantity theory holds, i.e. higher money growth rates lead to higher inflation rates. The present study complements this literature by introducing two currencies both of which can grow over time.

3 Theoretical Framework

In this section, we describe the theoretical framework that forms the basis for the experiments. The model is based on the two-country, two-currency model of Zhang (2014). An advantage of this framework is it provides microfoundations for the use of different currencies as media of exchange and is therefore amenable to laboratory experiments. The model also features divisible currencies and goods which makes it possible to study the effects of monetary policy through changes in the money growth rate. See Zhang (2014) for details in a slightly more general formalization.

Time is discrete and continues forever. There are two countries, Red and Blue, populated with a finite number of $2N_r$ and $2N_b$ agents, respectively, where $N_r$ and $N_b$ denote country sizes. Each period consists of two stages where economic activity will differ: stage 1 (CM) features centralized meetings where agents can trade a general good in order to rebalance their portfolios while stage 2 (DM) features pairwise meetings and bargaining over local and foreign goods. In the CM, all trade occurs in a frictionless competitive market where agents can consume a numéraire good which is produced with a linear production function in labor. The supply of hours in the CM is $h$, which implies the real wage is one. In the DM, agents from each country are evenly divided between buyers and sellers. Sellers from $s = \{r, b\}$ can produce output $q_s$ but do not want to consume, while buyers want to consume but cannot produce. In this study, we simplify by focusing on a uniform matching technology across countries where conditional on being a buyer, the probability of being matched with a domestic seller is $\alpha = 0.5$ and the probability of being matched with a foreign seller is $(1 - \alpha) = 0.5$.

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8Since the population is finite, informal enforcement schemes cannot be ruled out in theory (see Aliprantis, Camera, and Puzzello (2007a) and Araujo, Camargo, Minetti, and Puzzello (2012)). In a similar framework but with one currency, a closed economy, and constant money supply, Duffy and Puzzello (2014a) find outcomes are closer to the monetary equilibrium predictions and do not find support for the use of informal enforcement schemes in experimental economies with 6 and 14 subjects.

9More generally, search and information frictions can make international trade more difficult than local trade. See
For tractability, instantaneous utilities for buyers and sellers are additively separable and quasi-linear in hours:

\[
U_B = u(q_s) + U(x) - h,
\]

\[
U_S = -c(q_s) + U(x) - h.
\]

To ease presentation, functional forms for utilities and cost functions are assumed to be the same across countries. Further, \(u(\cdot)\) and \(c(\cdot)\) are assumed to be \(C^2\) with \(u' > 0, u'' < 0, c' > 0, c'' > 0\), \(u(0) = c(0) = c'(0) = 0\), and \(U'(0) = u'(0) = \infty\). Also, let \(q^* \equiv \{q : u'(q^*) = c'(q^*)\}\) and \(x^* \in (0, \infty)\) solve \(U'(x^*) = 1\). All goods are perishable, and agents discount the future between periods with a discount factor \(\beta \in (0, 1)\). Since agents lack commitment and individual histories are private information in the DM, unsecured credit cannot be used, which makes a medium of exchange essential for trade.

Each country issues its own fiat currency, \(i = \{r, b\}\), both intrinsically useful, divisible, and storable. Currency \(m_i \in \mathbb{R}_+\) is valued at \(\phi_i\), the price of money in terms of the numéraire. The nominal exchange rate is defined here as the price of the blue currency in terms of the red currency, \(e \equiv \phi_b / \phi_r\). Since market clearing in the CM implies that the law of one price holds, agents can trade currencies at the market clearing exchange rate. Hence, the CM also functions as a foreign exchange market. Money supplies, \(M_i\), grow or shrink each period at a constant rate (\(\gamma_i - 1\)), where \(\gamma_i \equiv M'_i / M_i\).

Variables with a prime denote next period’s parameters or choices. Changes in the money supply are implemented through lump-sum monetary transfers or taxes of domestic currency in the CM to that country’s buyers.

While domestic currency is perfectly recognizable, it is difficult for sellers to verify the quality of foreign currency. In particular, they must incur a fixed flow cost, \(\psi_s \geq 0\), at the start of the DM in order to recognize and hence accept payment in foreign money. For example, firms must invest in a verification device in order to authenticate genuine foreign notes from counterfeits. Alternatively, firms must install new technologies such as debit card devices and new cash registers, or incur administrative costs for dealing with multi-payment options. The fixed cost is homogenous across sellers within a country but can differ across countries. It is common knowledge in a match whether the seller has invested, and sellers do not accept currencies they do not recognize.\(^{10}\) In what follows, we focus on the model’s theoretical predictions in stationary equilibria where real balances are constant over time. The equations determining equilibrium are summarized in Appendix A.

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\(^{10}\) For example, sellers will reject payment if it is costless to produce worthless counterfeits: if sellers accepted unrecognizable currencies, buyers would just hand over counterfeits in each exchange. This assumption simplifies the pricing mechanism. Hence trade occurs under full information, and both currencies are accepted if and only if \(\psi_s\) is incurred.

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e.g. Zhang (2014) where buyers are mobile while sellers are immobile such that with probability \(\alpha\) a buyer stays in his country of origin and with probability \(1 - \alpha\), visits the foreign country. The number of trade matches in the DM of country \(j\) is then given by an aggregate matching function where a Red buyer meets a seller with probability \(a_r\) while conditional on being in the Blue country, a buyer meets a seller with probability \(a_b\). In that case, national and international trade frictions are controlled by the parameters \(N_r, N_b,\) and \(\alpha\). The parameter \(\alpha\) can be interpreted as the degree of economic integration: as \(\alpha \to 0\), countries become more integrated and meeting a foreigner is more likely, while \(\alpha \to 1\) corresponds to a closed economy where only locals trade.
4 Experimental Design

In this section, we first describe the parameter values chosen for the experimental treatments and summarize theoretical predictions. Next, we present details on experimental implementation, including a description of the decision aids built into the interface. Finally, we discuss experimental procedures and administration.

Table 1: Treatment Parameters and Theoretical Predictions

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline</th>
<th>HighBlue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money growth rate in Blue ($\gamma_b$)</td>
<td>1.05</td>
<td>1.30</td>
</tr>
<tr>
<td>Money growth rate in Red ($\gamma_r$)</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>Foreign token acceptance cost in Red ($\psi_r$)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Foreign token acceptance cost in Blue ($\psi_b$)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Degree of economic integration ($\alpha$)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Buyer’s bargaining power ($\theta$)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Discount factor ($\beta$)</td>
<td>0.875</td>
<td>0.875</td>
</tr>
</tbody>
</table>

Monetary Equilibrium

<table>
<thead>
<tr>
<th>Centralized Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation rate in Red market</td>
</tr>
<tr>
<td>Inflation rate in Blue market</td>
</tr>
<tr>
<td>Quantity consumed by Red buyers</td>
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<tr>
<td>Quantity consumed by Blue buyers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decentralized Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign currency acceptance by Red sellers</td>
</tr>
<tr>
<td>Foreign currency acceptance by Blue sellers</td>
</tr>
<tr>
<td>Quantity consumed by Red buyers</td>
</tr>
<tr>
<td>Quantity consumed by Blue buyers</td>
</tr>
</tbody>
</table>

Average Welfare

| Blue Country | 20.88 | 24.96 | 16.57 | 20.52 | 13.68 | 19.06 | 15.16 | 19.11 |

Notes: Welfare is measured by the utility of consumption and disutility from production. Average welfare is presented as the average welfare between buyers and sellers per round.

4.1 Parameters and Treatments

The objective of this paper is to study the impacts of monetary policy through changes in money growth rates on the dynamics of currency adoption and use. Our main treatment variable is therefore the money growth rates for each country. We label the countries in our experiment as the Red Group and Blue Group. The two treatments vary the money growth rates in the Blue country. In the Baseline treatment, both countries have the same money growth rate so that the money supply in both countries grows by 5% each period ($\gamma_r = \gamma_b = 1.05$). In the HighBlue treatment, the Blue country has a considerably higher money growth rate than in the Red country. In particular, in the Red country, the money supply grows by 5% each period ($\gamma_r = 1.05$), whereas in the Blue
country, the money supply grows by 30% in each period \((\gamma_b = 1.3)\). An advantageous feature of this design is that we can make comparisons both across treatments and across countries.

### 4.2 Instructions, Experimental Interface, and Decision-Aids

Since the main novelty of this study is the introduction of money growth rates for two currencies in an experiment based on Zhang (2014), we made several design choices that deserve more discussion. In particular, Figure 2b presents a screenshot of the instructions regarding the money supply increase schedule. We used both verbal and visual display of the information, such that subjects were instructed that at the beginning of each round, a specific amount of new tokens will be transferred to buyers of each group and that amount would increase by a certain percentage each round. Subjects could also hover over the graph to see the specific amounts for each round. In addition to the interactive graph, we also provided a printed version of the same graph as well as a printed version of a more extensive table of the money growth and lump-sum transfers for the duration of the experiment (see Appendix C).

The added complexity associated with introducing positive money growth motivated several additional changes relative to the design in Ding and Puzzello (2020). First, we used the same functional forms for the utility of consumption and cost of production in both CM and DM stages within a round (see Figure 2a). Second, we switched the order of the CM and DM, to facilitate token transfers at the beginning of each round. Finally, at the beginning of each sequence, we randomly assigned half the participants in each group to be buyers in the CM and sellers in the DM, and the other half to be sellers in the CM and buyers in the DM. These changes streamlined the presentation of the environment while making the earnings across participants symmetric (e.g., there is then no need for exogenous transfers to sellers as in Ding and Puzzello (2020)). Figure 1 illustrates the timing of events within a round of a typical sequence.

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11There are several reasons for our choice of the magnitudes for the money growth rates in the two treatments. First, we chose 5% money growth rates in the Baseline treatment rather than 0% money growth since we did not want a completely constant money supply to be a focal point for the experiment. Second, we chose 30% money growth for the Blue country since this magnitude is considerably higher than the baseline magnitude of 5% growth and in line with magnitudes used in the literature, e.g. Duffy and Puzzello (2022) and Jiang, Puzzello, and Zhang (2023).
To ensure subjects understood the environment and the consequences of their decisions, we undertook the following steps. First, we provided printed copies of the instructions to be available for reference for the duration of the experiment. Second, at the end of the instructions phase, subjects were required to answer ten quiz questions. Although the questions were not incentivized, subjects could only proceed to the experiment if they answered all questions. In the case that they missed a question they were given a hint directing them to a specific page of the instructions and they had an option to ask for an additional explanation from the experimenter. Finally, throughout the experiment, subjects could use decision aids within the computer interface. Specifically, upon entering a potential decision but before submitting it, subjects could see the consequences of that decision. For example, if in stage 1 a buyer enters how many red tokens they would like to spend on the consumption good, the interface displays the impact on their token balance (see Figure 3a). Similarly, during the offer proposal and response decisions, subjects could see the consequences of their proposal for both of the players (see Figure 4b).

Figures 3 and 4 show screenshots of the interface for stages 1 and 2, respectively. Within a sequence, subjects had access to the history of prices and foreign token token acceptance decisions (denoted by bullets 4 and 5 in Figures 3 and 4). In addition, the history graphs were made interactive so that subjects could hover over each point to get more detailed information (e.g., the exact price in round 3). The interactive history part of the screen was available on all pages including the waiting pages.
Figure 2: Instructions Screenshots

Each round consists of two stages. In each stage, you may be a Buyer or a Seller such that if you are a buyer in stage 1, you will be a seller in stage 2, and vice versa.

A Buyer will decide how many units of a consumption good to consume given the earnings (in points). A Seller will decide how many units of a consumption good to produce given the costs (in points).

For example, consuming 20 units yields 53.67 points for the buyer, while producing 20 units costs 20 points to the seller. Notice that for the duration of the experiment, you are provided with a separate print-out that contains this graph as well as the detailed table of earnings and costs.

Points from consumption and production accumulate across rounds and sequences and are converted into cash at the exchange rate of 20 points $= 1$

(a) Instructions Regarding Buyers’ Utility and Sellers’ Cost

At the beginning of round 1, all Stage-1 Buyers are given an initial endowment of tokens. Specifically, each Red Buyer receives 25 Red Tokens and 15 Blue Tokens and each Blue Buyer receives 15 Red Tokens and 25 Blue Tokens.

Thus, at the start of each sequence there are 200 Red Tokens and 200 Blue Tokens in total.

The total number of Red Tokens and Blue Tokens available will increase in each round over the course of a sequence according to a predetermined schedule. Specifically, the amount of Red Tokens increases by 5% each round while the amount of Blue Tokens increases by 30% each round. For example, the total number of tokens over the first 10 rounds is displayed below.

The additional tokens are transferred equally among the buyers of the corresponding group. For example, at the beginning of round 2, an additional 2 Red Tokens are transferred to each Red Buyer, so that the total number of Red Tokens is 210.0. Similarly, at the beginning of round 2, an additional 12 Blue Tokens are transferred to each Blue Buyers so that the total number of Blue Tokens is 260.0. Notice that in rounds 2, 3, 4 ... Red Buyers do not receive transfers of Blue Tokens and Blue Buyers do not receive transfers of Red Tokens.

Notice that for the duration of the experiment, you are provided with a separate print-out that contains this graph as well as the detailed table of token transfers.

When a new sequence begins, the token holdings of all participants will reset.

(b) Instructions Regarding Tokens
Figure 3: Centralized Market Screenshots

(a) Buyer’s Decision

Notes: The screenshots show decision screens in the HighBlue treatment. (1) current round and stage summary; (2) impact of decision on points and token balances (updated upon entry); (3) decision entry; (4) history of prices in the centralized market; (5) history of foreign token acceptance decisions in the decentralized market.
Figure 4: Decentralized Market Screenshots

(a) Sellers’ Token Acceptance Decision

Notes: The screenshots show decision screens in the HighBlue treatment. (1) current round and stage summary; (2) impact of decision on points and token balances are updated upon entry; (3) decision entry; (4) history of prices in the centralized market; (5) history of foreign token acceptance decisions in the decentralized market.
4.3 Experimental Protocol and Administration

The experiments were conducted at Purdue University in February and March of 2023. We used the ORSEE software (Greiner, 2015) to recruit 160 students for 8 sessions. No subject participated in more than one session, although some subjects may have previously participated in other economics experiments. We adopted a between-subjects design where each session of the experiment consisted of subjects making decisions under either the Baseline or HighBlue parameter set. Subjects in each session were evenly split into Red and Blue groups, and subjects remained in their assigned group for the duration of the experiment. Sessions lasted approximately 2.5 hours with an average earnings of $36.6 (including the $5 show-up fee). Table 2 summarizes session details for the two treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Session</th>
<th>Seq. lengths</th>
<th>Subjects</th>
<th>Red</th>
<th>Blue</th>
<th>Rounds</th>
<th>Sequences</th>
<th>Duration</th>
<th>Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1</td>
<td>11,7,2,15,6</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>32</td>
<td>3.8</td>
<td>108 min.</td>
<td>44</td>
</tr>
<tr>
<td>Baseline</td>
<td>2</td>
<td>3,5,16,8,9</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>25</td>
<td>3.1</td>
<td>104 min.</td>
<td>34</td>
</tr>
<tr>
<td>Baseline</td>
<td>3</td>
<td>7,9,6,1,12</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>26</td>
<td>4.3</td>
<td>102 min.</td>
<td>39.2</td>
</tr>
<tr>
<td>Baseline</td>
<td>4</td>
<td>9,3,16,4,13</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>29</td>
<td>3.3</td>
<td>119 min.</td>
<td>39</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>28</td>
<td>3.6</td>
<td>108.3 min.</td>
<td>39.0</td>
</tr>
<tr>
<td>HighBlue</td>
<td>1</td>
<td>11,7,2,15,6</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>22</td>
<td>3.1</td>
<td>92 min.</td>
<td>34.7</td>
</tr>
<tr>
<td>HighBlue</td>
<td>2</td>
<td>3,5,16,8,9</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>32</td>
<td>4</td>
<td>112 min.</td>
<td>32.1</td>
</tr>
<tr>
<td>HighBlue</td>
<td>3</td>
<td>7,9,6,1,12</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>35</td>
<td>5</td>
<td>113 min.</td>
<td>38.7</td>
</tr>
<tr>
<td>HighBlue</td>
<td>4</td>
<td>9,3,16,4,13</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>28</td>
<td>3</td>
<td>116 min.</td>
<td>40.9</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>29.3</td>
<td>3.8</td>
<td>108.3 min.</td>
<td>36.6</td>
</tr>
</tbody>
</table>

Notes: Red and Blue denote number of subjects assigned to Red and Blue groups, respectively. Rounds denote the total number of rounds completed. Sequences denote the number of sequences completed with the decimal representing the proportion of rounds of the last sequence completed. For example, 3.8 for Session 1 of the Baseline treatment denotes that subjects completed 3 full sequences and 12 out of 15 rounds (or 80%) of the fourth sequence. Duration denotes the duration of the main experiment portion (i.e., instructions, quiz, and post-experimental survey are excluded). Earnings denotes the average earning for the experiment accounting for the fact that subjects who earned less than $15 were paid $15 to ensure some minimal earning for the 2.5 hours of their time.

We implemented the infinite horizon using random termination where each session consisted of multiple sequences which lasted for an indefinite number of rounds (Roth and Murnighan, 1978). To implement a discount factor of $\beta = 0.875$, we instructed subjects that at the end of each round, the computer would roll a fair eight-sided dice, such that the sequence would end if 1 is rolled and the sequence would continue to the next round if 2–8 is rolled.\textsuperscript{12} Table 2 presents sequence length used in the experiment. Importantly, same sequence lengths were matched between the Baseline

\textsuperscript{12}As part of the instructions, subjects needed to test this procedure five times (see page 3 of Appendix C). This allowed subjects to observe different possible realizations of sequence lengths, including some very short sequences and some much longer ones.
and HighBlue sessions.

Subjects were assigned roles as either buyers or sellers in stage 1 and would reverse roles in stage 2. The assignment of roles was randomly selected at the beginning of the sequence but remained fixed for the duration of the sequence. We allowed subjects to act as a buyer and a seller within a round for two main reasons. First, we wanted to give subjects experience with playing roles as buyers or sellers in a given stage. This choice ensured that subjects learned the consequences of decisions for both sides (e.g., linear cost of production, concave utility of consumption). Second, we wanted to roughly equalize payoffs across subjects. Since sellers would consistently lose points from producing while buyers would gain points from consuming, there was a potential for widely different payments if the roles were fixed.

There are two aspects of the experiment that differ from the environment described in Section 3 regarding subjects’ actions in the CM and DM. First, recall all agents in the model can consume and produce the general good in the CM in order to rebalance their portfolio of currencies. In the experiment, we assigned and fixed subjects’ roles as buyers or sellers in the CM where only buyers can consume the good and only sellers can produce. This does not change the model’s theoretical predictions and has the advantage of simplifying subjects’ choice sets. Second, our implementation of Kalai (1977) bargaining in the DM follows the bargaining game in Ding and Puzzello (2020) where upon being matched, a subject in a pair is selected to be a proposer with probability $\theta = 0.5$ while the other is the responder with complementary probability.\footnote{Hu and Rocheteau (2020) provide microfoundations for Kalai bargaining by applying the gradual bargaining approach in decentralized markets of Rocheteau, Hu, Lebeau, and In (2021). Duffy, Lebeau, and Puzzello (2022) investigate Nash and Kalai bargaining solutions in the laboratory and find subjects’ actions are closer to the Kalai solution where both parties receive roughly half of the match surplus.}

Finally, we implement competitive pricing in the CM by having subjects participate in a market game based on Shapley and Shubik (1977), which provides non-cooperative foundations for competitive equilibrium outcomes.\footnote{There are several experiments that use the market game to implement competitive markets. See e.g., Arifovic (1996), Duffy, Matros, and Temzeledis (2011), Duffy and Puzzello (2014a), Duffy and Puzzello (2014b), Duffy and Puzzello (2022), and Jiang, Puzzello, and Zhang (2023), among many others.} In the beginning of each CM, sellers submit a quantity to produce for red and/or blue tokens while buyers submit a bid of red and/or blue tokens the consumption good. The market price for red (blue) tokens is then computed as the sum of red (blue) tokens bid divided by the sum of production for red (blue) tokens.

## 5 Results

We now discuss the main results from the experiments. We organize this discussion in terms of three key categories of observables that are central to our study: prices and inflation in Section 5.1, sellers’ foreign currency acceptance rates in Section 5.2, and consumption, production, and welfare in Section 5.3. Unless stated otherwise, all results presented in this section are based on data from the second half of the experiment. An analogous set of analysis using data from the entire experiment is presented in Appendix B.
5.1 Prices and Inflation

Figure 5 presents CM prices and inflation from the experiment. Overall, the behavior of both prices and inflation are consistent with theoretical predictions. Panel (a) shows red and blue prices are close to each other across rounds in the Baseline treatment, while the increase in blue prices exceeds the increase in the red prices in the HighBlue Treatment. Panel (b) presents estimated inflation rates in each treatment with error bars denoting 95% confidence intervals. We follow the procedure in Jiang, Puzzello, and Zhang (2023) and estimate red inflation is 9.9% and 4.6% in the Baseline and HighBlue treatments, respectively, while blue inflation is 9.8% and 34.3% in the Baseline and HighBlue treatments (we provide more details in Appendix B).

![Figure 5: Prices and Inflation](image)

**Notes:** (a) solid lines represent observed prices in the experiments; opaque lines represent the theoretical values in the different regimes. (b) the black solid line corresponds to the theoretical inflation rate of 0.05 in the Baseline treatment; black dotted lines correspond to the theoretical inflation rates of 0.05 for the red country (lower line) and 0.30 for the blue country (upper line).
There are several notable observations in Figure 5. First, blue inflation in the HighBlue treatment is significantly higher than blue inflation in the Baseline treatment as well as the red inflation in both the HighBlue and Baseline treatments. Second, inflation rates for treatments where theory predicts the same inflation rate (i.e., 5% inflation in the Baseline treatment), are not significantly different from each other. Third, inflation rates across treatments and countries are slightly higher than theoretical predictions.\(^\text{15}\) We summarize these observations with Result 1.

**Result 1** *Inflation rates respond to money growth rates in line with theory.*

(a) *Red and Blue inflation rates are the same in the Baseline Treatment,*

(b) *Blue inflation rates are higher than Red inflation rates in the HighBlue treatment,*

(c) *Red inflation rates are the same in the HighBlue treatment and in the Baseline treatment,*

(d) *Blue inflation rates are higher in the HighBlue treatment than in the Baseline treatment.*

There are several reasons why Result 1 is important. First and foremost, our results on inflation can be used as a check whether our experiment design leads to sensible outcomes. That is, in instances where theory predicts the same inflation rate across treatments or countries, we indeed observe inflation is not statistically different; in addition, in the instance where theory predicts higher inflation in the Blue country, we observed significantly higher inflation in the Blue country. Second, the theory of provides precise point predictions regarding the inflation rates given the money growth rates. The fact that the inflation rates are close to the theoretically predicted ones is encouraging. Although inflation observed in the experiment is slightly higher than theoretically predicted, it is reasonable in light of previous studies with money growth and a single currency (e.g., Duffy and Puzzello (2022), Jiang, Puzzello, and Zhang (2023)). Combined, our findings on prices and inflation are reassuring and increase confidence in other results that are more unique to the particular model we implement – namely foreign currency acceptance rates, consumption, production, and welfare.

\(^\text{15}\)In Appendix B, we also present estimates of inflation using all the data and find evidence that inflation estimates get closer to theoretical predictions over time.
Table 3: Main Results

<table>
<thead>
<tr>
<th>(a) Inflation</th>
<th>(b) Foreign currency acceptance</th>
<th>(c) Per round welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>HighBlue</td>
</tr>
<tr>
<td>Red</td>
<td>0.099</td>
<td>0.046</td>
</tr>
<tr>
<td>(0.012)</td>
<td>(0.033)</td>
<td>(0.057)</td>
</tr>
<tr>
<td>Blue</td>
<td>0.098</td>
<td>&lt;***</td>
</tr>
<tr>
<td>(0.017)</td>
<td>(0.017)</td>
<td>(0.037)</td>
</tr>
</tbody>
</table>

Notes: Standard errors clustered at session level in parentheses. Statistical significance is assessed using regressions with an indicator variable for each relevant category. *p<0.1; **p<0.05; ***p<0.01.

5.2 Foreign Currency Acceptance

We next turn our attention to the behavior of foreign currency acceptance rates. Figure 6 presents the average foreign token acceptance rates across rounds within sequences. In the Baseline treatment, the trends for both currencies are largely constant over time, whereas, in the HighBlue treatment, there is a larger difference between the proclivity of sellers to accept foreign tokens in both countries. Table 3(b) summarizes the average foreign currency acceptance rates by the sellers aggregated across rounds.

Figure 6: Foreign Currency Acceptance Rates

Table 3 and Figure 6 demonstrate Red sellers are more reluctant to accept blue tokens in the HighBlue treatment than in the Baseline treatment. Furthermore, within the HighBlue treatment, Red sellers are less likely to accept blue token than Blue sellers accepting red tokens. We summarize these observations with Result 2.

Result 2 Currency acceptance decisions depend on the money growth rates:
(a) Foreign currency acceptance rates by Red sellers are lower than Blue sellers in the HighBlue treatment.

(b) Foreign currency acceptance rates by Red sellers are lower in the HighBlue treatment than in the Baseline treatment.

(c) Foreign currency acceptance rates by Red sellers are not significantly different from the foreign currency acceptance rates by Blue sellers in the Baseline treatment.

(d) Foreign currency acceptance rates by Blue sellers are marginally higher in the HighBlue treatment than in the Baseline treatment.

5.3 Production, Consumption, and Welfare

We now turn our attention to production, consumption, and welfare. Table 4 summarizes production by sellers and consumption by buyers across countries. In addition, the table shows aggregate welfare in the two countries and aggregate global welfare in each of the two treatments.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>HighBlue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red</td>
<td>Blue</td>
<td>Red</td>
<td>Blue</td>
</tr>
<tr>
<td><strong>Centralized Market</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity produced by sellers</td>
<td>11.77</td>
<td>9.43</td>
<td>11.94</td>
<td>9.57</td>
</tr>
<tr>
<td>Quantity consumed by buyers</td>
<td>10.26</td>
<td>10.94</td>
<td>9.94</td>
<td>11.58</td>
</tr>
<tr>
<td><strong>Decentralized Market</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity produced by sellers</td>
<td>15.49</td>
<td>14.13</td>
<td>15.82</td>
<td>14.87</td>
</tr>
<tr>
<td>Quantity consumed by buyers</td>
<td>16.79</td>
<td>13.08</td>
<td>16.52</td>
<td>14.26</td>
</tr>
<tr>
<td>Offer acceptance rate</td>
<td>0.752</td>
<td>0.733</td>
<td>0.702</td>
<td>0.637</td>
</tr>
<tr>
<td>Offer acceptance rate average</td>
<td>0.743</td>
<td>0.670</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average Welfare</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per round</td>
<td>20.88</td>
<td>22.58</td>
<td>18.71</td>
<td>21.86</td>
</tr>
<tr>
<td>Treatment average</td>
<td>21.73</td>
<td>20.29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Welfare is measured as the utility of consumption minus the dis-utility from production. Average welfare is calculated as the average between buyers’ and sellers’ welfare. In the Decentralized Market, the average of quantities produced and consumed within a treatment may not coincide due to random matching across countries.

Table 4 shows production and consumption decisions are relatively balanced. A noteworthy observation is the offer acceptance rates in the DM bargaining is lower in the HighBlue treatment relative to the Baseline treatment (0.743 compared to 0.670), indicating subjects may find it more difficult to find mutually acceptable trades in the DM when Blue inflation is high. This leads to a differences in aggregate welfare between the two treatments (21.73 in the Baseline treatment com-
pared to 20.29 in the HighBlue treatment). However, we do not find significant welfare differences across treatments.\textsuperscript{16} We summarize these observations with Result 3.

\textbf{Result 3} Average welfare in the HighBlue treatment is lower than in the Baseline treatment, but the difference is not significant.

\section{Conclusion}

In this paper, we designed a human subject experiment to study how monetary policy through changes in money growth affects the emergence of international currency regimes, prices, acceptance rates, and welfare. The experiments are based on a two-country, two-currency search model where buyers and sellers jointly make currency portfolio and acceptance decisions. The theory generates multiple equilibria based on sellers’ acceptance currency acceptance decisions where zero, one, or two international currencies can circulate. To evaluate the model’s testable predictions and resolve issues related to equilibrium selection, we implement the theoretical environment in the lab. We designed the experiments specifically to investigate how prices, acceptance rates, trade, and welfare change when relative money growth rates in the two countries vary. We considered the money growth rate as the primary treatment variable and compared results from the experiment with the outcomes predicted by the theory.

Our study opens several avenues for future work. First, the present study focuses on economies defined by different monetary policies for money growth and therefore different inflation rates. The underlying theoretical model however is much richer and has several other dimensions we plan on exploring in future work. Among these is the parameter capturing the degree of economic integration, i.e. how likely sellers in one country are to interact with buyers from another country. This dimension may be increasingly important as economies become more globalized. Second, we implemented a between-subject design in the present study where each subject was assigned to only one treatment and one country. It would be interesting to implement a within-subject design and explore how experience with high inflation affects prices, currency acceptance, and welfare when money growth goes back down. This particularly topical as countries around the world aim to curb inflation through more active monetary policies. Finally, this paper implemented experiments with human subjects, which necessarily imposes limits on the number of agents that could feasibly interact within each treatment and the time it takes to run the experiment. Complementing this work with agent-based simulations has the potential to shed new insight in conditions that may not be possible or feasible to run in the lab.\textsuperscript{17}

\textsuperscript{16}In a similar framework but with no money growth, Ding and Puzzello (2020) find offer acceptance rates between 0.533 and 0.712. These findings are within the same magnitudes as ours. In addition, Ding and Puzzello (2020) also do not find significant differences in welfare across their treatments that vary the extent of legal restrictions and cost of accepting foreign currency.

\textsuperscript{17}Jasmina Arifovic pioneered the agent-based simulation approach with her implementation of genetic algorithm to study macroeconomic questions in Arifovic (1994, 1995, 1996, 2001). In a companion project, we incorporated a genetic algorithm for the environment studied here but decided to leave out the results in order to focus on the experimental contribution. We also plan to further explore the behavior of exchange rates in our setting and compare
References


with Arifovic (1996).


Appendices

Appendix A: Equilibrium of Theoretical Model

Here we describe the stationary equilibrium of the two-country, two-currency model where aggregate real balances in each country are constant over time. This implies the rate of return of currency $i$ in each country is constant and will equal the inverse of the money growth rate, $\gamma_i^{-1} = \frac{\phi_i}{\sigma_i}$.

Centralized Market (CM) Value Functions

In the centralized market, a representative buyer of each country chooses consumption of the numéraire good $x$, labor $h$, and real balances to bring forward next period. Portfolios are expressed in real terms: let $z = (z_r, z_b) \in \mathbb{R}^2_+$ represent a Red buyer’s portfolio of assets, and let $\tilde{z} = (\bar{z}_r, \bar{z}_b) \equiv (\phi_r m_r, \phi_b m_b) \in \mathbb{R}^2_+$ denote a Blue buyer’s portfolio. Also let $W_r^B(z)$ and $V_i^B(z)$ ($W_b^B(\tilde{z})$ and $V_i^B(\tilde{z})$) denote value functions for buyers from Red (Blue) in the CM and DM, respectively.

In the beginning of the CM, a buyer from the Red country faces the following maximization problem:

$$W_r^B(z) = \max_{x, h, z'} \left\{ U(x) - h + V_r^B(z') \right\}$$

subject to:

$$x + \phi_r m_r' + \phi_b m_b' = h + z_r + z_b + T_r$$

$$T_r \equiv (\gamma_r - 1) \phi_r M_r.$$  \hspace{1cm} (2)

The portfolio taken into the DM is $z' = (z'_r, z'_b) = (\phi_r' m'_r, \phi_b' m'_b)$, while $T_r$ is the lump-sum transfer of domestic currency from the government (expressed in numéraire goods). Substituting $m'_c = \frac{z'_c}{\phi_c}$ for currency $c = \{r, b\}$ into the budget constraint and then eliminating $h$ yields

$$W_r^B(z) = U(x^*) - x^* + z_r + z_b + T_r + \max_{z' \in \mathbb{R}^2_+} \left\{ -\gamma_r z_r' - \gamma_b z_b' + V_r^B(z') \right\}.$$  \hspace{1cm} (4)

A Red buyer’s lifetime utility at the beginning of the CM is the sum of his net consumption in the CM, real balances in domestic and foreign currency, the lump-sum transfer from the local government, and the continuation value at the beginning of the DM minus the investment in real balances. The value function for a Blue buyer is similar. Notice that with quasi-linear preferences, the lump-sum transfer does not affect the buyer’s problem in the CM.

A few results from the CM value function are worth highlighting. First, $W_r^B(z)$ is linear in total wealth $\bar{z} = z_r + z_b$: $W_r^B(\bar{z}) = 1$. Second, there are no wealth effects since $z'$ is independent of $z$, which follows from the quasi-linearity of the utility function. So long as holding money is costly, i.e. $\gamma_c \geq \beta$, sellers have no strict incentive to carry real balances in the DM, and they will leave the CM with no asset holdings. Consequently, their CM value function can be written as $W_i^S(z) = U(x^*) - x^* + z_i + z_j + V_i^S(\mathbf{0})$, which is also linear in total wealth.

Provided the DM value functions are strictly concave, there will generally be a unique portfolio where all buyers in a country demand the same real balances. A caveat is when the two currencies are perfect substitutes; in that case, buyers can hold different portfolios but they will have the same total value.
Terms of Trade

Terms of trade in the DM are determined according to Kalai (1977)’s proportional bargaining rule. This pricing mechanism permits sellers to extract a constant fraction of the match surplus in order to recover some of their ex-ante investment. Under proportional bargaining, a buyer acquires output in exchange for payment to the seller and receives a constant share, $\frac{\theta}{1-\theta}$, of the seller’s surplus, where $\theta \in (0,1]$ measures the buyer’s bargaining power, and threat points are given by continuation values.

Given the model specification, terms of trade will depend on buyers’ portfolios and private sellers’ acceptance strategy. To apply the pricing mechanism, notice that the surplus of a buyer who gets $q_s$ for payment $d_s$ to a seller is $u(q_s) + \beta W_i^B(z - d_s) - \beta W_i^B(z) = u(q_s) - \beta d_s$, by the linearity of $W_i^B$. Similarly, the seller’s surplus is $\beta d_s - c(q_s)$.

Consider first a meeting between a Red buyer and a seller from $s$ who only accepts domestic currency. Under proportional bargaining, quantity traded and payment to the seller, $(q_s, d_s)$ solves

$$\max_{q_s, d_s} [u(q_s) - \beta d_s]$$

s.t. $u(q_s) - \beta d_s = \frac{\theta}{1-\theta} [\beta d_s - c(q_s)]$ \hspace{1cm} (6)

$$d_s \leq z_s.$$ \hspace{1cm} (7)

The bargaining problem maximizes the buyer’s surplus, subject to each party receiving a constant share of the match surplus, and a feasibility constraint (7) that says the buyer cannot transfer more real balances than he currently holds, which is just real balances in the seller’s domestic currency, $z_s$. Consequently, the bargaining problem must satisfy

$q_s \in \arg \max \theta[u(q_s) - c(q_s)]$

s.t. $d_s = (1-\theta)u(q_s) + \theta c(q_s) \leq z_s.$

The transfer of wealth from buyers to sellers is therefore given by $p(q_s) \equiv \theta c(q_s) + (1-\theta)u(q_s)$. As a result, output $q_s$ solves

$$p(q_s) = \min\{p(q^*), z_s\} \hspace{1cm} (8)$$

where

$$p(q_s) = \theta c(q_s) + (1-\theta)u(q_s). \hspace{1cm} (9)$$

The bargaining solution simply says that when $z_s \geq p(q^*)$, the buyer has enough wealth to finance purchase of the first-best $q^*$, and payment to the seller will be $p(q^*) = \theta c(q^*) + (1-\theta)u(q^*)$. When $z_s < p(q^*)$, the buyer just gives the seller his cash on hand, $z_s$, and gets in return $q_s < q^*$.

When instead the seller incurs the fixed cost to accept both currencies, terms of trade satisfy a similar problem as (5) – (6), but with the feasibility constraint $d_s^f \leq z_r + z_b$ since the buyer can now pay with both currencies. In what follows, the superscript $f$ is used to distinguish variables when sellers accept both domestic and foreign currencies. Consequently, output $q_s^f$ solves

$$p(q_s^f) = \min\{p(q^*), z_r + z_b\} \hspace{1cm} (10)$$

where

$$p(q_s^f) = \theta c(q_s^f) + (1-\theta)u(q_s^f). \hspace{1cm} (11)$$
Foreign Currency Acceptance Decision

Before matches are formed in the DM, private sellers can acquire at some cost the information, or technology, in order to accept payment in foreign currency. Since the decision to acquire information about a currency determines its acceptability in trade, this breaks the indeterminacy that results when multiple assets can be used as means of payment. Without this decision, the model would predict that the two currencies are perfect substitutes that circulate at the same rate of return.

Sellers’ strategies are given by \( \sigma_s \in [0, 1] \), where \( \sigma_s = 0 \) if a private seller from \( s = \{r, b\} \) rejects payment in foreign currency and \( \sigma_s = 1 \) if foreign currency is accepted. When \( \sigma_s \in (0, 1) \), both currencies are accepted in a fraction of trades.

Given the bargaining solution, a seller’s expected payoff if he rejects payment in foreign currency is

\[
\Pi_s \equiv (1 - \theta) \{ \lambda_{rs}[u(q_s) - c(q_s)] + \lambda_{bs}[u(q_s) - c(q_s)] \}
\]

where \( \lambda_{is} \) denotes the probability that a seller from \( s = \{r, b\} \) meets a buyer from \( i = \{r, b\} \), \( (1 - \theta) \) is the seller’s share in the trade surplus, and \( \tilde{q}_s \) is DM output in meetings with Blue buyers. Notice this expression omits the seller’s continuation value in the CM since the terms of trade do not depend on the seller’s portfolio as sellers do not carry real balances into the DM.

If a seller incurs the fixed cost to accept foreign money, his expected payoff is

\[
\Pi_f^s \equiv -\psi_s + (1 - \theta) \{ \lambda_{rs}[u(q_f^s) - c(q_f^s)] + \lambda_{bs}[u(q_f^s) - c(q_f^s)] \}
\]

A private seller’s expected gain from accepting both currencies is therefore

\[
\Delta_s \equiv \Pi_f^s - \Pi_s
\]

\[
= -\psi_s + (1 - \theta) \{ \lambda_{rs}[S(q_f^s) - S(q_r)] + \lambda_{bs}[S(q_f^s) - S(q_b)] \},
\]

where \( S(\cdot) \equiv u(\cdot) - c(\cdot) \) defines total surplus in DM trades.

Consequently, the seller will choose to invest if \( \Delta_s > 0 \) and not invest if \( \Delta_s < 0 \). When \( \Delta_s = 0 \), sellers are indifferent and invest with an arbitrary probability. Optimal strategies \( \sigma = (\sigma_r, \sigma_b) \) must therefore satisfy

\[
\sigma_s = \begin{cases} 
1 & \text{if } \Delta_s > 0, \\
0 & \text{if } \Delta_s < 0.
\end{cases} \quad (12)
\]

The focus is on Nash equilibria where all sellers in a country adopt optimal strategies. Since sellers will reject currencies they do not recognize and it is common knowledge whether the seller is informed, trade occurs under full information.

Decentralized Markets (DM) Value Function

Given the bargaining solution, the DM value functions simplify greatly. Since the terms of trade do not depend on sellers’ portfolios, the DM value function can be written solely in terms of the buyer’s problem.

Consider a representative buyer from country 1. Using the linearity of \( W_r^B(z) \) and the bargaining solution, the DM value function simplifies to:

\[
V_r^B(z) = \alpha a_r \theta [\sigma_r S(q_r^1) + (1 - \sigma_r) S(q_r)] + (1 - \alpha) a_b \theta [\sigma_b S(q_b^1) + (1 - \sigma_b) S(q_b)]
\]

(13)
\[ + \beta [z_r + z_b + W_r^B(0)] \]

The last terms result from the linearity of \( W_r^B(z) \) and is the value of proceeding to the next period’s CM with one’s portfolio intact. A Blue country buyer’s value function can be obtained by reversing the subscripts, replacing \( z \) with \( \tilde{z} \), and replacing \( q \) with \( \tilde{q} \).

Upon substituting the DM value function into the CM value function to yields the buyer’s optimal choice of real balances:

\[
\max_{z \in \mathbb{R}_+^2} \left\{ - (\gamma_r - \beta) z_r - (\gamma_b - \beta) z_b + \alpha a_r \left\{ \theta [\sigma_r S(q_r^b) + (1 - \sigma_r)] S(q_r) \right\} \right. \\
+ (1 - \alpha) a_b \left\{ \theta [\sigma_b S(q_b^r) + (1 - \sigma_b)] S(q_b) \right\} \right. \\
\]

The objective function simply says that a buyer chooses a portfolio to maximize his expected surplus in domestic and foreign meetings, net of the cost of holding currency. Since the objective is continuous and maximizes over a compact set, a solution to the buyer’s problem exists.

Given monetary policy described by \((\gamma_r, \gamma_b)\), a stationary monetary equilibrium is a list of quantities traded \(\{(q_s, q_s^r), (\tilde{q}_s, \tilde{q}_s^r)\}\), sellers’ strategies \(\sigma_s\), and real balances \(\{z \equiv (z_r, z_b), \tilde{z} \equiv (\tilde{z}_r, \tilde{z}_b)\} \forall s = \{r, b\}\) such that

1. \(\{(q_s, q_s^r), (\tilde{q}_s, \tilde{q}_s^r)\} \in \mathbb{R}_+^2 \times \mathbb{R}_+^2\) solves the bargaining problem;
2. \(\sigma_s \in [0, 1]\) solves sellers’ currency acceptance decision;
3. \(\{(z_r, z_b), (\tilde{z}_r, \tilde{z}_b)\} \in \mathbb{R}_+^2 \times \mathbb{R}_+^2\) solves buyers’ portfolio problem;
4. Money markets clear.

In a monetary equilibrium where both currencies are valued, \(z_r > 0\) and \(z_b > 0\), DM output solves

\[
\gamma_r - \beta = \alpha a_r [\sigma_r L(q_r^b) + (1 - \sigma_r) L(q_r)] + (1 - \alpha) a_b [\sigma_b L(q_b^r)] \quad (15) \\
\gamma_b - \beta = \alpha a_r [\sigma_r L(q_r^b)] + (1 - \alpha) a_b [\sigma_b L(q_b^r)] + (1 - \sigma_b) L(q_b) \quad (16)
\]

where

\[ L(\cdot) \equiv \frac{\theta [u'(\cdot) - c'(\cdot)]}{\theta c'(\cdot) + (1 - \theta) u'(\cdot)}. \]

Buyers wish to bring currencies into the DM since these objects facilitate trade across different meeting types, but doing so is costly as captured by the terms \(\gamma_r - \beta\) and \(\gamma_b - \beta\) on the left sides of (15) and (16). The function \(L(\cdot)\) is the liquidity premium and represents the marginal payoff an agent gets from his liquid wealth that can be used to acquire more output in the DM instead of carrying it over to the next CM. There are analogous equations for buyers in country 2: for \(\tilde{z}_r > 0\) and \(\tilde{z}_b > 0\), DM output must satisfy

\[
\gamma_r - \beta = (1 - \alpha) a_r [\sigma_r L(q_r^b)] + (1 - \sigma_r) L(q_r)] + \alpha a_b [\sigma_b L(q_b^r)], \quad (17) \\
\gamma_b - \beta = (1 - \alpha) a_r [\sigma_r L(q_r^b)] + \alpha a_b [\sigma_b L(q_b^r)] + (1 - \sigma_b) L(q_b). \quad (18)
\]

Intuitively, the equilibrium conditions equate the marginal benefit of liquidity to its cost. As a result, a currency demands a liquidity premium only if it is accepted in trade, as determined by \(\sigma_s\). When no sellers accept a currency, it will not be valued. Also notice that \(L(\cdot)\) is strictly decreasing in DM output over the relevant range: that is, \(L'(\cdot) < 0\) for \(q \in [0, q^*]\). In what follows, the focus is on equilibria where \(\gamma_b \geq \beta\), since there is no solution otherwise.
Notice when there are no asymmetries in meeting arrangements – i.e., when the economy is perfectly integrated ($\alpha = \frac{1}{2}$) and both countries and governments are of equal sizes ($N_r = N_b$) – then all buyers, irrespective of country origin, will hold the same portfolios.

Finally to close the model, market clearing implies that for each currency, aggregate supply must equal aggregate demand. As a result, all buyers from the same country hold the same portfolio when currencies are not perfect substitutes. Total demand for the red currency is $N_r m_r + N_b \hat{m}_r$ and total demand for the blue currency is $N_r m_b + N_b \hat{m}_b$. Market clearing then implies

\begin{align}
N_r m_r + N_b \hat{m}_r &= M_r, \\
N_r m_b + N_b \hat{m}_b &= M_b.
\end{align}

(19) \quad (20)
Appendix B: Additional Results

Table 5: Inflation OLS Estimates

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>HighBlue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>log(Red price)</td>
<td></td>
<td>log(Red price)</td>
</tr>
<tr>
<td>Round</td>
<td>0.119***</td>
<td>0.122***</td>
<td>0.082***</td>
<td>0.374***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.019)</td>
<td>(0.031)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Constant</td>
<td>−0.761***</td>
<td>−0.743***</td>
<td>−0.464***</td>
<td>−0.667***</td>
</tr>
<tr>
<td></td>
<td>(0.113)</td>
<td>(0.124)</td>
<td>(0.083)</td>
<td>(0.124)</td>
</tr>
<tr>
<td>Observations</td>
<td>2,240</td>
<td>2,240</td>
<td>2,340</td>
<td>2,340</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.389</td>
<td>0.353</td>
<td>0.149</td>
<td>0.743</td>
</tr>
</tbody>
</table>

(a) All data.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>HighBlue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>log(Red price)</td>
<td></td>
<td>log(Red price)</td>
</tr>
<tr>
<td>Round</td>
<td>0.099***</td>
<td>0.098***</td>
<td>0.046</td>
<td>0.343***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.017)</td>
<td>(0.033)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>Constant</td>
<td>−0.317***</td>
<td>−0.234**</td>
<td>0.060</td>
<td>−0.001</td>
</tr>
<tr>
<td></td>
<td>(0.136)</td>
<td>(0.106)</td>
<td>(0.322)</td>
<td>(0.136)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,140</td>
<td>1,140</td>
<td>1,180</td>
<td>1,180</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.497</td>
<td>0.387</td>
<td>0.093</td>
<td>0.786</td>
</tr>
</tbody>
</table>

(b) 2nd half of data.

Notes: Standard errors clustered at session level in parentheses. *p<0.1; **p<0.05; ***p<0.01.
Table 6: Probit regression estimates of foreign currency acceptance decisions.

<table>
<thead>
<tr>
<th></th>
<th>All data</th>
<th>2nd half of data</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Red acceptance</td>
<td>Blue acceptance</td>
<td>Red acceptance</td>
<td>Blue acceptance</td>
</tr>
<tr>
<td>Round</td>
<td>−0.001</td>
<td>−0.040**</td>
<td>0.002</td>
<td>−0.023</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.019)</td>
<td>(0.150)</td>
<td>(0.187)</td>
</tr>
<tr>
<td>HighBlue</td>
<td>0.168</td>
<td>−0.516***</td>
<td>0.280*</td>
<td>−0.608***</td>
</tr>
<tr>
<td></td>
<td>(0.208)</td>
<td>(0.103)</td>
<td>(0.150)</td>
<td>(0.187)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.271*</td>
<td>0.866***</td>
<td>0.130</td>
<td>0.676***</td>
</tr>
<tr>
<td></td>
<td>(0.147)</td>
<td>(0.164)</td>
<td>(0.187)</td>
<td>(0.247)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,145</td>
<td>1,145</td>
<td>1,145</td>
<td>1,145</td>
</tr>
<tr>
<td>Log Likelihood</td>
<td>−748.410</td>
<td>−715.636</td>
<td>−383.845</td>
<td>−377.261</td>
</tr>
</tbody>
</table>

Notes: The dependent variable is the foreign currency acceptance decision by sellers in each country. Standard errors clustered at session level in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Figure 7: Foreign currency acceptance for all the data.
Figure 8: Prices and Inflation for all data.

Notes: In Figure 8a, the solid red and blue lines represent the actual observed prices in the experimental sessions, while the opaque lines represent the theoretical values in the different regimes. In Figure 8b, the black solid line corresponds to the theoretical inflation rate of 0.05 in the Baseline treatment; the black dotted lines correspond to the theoretical inflation rates of 0.05 for Red (lower line) and 0.30 for Blue (upper line).
Experiment Instructions (Page 1 of 10)

Today's experiment will last about 2 hours and 25 minutes.

You will be paid a show-up fee of $5 together with any money you accumulate during this experiment. The amount of money you accumulate will depend partly on your actions, partly on the actions of other participants, and partly on chance. All earnings during the experiment will be recorded in points. At the end of the experiment, your total points earned are converted to dollars at the rate of 20 points = $1.00 US Dollar.

It is important that during the experiment you remain silent. If you have a question or need assistance of any kind, please raise your hand, but do not speak - and an experiment administrator will come to you, and you may then whisper your question.

In addition, please turn off your cell phones and put them away now. Please do not use or place on your desk any personal items, including pens, paper, phones, etc. Please do not look into anyone else's booth at any time.

Anybody who breaks these rules will be asked to leave.

Agenda:
- Instructions
- Quiz to ensure everyone understands the instructions
- Experiment
- Questionnaire
Groups (Page 2 of 10)

There are 20 participants in today's session.

At the beginning of the session, each participant is randomly assigned to a group: Red Group or Blue Group. Specifically, 10 participants are assigned to the Red Group and 10 participants are assigned to the Blue Group.

You will remain in your assigned group for the entire duration of the experiment.
Sequences of Rounds (Page 3 of 10)

The experiment consists of 5 sequences of rounds in which participants will make production and consumption decisions.

Each sequence will last for a random number of rounds as follows:

- At the end of each round, the computer rolls a eight-sided fair dice to determine whether the sequence will continue with a new round.
- If the number is “1”, “2”, ..., “7”, the sequence continues for at least one more round (87.5% chance).
- If the number is “8”, the sequence ends (12.5% chance).
- This means after each round, there is always a 87.5% chance the sequence continues to a new round and a 12.5% chance the sequence ends.

To test this procedure, click the 'Test' button below. You will need to test this procedure 5 times.

<table>
<thead>
<tr>
<th>Round</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dice Roll</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Remember that at the end of each round the computer rolls an eight-sided fair dice. The sequence ends when the computer rolls an 8.
Each round consists of two stages. In each stage, you may be a Buyer or a Seller such that if you are a buyer in stage 1, you will be a seller in stage 2, and vice versa.

A Buyer will decide how many units of a consumption good to consume given the earnings (in points). A Seller will decide how many units of a consumption good to produce given the costs (in points).

For example, consuming 20 units yields 53.67 points for the buyer, while producing 20 units costs 20 points to the seller. Notice that for the duration of the experiment, you are provided with a separate print-out that contains this graph as well as the detailed table of earnings and costs.

Points from consumption and production accumulate across rounds and sequences and are converted into cash at the exchange rate of 20 points = $1.
Trade between Buyers and Sellers is facilitated using two types of tokens: Red Tokens and Blue Tokens.

For example, when you are a Buyer in a stage, you can decide to use tokens to purchase the good from a Seller in order to get points from consumption; when you are a Seller in a stage, you can decide to produce the good in exchange for tokens which you then can use in the next stage where you will be a Buyer.

Notice that tokens, the consumption good, and points are all different objects. You can trade tokens in exchange for the consumption good, but you cannot consume tokens (which means that holding tokens does not yield points). Only consuming the good yields points.

To summarize:

- The consumption good is produced and consumed within each stage and cannot be saved for the future.
  - If you are a Buyer, you can consume the good to earn points.
  - If you are a Seller, you can produce the good, which costs points.
- You can trade using Red Tokens and Blue Tokens.
- Tokens can be transferred into future stages and rounds but not future sequences.
- Points from consumption and production of the good accumulate across rounds and sequences and are converted into cash at the exchange rate of 20 points = $1.
In Stage 1 each participant will be assigned to be either a **Buyer** or a **Seller**. The assignment occurs before the sequence begins and remains fixed for all Stage 1 decisions in the sequence.

### Buyers Decide
- The quantity of **Red Tokens** to spend (denoted $S_R$) to purchase a consumption good
- The quantity of **Blue Tokens** to spend (denoted $S_B$) to purchase a consumption good

### Sellers Decide
- The quantity of a consumption good to produce for **Red Tokens** (denoted $Q_R$)
- The quantity of a consumption good to produce for **Blue Tokens** (denoted $Q_B$)

After all participants make their decisions, the Stage 1 market prices are determined using the supply and demand of corresponding tokens:

\[ P_R = \frac{\text{Sum of Red Tokens Spent by all the Buyers}}{\text{Total Quantity of the Consumption Good Produced for Red Tokens by all the Sellers}} \]

\[ P_B = \frac{\text{Sum of Blue Tokens Spent by all the Buyers}}{\text{Total Quantity of the Consumption Good Produced for Blue Tokens by all the Sellers}} \]

*If either the numerator or denominator in the above are zero, then the associated price is zero and no trade takes place for those tokens.*

After Stage 1 prices are determined, the following will occur.

### If you are a Buyer
- You spend quantities of tokens you have chosen ($S_R$ and $S_B$)
- You receive the quantity of the good you afford at market prices ($S_R / P_R + S_B / P_B$)
- Your token balances are adjusted to reflect your expenditures
- Your point earnings are increased to reflect your consumption

### If you are a Seller
- You sell quantities of the good you have chosen ($Q_R$ and $Q_B$)
- You receive tokens from the sale at market prices ($Q_R \times P_R$ **Red Tokens** and $Q_B \times P_B$ **Blue Tokens**)
- Your token balances are adjusted to reflect your sales
- Your point earnings are reduced to reflect your production costs
Stage 2 Details (Page 7 of 10)

Buyers in Stage 1 become Sellers in Stage 2 and vice versa.

At the beginning of Stage 2, Sellers first must decide whether to accept both types of tokens. By default, a Seller from the **Red Group** always can accept **Red Tokens** at no cost, and a Seller from **Blue Group** always can accept **Blue Tokens** at no cost. However, **Red Sellers** can purchase the option to accept **Blue Tokens** for 2 points. Similarly, **Blue Sellers** can purchase the option to accept **Red Tokens** for 2 points.

After Sellers make their acceptance decision, all participants will be randomly split into buyer-seller pairs according to the following probabilities:

<table>
<thead>
<tr>
<th>Probability Paired with Red Seller</th>
<th>Probability Paired with Blue Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red Buyer</strong></td>
<td>50%</td>
</tr>
<tr>
<td>Blue Buyer</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Blue Buyer</strong></td>
<td>50%</td>
</tr>
</tbody>
</table>

For instance, the probability a **Red Buyer** is paired with a **Red Seller** is 50% and the probability a **Red Buyer** is paired with a **Blue Seller** is 50%. Similarly, the probability a **Blue Buyer** is paired with a **Red Seller** is 50% and the probability a **Blue Buyer** is paired with a **Blue Seller** is 50%.

We will refer to the participant you are matched with as your “partner” for that round. Notice that in Stage 2 of the next round, you may be paired with a different partner.
Stage 2 Details Continued (Page 8 of 10)

After all participants are paired, the computer will randomly pick one partner to be a proposer and one to be a responder. Specifically, there is a 50% chance the Buyer will be the proposer and a 50% chance the Seller will be the proposer. The proposer is informed of his/her own token holdings, the token holdings of the partner, the partner's group, and if the partner is a Seller, the type(s) of token accepted by the partner.

**Trade Proposal Consists Of**

- The quantity of the **consumption good** to be transferred to the **Buyer**
- The quantity of **Red Tokens and/or Blue Tokens**
  to be transferred to the **Seller**

After the proposal is submitted, the other participant will decide whether to accept or reject the proposal. Specifically,

**Responders Decision**

- Accept
  - The proposed exchange takes place. The Seller incurs a cost (in points) from producing the required quantity but receives the tokens (if any) that were offered in exchange. The Buyer receives a benefit (in points) from the consumption of the good, but gives up tokens offered in exchange.

- Reject
  - If the proposal is rejected, then no trade takes place. This means the token and point balances of both participants will remain unchanged.

**Next**
Tokens (Page 9 of 10)

At the beginning of round 1, all Stage-1 Buyers are given an initial endowment of tokens. Specifically, each Red Buyer receives 25 Red Tokens and 15 Blue Tokens and each Blue Buyer receives 15 Red Tokens and 25 Blue Tokens.

Thus, at the start of each sequence there are 200 Red Tokens and 200 Blue Tokens in total.

The total number of Red Tokens and Blue Tokens available will increase in each round over the course of a sequence according to a predetermined schedule. Specifically, the amount of Red Tokens increases by 5% each round while the amount of Blue Tokens increases by 30% each round. For example, the total number of tokens over the first 10 rounds is displayed below.

![Graph showing the increase in tokens over rounds]

The additional tokens are transferred equally among the buyers of the corresponding group. For example, at the beginning of round 2, an additional 2 Red Tokens are transferred to each Red Buyer, so that the total number of Red Tokens is 210.0. Similarly, at the beginning of round 2, an additional 12 Blue Tokens are transferred to each Blue Buyer so that the total number of Blue Tokens is 260.0. Notice that in rounds 2, 3, 4… Red Buyers do not receive transfers of Blue Tokens and Blue Buyers do not receive transfers of Red Tokens.

Notice that for the duration of the experiment, you are provided with a separate print-out that contains this graph as well as the detailed table of token transfers.

When a new sequence begins, the token holdings of all participants will reset.
Each participant will be randomly assigned to either Red Group or Blue Group for the duration of the experiment. The experiment is made up of 3 sequences. The number of rounds in a sequence is random and described in the instructions. Each round consists of 2 stages, and in each stage you will either be a Buyer or a Seller. If you are a Buyer in Stage 1 you will be a Seller in Stage 2 and vice-versa.

- In Stage 1, all participants will make consumption and production decisions together (prices will be determined by the supply and demand for the consumption good).
- In Stage 2, all participants are matched in partner pairs. One of two participants is randomly chosen to be the proposer and one the responder.
  - The proposer makes a trade proposal that consists of a consumption good quantity and a price in tokens.
  - The responder accepts or rejects the proposal.

A consumption good is produced and consumed within each stage.

- Buyers earn points by buying and consuming the consumption good.
- Sellers spend points by producing and selling the consumption good.
- The consumption good cannot be saved or transferred to future rounds.

Buyers and Sellers can trade the consumption good in exchange for Red Tokens and Blue Tokens.

- Holding tokens do not yield any points. Therefore, any token balances at the end of the session cannot be exchanged for points or converted to cash.
- Tokens can be transferred to future stages and rounds within a sequence, but not from one sequence to the next.

Points earned from consumption and production accumulate across rounds and sequences and are converted into cash at the end of the experiment at the exchange rate of 20 points = $1.
C.1. Additional printed materials

**Benefit of consuming and cost of producing the consumption good:**

![Graph showing the relationship between consumption units and earnings/cost of production](image)

The schedule below shows the earnings of buying and consuming units of the consumption good, and the cost of producing and selling them.

<table>
<thead>
<tr>
<th>Values for 0 to 25 units</th>
<th>Values for 26 to 50 units</th>
<th>Values for 51 to 75 units</th>
<th>Values for 76 to 100 units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Units of consumption</strong></td>
<td><strong>Earnings (points)</strong></td>
<td><strong>Cost (points)</strong></td>
<td><strong>Units of consumption</strong></td>
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<tr>
<td>0</td>
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<td>1</td>
<td>12</td>
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<td>90</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>25</td>
<td>60</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>
The schedule below shows the total number of tokens held among all 20 participants in each round.

The first column (rounds 1 to 10) corresponds to what is presented in the graph above.

The experiment may last longer than 1 block depending on the random number realization.

<table>
<thead>
<tr>
<th>Values for rounds 1 to 10</th>
<th>Values rounds for 11 to 20</th>
<th>Values for rounds 21 to 30</th>
<th>Values for rounds 31 to 40</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Round</strong></td>
<td><strong>Red Token total quantity</strong></td>
<td><strong>Blue Token total quantity</strong></td>
<td><strong>Red Token total quantity</strong></td>
</tr>
<tr>
<td>1</td>
<td>200.0</td>
<td>200.0</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>210.00</td>
<td>260.0</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>220.50</td>
<td>338.0</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>231.53</td>
<td>439.4</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>248.10</td>
<td>571.2</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>255.26</td>
<td>742.6</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>268.02</td>
<td>965.4</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>281.42</td>
<td>1,255.0</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>295.49</td>
<td>1,631.5</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>310.27</td>
<td>2,120.9</td>
<td>20</td>
</tr>
</tbody>
</table>