

# Global stores of value and the international role of the renminbi

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## Abstract

We explore the conditions under which a financial asset emerges as a global store of value and can co-exist with a pre-existing (incumbent) store of value. In our model the acceptability of an asset as a global store is driven by the issuing region's financial development, growth rate, degree of capital liberalization, and by strategic complementarities across investors vying to purchase and sell financial assets. Our model contributes to the debate on the internationalization of the renminbi, supporting the view that deep financial reforms should precede capital account liberalization to sustain the renminbi's international status over the medium term.

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*“... it is not nationalism which spreads the use of the dollar and the use of English; it is the ordinary search of the world for **short cuts** in getting things done...”*

Kindleberger (1967, p.10, emphasis added)

## **1. Introduction**

The global financial crisis of 2007-8, the euro area crisis of 2010-12, and the political disputes over the US debt ceiling in 2013, have renewed interest in the future of the international monetary system. Policymakers and academics alike have questioned the viability of the existing US dollar-based system. Some argue for wider use of the IMF's Special Drawing Rights (SDR) as a global store of value (Zhou, 2009), while others point to the inevitability of a multipolar system in which the US dollar shares its international currency status with other currencies, notably the renminbi (Eichengreen, 2011). Dissatisfaction with the status quo has also prompted China to formally embark on a policy to internationalize the renminbi, despite its transitional stage of financial development and before fully liberalizing the capital account (McCauley, 2011; Yu, 2014).

The literature on international currency status has typically emphasized the role of strategic externalities and economies of scale (Krugman, 1980; Matsuyama et al., 1993; Rey, 2001; Flandreau and Jobst, 2009). An agent's incentive to accept a currency depends on the extent to which future counterparties are likely to do the same. Currencies with sizable areas of circulation thus emerge as international currencies since opportunities to trade with a consenting counterparty are greatest. This, in turn, generates persistence and path dependency, since new transactions gravitate towards the largest countries. Viewed from this perspective, the international monetary system is likely to remain unipolar, with any shift away from the dollar to a new dominant international currency only taking place glacially (Frankel, 2011; Kenen, 2011).

Recent work by Eichengreen and Flandreau (2009, 2012) questions this narrative. They re-examine the thesis that the dollar dethroned sterling after World War II and conclude that international currency status was shared between the dollar and sterling as early as the inter-war years. Chițu et al. (2013) further suggest that financial development and market liquidity may have been more critical than size in propelling the international currency status of the dollar during this period. The implication is that

multipolar systems are quite plausible, and that policies aimed at sustainable financial deepening and integration could promote the international currency status of currencies other than the dollar.

In this paper, we provide some theoretical underpinnings for Eichengreen and Flandreau’s “new view” by analyzing: (a) the conditions under which a financial asset emerges as a global store of value; (b) the conditions under which it can co-exist with a pre-existing (incumbent) store of value; and (c) the role that policies geared towards financial development, capital account liberalization, and enhanced liquidity of funding markets play in that process. We then draw upon the insights of our model to evaluate the recent policy debate on the process of renminbi internationalization.

Our approach to modeling global stores of value lays emphasis on the role of information frictions. In our framework, it is difficult for investors to distinguish the underlying quality of collateral backing the financial asset (a bond). For the asset to emerge as a global store of value, it must be exchanged in “money-like” fashion without the need for costly information acquisition about collateral quality. We treat as endogenous the decision of investors to gather costly information about the asset, and show how this depends on a strategic complementarity – the payoff to an investor from choosing not to collect information is increasing in his beliefs over counterparties who behave likewise. Liquidity thus depends on *acceptability*, in the sense that investors regard the store of value as ‘safe’, and are prepared to trade it without monitoring.<sup>1</sup>

We show that the emergence of an internationally acceptable store of value is linearly related to information costs and fundamentals, i.e. the growth rate of the economy and the extent of financial development. The results are intuitive. Investors readily accept a store of value issued by a financially well-developed economy with a high growth rate. But other combinations of fundamentals can also support asset acceptability. For instance, assets may be accepted as stores of value when growth rates are low, provided financial development is well advanced and vice versa. Furthermore, as differences in opinion on the bond’s underlying characteristics diminish and as information costs de-

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<sup>1</sup>As noted by Kindleberger (1967) in the epigraph, transaction costs are central to the theory of international currency. While traditional models of international currency status typically relate transactions costs to market size, we link transactions costs to an intrinsic property of the asset, i.e. collateral quality. We thus follow Jevons (1875), Menger (1892), Alchian (1977), Banerjee and Maskin (1996) and, more recently, Lester et al. (2012) and Berentsen et al. (2014) in associating information and liquidity. Dang et al. (2010) and Yang (2013) also emphasize the role of “information insensitivity” as a key property underpinning the safety of debt instruments.

cline, asset acceptability is supported for a wider range of fundamentals.

We extend the basic model to a two-region setting in which one region (Blue) plays the role of incumbent, providing a global store of value with an underlying quality of collateral that is beyond doubt. The other region (Red) is characterized by faster growth, lower financial development, and capital controls. A multipolar world, in which the stores of value of both regions co-exist, now requires investors to accept both assets without monitoring. In addition to fundamentals and information costs, asset acceptability is also influenced by the degree of capital controls and measures that cushion price falls in the event of distress asset sales. We establish the combinations of these parameters that are consistent with the co-existence of stores of value in the world economy and demonstrate intuitive relationships between them.

In our model, the Blue region commands an “exorbitant privilege” (Obstfeld and Rogoff, 2005; Gourinchas and Rey, 2007; Gourinchas et al. 2010). It enjoys a negative foreign asset position and a lower cost of borrowing in return for providing liquidity to the rest of the world. This privilege erodes as the new store of value gains acceptance amongst investors. We identify the critical value of the shock to Blue fundamentals at which co-existence emerges. The effects on world interest rates are non-linear, and we show how policy actions by Red region can bring forward this transition.

Although stylized, our model setup has implications for the debate on the internationalization of the renminbi. Eichengreen (2014) identifies three pathways along which the process of renminbi internationalization might unfold. The first pathway involves building a robust and efficient domestic financial system before embarking on currency internationalization. The second pathway relies on a strategy of rapid capital liberalization to attain international currency status in the hope of eventually catalyzing domestic financial reform. And a third pathway follows an intermediate route – gradual financial reform and relaxation of capital controls, together with special offshore zones and a network of swap lines, to facilitate the international use of the renminbi.

Our results clarify some of the trade-offs involved in choosing these pathways. For instance, if capital controls are liberalized to some extent and if a rich network of swap lines is put in place, the degree of fundamental domestic financial reform necessary to facilitate international currency status is lower. Moreover, emphasizing one pathway over the others is likely to prove counterproductive. In particular, rapid capital liberalization without meaningful financial reform or the safeguard of swap lines is likely to result in

situations where international currency status is very fragile and vulnerable to small shocks. We conclude with a brief discussion of how a model such as ours can shed light on the role that offshore financial centres might play in speeding up the process of currency internationalization.

Our paper is related to, but distinct from, several recent contributions. We extend Caballero et al. (2008) to allow for endogenous asset safety by letting agents invest in costly information about underlying collateral quality. Like us, Gourinchas and Jeanne (2012) also use the Caballero et al. (2008) framework to study global safe assets. But they treat asset safety as exogenous and do not consider how the frontier between safe and unsafe assets is determined. Moreover, the large closed economy setting in their paper precludes an analysis of the coexistence of global safe assets and the role of macroeconomic fundamentals and information costs in promoting international currency status.

Our paper also shares common ground with Lester et al. (2012). In their extension of Lagos and Wright (2005), agents “recognize” the quality of an asset by investing in information and this, in turn, renders liquidity endogenous. While the Lester et al. (2012) treatment of recognizability is very similar to our notion of acceptability, the information acquisition process in the two models have a very different game-theoretic underpinning. Moreover, their primary focus is on monetary policy rather than on problems of co-existing global stores of value. And their search-theoretic apparatus precludes consideration of issues central to Eichengreen and Flandreau’s “new view”, such as capital liberalization and financial development.<sup>2</sup>

Finally, Zhang (2012) extends Lester et al. (2012) to a two-country setting in order to explore the issue of international currency status. As in our paper, strategic complementarities in information acquisition decisions also lead to multiple equilibria, including the possibility of co-existing international currencies. But her focus is on the role that inflation plays in disciplining countries seeking international status for their currencies. Zhang also considers the strategic interplay between monetary authorities in the two regions, a topic that is beyond the scope of our paper.

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<sup>2</sup>Other papers on international currencies in the search-theoretic tradition include Zhou (1997), Trejos and Wright (2001), Head and Shi (2003), and Li and Matsui (2009). Most recently, Rose and Spiegel (2012) use an international variant of Lester et al. (2012) to explore the link between the difficulties associated with opaque US assets and the US dollar during the financial crisis.

## 2. A model of acceptable stores of value

We begin by describing a large closed economy comprising overlapping generations of agents with access to a single savings vehicle. We develop the baseline model in three steps. First, we describe the trading environment for the store of value. Second, we portray the decision by agents to gather costly information about the asset. And third, we show how asset acceptability arises endogenously and relates to the key parameters of the model.

### 2.1. The trading environment

Time evolves in discrete steps,  $t = 0, 1, 2, \dots$ . The economy consists of  $N$  islands producing  $X_t$  of output in each period and growing at a constant rate  $g$ . A risk-neutral agent is born on every island, is economically active in each period  $t$ , and dies at the start of period  $t + 1$  to make way for the next generation. There is, additionally, one infinitely long-lived agents born at  $t = 0$ , that can be regarded as the “central bank” of the island economy.

Agents born in period  $t$  receive an endowment,  $(1 - \delta)X_t$ , at birth but can only consume these resources at the time of death. This discrepancy between income and expenditure creates a demand for savings instruments in the economy.

A bond – the sole financial asset and store of value in the economy – is backed by a pledged stream  $\{\kappa_t X_t\}_{t=0}^{\infty}$  of capitalizable output, where  $\kappa_t \in \{0, \delta\}$ . The parameter  $\delta$  can be thought of as a measure of the degree of financial development of the economy since it captures how well property rights over earnings are defined.

At  $t = 0$ , Nature determines  $\kappa_t = \delta$  for all periods. While the future path of realizations is not observable, the history  $h_t = \{\kappa_0, \kappa_1, \dots, \kappa_{t-1}\}$  is public information in each period  $t$ . Would-be buyers of the bond must therefore decide whether to acquire costly private information about the pledged collateral, or form expectations based on the publicly available information.

Trade is facilitated in period  $t$  by randomly matching each young buyer,  $j$ , seeking to purchase a bond, with an old seller,  $i$ , in possession of a bond. If the buyer does not acquire private information, then the expectation on the collateral is a martingale, i.e.,  $\mathbb{E}_{jt}[\kappa_{t'} | h_t] = \delta$  for all  $t' \geq t$ . Trade takes place and agent  $j$  consumes the dividend at the end of period  $t$ , and attempts to sell the bond at the start of period  $t + 1$  to a young agent

$k$ . If trade is successful, then capital gains are consumed just prior to the death of agent  $j$ , at the start of period  $t + 1$ .

If, on the other hand, agent  $j$  chooses to acquire costly private information, then with probability  $\gamma < 1/2$  the buyer is unable to verify the collateral and there is no trade. In this case, the old agent on island  $i$  must sell the bond to the central bank. If the seller had previously acquired private information, the sale is seamless. However, in the spirit of Amihud and Mendelson (1986), if the seller did not acquire private information, then this transaction entails real costs,  $C_t$ , to the seller's consumption. The central bank, in turn, certifies and reissues the bond to young agents born in period  $t + 2$  seeking stores of value. Figure 1 depicts the sequence of events in our model.

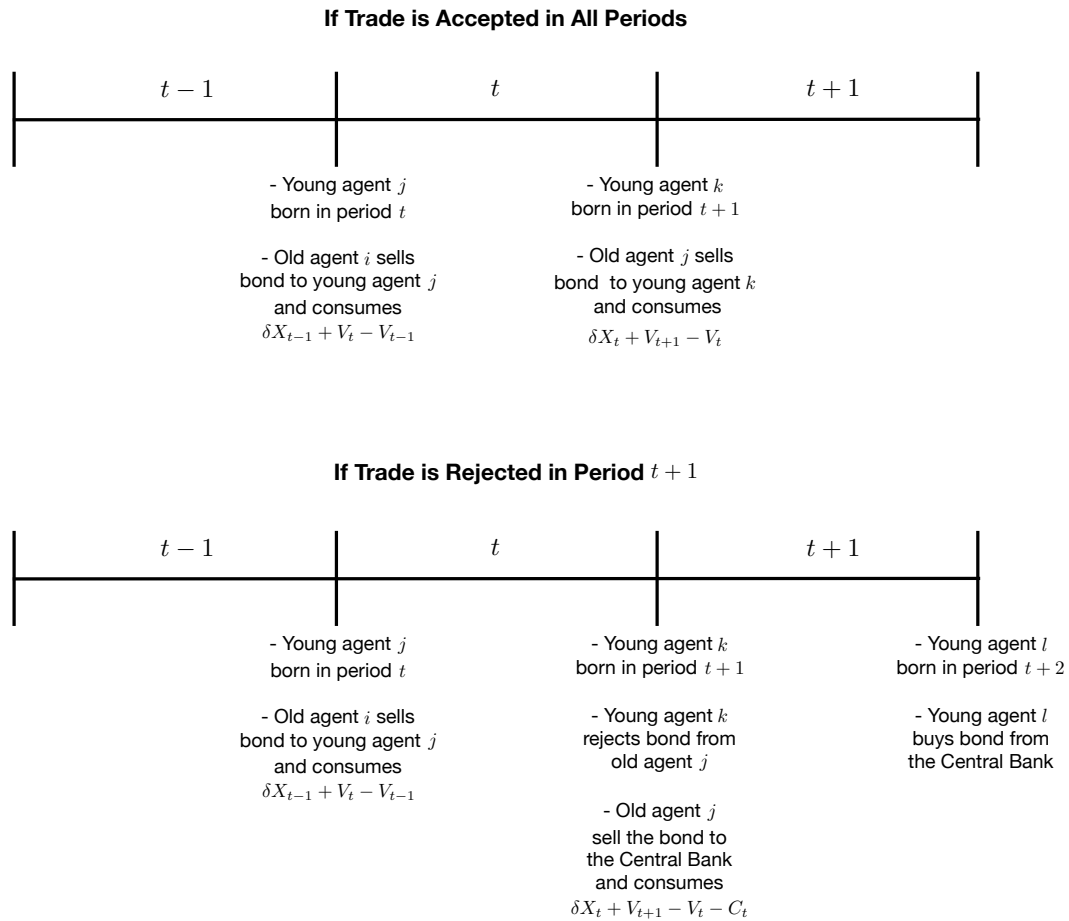


Figure 1: The sequence of events. The upper time-line depicts the events when trade between generations takes place, while the lower time-line shows how, if trade is rejected, the old agent sells the bond to the central bank, who then reissues the bond to an agent born in  $t + 2$ .

The fundamental value of the bond is given by the discounted sum of future dividends,

which at time  $t$  is

$$V_t = \sum_{j=0}^{\infty} \beta^j (\delta X_{t+j}) = \sum_{j=0}^{\infty} \frac{\delta X_{t+j}}{(1+r)^{j+1}} = \frac{\delta X_t}{r-g}, \quad (1)$$

where  $\beta = 1/(1+r)$  is the discount rate, and  $r$  is the real interest rate. We assume that  $g < r < 1$  so that the value of the bond is always positive. And, at the beginning of period  $t+1$ , the agent attempts to sell the bond to younger-generation agents for

$$V_{t+1} = \frac{\delta X_{t+1}}{1+r} + \frac{\delta X_{t+2}}{(1+r)^2} + \dots = \frac{\delta X_t(1+g)}{r-g} \quad (2)$$

resulting in a capital gain of  $(V_{t+1} - V_t)/V_t = g$ .

Agent  $j$ 's objective is to maximize expected end of life consumption,  $\mathbb{E}[c_{j,t+1}]$ , by choosing whether to gather private information about the bond,  $z_{j,t} \in \{0, 1\}$ , at date  $t$ , at a cost  $M_t$ . Section 2.2 characterizes the binary choice problem facing agent  $j$ .

For the bond to serve as a secure store of value in the economy, it should be “*readily acceptable*” to all agents – buyers of the bond should not have any incentive to acquire costly private information. At root, the acceptability of the bond hinges on an inter-generational strategic complementarity, i.e., the willingness of agents in period  $t$  to trade the bond on public information depends on the willingness of agents in period  $t+1$ , and so on.

Let  $\bar{\pi}_{t+1} \in [0, 1]$  be the fraction of period  $t+1$  agents who are willing to trade without acquiring private information. If all period  $t+1$  agents are willing, the market is liquid ( $\bar{\pi}_{t+1} = 1$ ) and capital gains are realized in their entirety. However, when there are doubts over collateral, period  $t+1$  agents will acquire private information and with probability  $\gamma$  reject the trade. The period  $t$  agent, thus, sells the bond at a fire-sale price to the central bank. Thus,

$$r_t = \frac{V_{t+1} - V_t}{V_t} - \frac{C_t \gamma [1 - \bar{\pi}_{t+1}]}{V_t} + \frac{\delta X_t}{V_t}, \quad (3)$$

where  $C_t = \phi V_t$  is the cost to the period  $t$  agent from a distress bond sale, where  $\phi \leq 1$ .

In the steady state (i.e.,  $\bar{\pi}_{t+1} = \bar{\pi}_t$ ), the market value of the bond must equal the aggregate wealth, so that  $V_t = W_t = X_t$ . Accordingly, the equilibrium interest rate is

$$r \equiv r(\bar{\pi}) = \delta + g - \gamma(1 - \bar{\pi})\phi, \quad (4)$$

which is increasing in agents' willingness to trade without acquiring private information. Conversely, when disagreement over collateral ( $\gamma$ ) is widespread and the fire-sale cost ( $\phi$ )



is large, the equilibrium interest rate must decrease in order to keep the value of the bond constant.

## 2.2. Information acquisition

We now consider the period  $t$  decision by agent  $j$  to gather private information about collateral. The decision is a discrete choice. Let  $z_{j,t} = 1$  be the decision by agent  $j$  to trade without acquiring private information, and let  $z_{j,t} = 0$  be the decision to acquire costly private information. The cost of information acquisition,  $M_t = \mu V_t$ , scales with the value of the bond, where  $\mu$  represents the marginal cost of information. Our formalization departs from the traditional approach to modelling international currencies, where transaction costs scales with the size of a country (e.g., Matsuyama et al. 1993) and, instead, links information costs to intrinsic properties of the bond.

In addition to being costly, identifying good collateral is inexact. Financial firms typically employ credit risk models and apply arbitrary rules of thumb when making credit decisions. Consequently, with posterior probability  $1 - \gamma$ , agent  $j$  correctly identifies that the bond is backed by collateral worth  $\delta$  of total output in all future periods. While, with posterior probability  $\gamma$ , agent  $j$  is unable to verify the collateral.

Figure 2 illustrates the decision tree facing agent  $j$ . If the agent decides to acquire private information, then  $z_{j,t} = 0$ . With probability  $\gamma$ , agent  $j$  is unable to verify the collateral and is better off rejecting the trade. Thus, agent  $j$  receives zero. With probability  $1 - \gamma$ , the agent correctly determines the fraction of capitalizable output to be  $\delta$  in all future periods and buys the bond to earn both dividend and capital gains, for a payoff

$$V_{t+1} - V_t + \delta X_t - M_t = V_t [r - \mu]. \quad (5)$$

In deriving this payoff we assume that by choosing to acquire private information, agent  $j$  is always able to sell the bond for  $V_{t+1}$  in the next period, either to another agent or the central bank without incurring any additional cost. To ensure that consumption is strictly positive we assume that  $\mu < \delta + g - \phi\gamma$ .

Should the agent decide, instead, not to gather costly private information, then  $z_{j,t} = 1$ . The payoff to agent  $j$  now depends on whether, upon resale, younger-generation trading partners also accept the bond at face value or opt to gather private information. Defining  $\bar{\pi}_{j,t+1}$  to be agent  $j$ 's expectation over the fraction of younger-generation agents

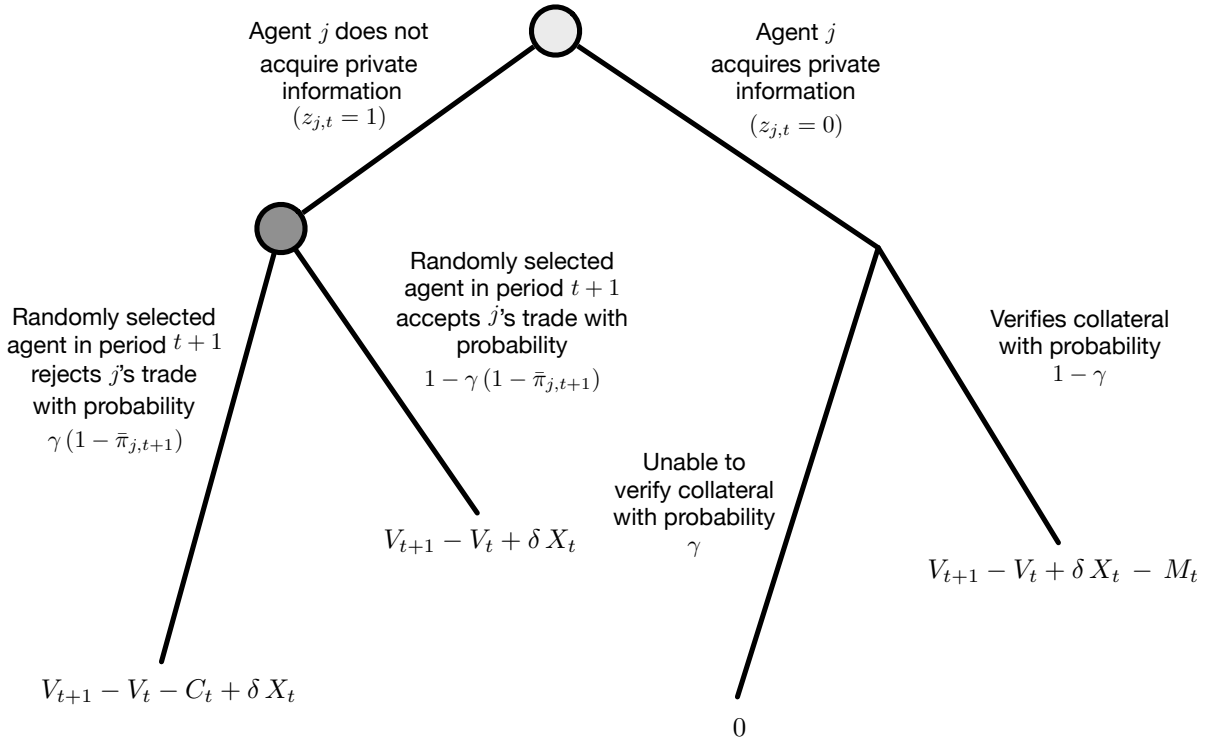


Figure 2: Agent  $j$ 's decision to monitor.

willing to trade without acquiring private information,

$$\bar{\pi}_{j,t+1} = \frac{1}{N-1} \sum_{l \neq j}^{N-1} \mathbb{E}[z_{l,t+1}], \quad (6)$$

the probability that a randomly selected younger-generation investor choose to acquire private information and rejects trade is  $\gamma(1 - \bar{\pi}_{j,t+1})$ . In this case, agent  $j$  must sell the bond to the market maker, incurring a cost  $C_t = \phi V_t$ . The payoff to agent  $j$  is

$$V_{t+1} - C_t + V_t + \delta X_t = V_t [r - \phi]. \quad (7)$$

This payoff assumes that agent  $j$ 's consumption is strictly positive, which implies that  $\phi < r$ .<sup>3</sup>

With probability  $\bar{\pi}_{j,t+1}$  the young agent accepts the bond, while with probability  $(1 - \gamma)(1 - \bar{\pi}_{j,t+1})$ , the young agent who acquires private information agrees that collateral is  $\delta$ . Summing the two, we obtain that trade occurs with probability  $1 - \gamma(1 - \bar{\pi}_{j,t+1})$ , and the payoff to  $j$

<sup>3</sup>A sufficient condition for this is to take  $\phi < (\delta + g)/(1 + \gamma)$ . Taken together with the condition for the payoff in equation (5), we obtain a tighter bound  $\mu < \gamma(\delta + g)/(1 + \gamma)$  for the cost of information.

is

$$V_{t+1} - V_t + \delta X_t = V_t r. \quad (8)$$

The expected payoff in period  $t$  to agent  $j$  from trading without acquiring private information is thus

$$V_t [r - \gamma(1 - \bar{\pi}_{j,t+1}) \phi], \quad (9)$$

while the expected payoff from acquiring private information is

$$V_t [(1 - \gamma)(r - \mu)]. \quad (10)$$

Note that the payoff to agent  $j$  from choosing  $z_{j,t} = 1$  is increasing in  $\bar{\pi}_{j,t+1}$ . Furthermore, by recursively writing out the payoffs for  $j$ 's future generation trading partners, their payoffs from choosing not to monitor will also be increasing in their beliefs over future generation agents who do not monitor. Strategic complementarity across counter parties is, therefore, inter-generational.

### 2.3. Asset acceptability

Comparing the payoffs between acquiring private information (equation 9) and not acquiring private information (equation 10), agent  $j$  selects  $z_{j,t} = 1$  whenever

$$r - \gamma(1 - \bar{\pi}_{j,t+1}) \phi > (1 - \gamma)(r - \mu), \quad (11)$$

which, upon rearranging, yields the optimal choice

$$z_{j,t}^* = \begin{cases} 1, & \text{if } \gamma \left[ \phi \left( \frac{1}{N-1} \sum_l z_{l,t+1}^* - 1 \right) + r \right] + (1 - \gamma)\mu \geq 0 \\ 0, & \text{otherwise} \end{cases}. \quad (12)$$

In deriving equation (12), we make use of the fact that the belief of agent  $j$  over the actions of the next generation must be consistent with the best responses of the next generation of agents. Equation (12) makes clear that the best response of agent  $j$  at time  $t$  depends on the best responses of the trading partners at time  $t + 1$ . These, in turn, will depend on the best responses of other agents in the future.

**Proposition 1.** *The Nash equilibria in pure strategies are given by the stationary values*

of  $\bar{\pi}$  that solve the fixed-point equation

$$\bar{\pi} = \sum_{\ell=0}^{N-1} \binom{N-1}{\ell} \bar{\pi}^{\ell} (1-\bar{\pi})^{N-1-\ell} \mathbf{1} \left\{ \gamma \left( \delta + g - \gamma(1-\bar{\pi})\phi - \left(1 - \frac{\ell}{N-1}\right)\phi \right) + (1-\gamma)\mu \right\}, \quad (13)$$

where  $\mathbf{1}\{\dots\}$  is the indicator function.

*Proof.* See the appendix. □

Figure 3 illustrates Proposition 1 by plot the solutions to equation (13) for different values of  $\gamma$ . For small  $\gamma$ , where private information acquisition precisely reveals that the collateral is  $\delta$ , there is a unique solution with  $\bar{\pi} = 1$ . All agents accept the bond without acquiring private information. As  $\gamma$  increases, two more solutions emerge – a stable one at  $\bar{\pi} = 0$  where all agents acquire private information and active trading of the bond is curtailed, and an unstable solution with  $\bar{\pi} < 1$ . The basin of attraction for the  $\bar{\pi} = 0$  solution grows with  $\gamma$ , while that for the  $\bar{\pi} = 1$  solution depletes.

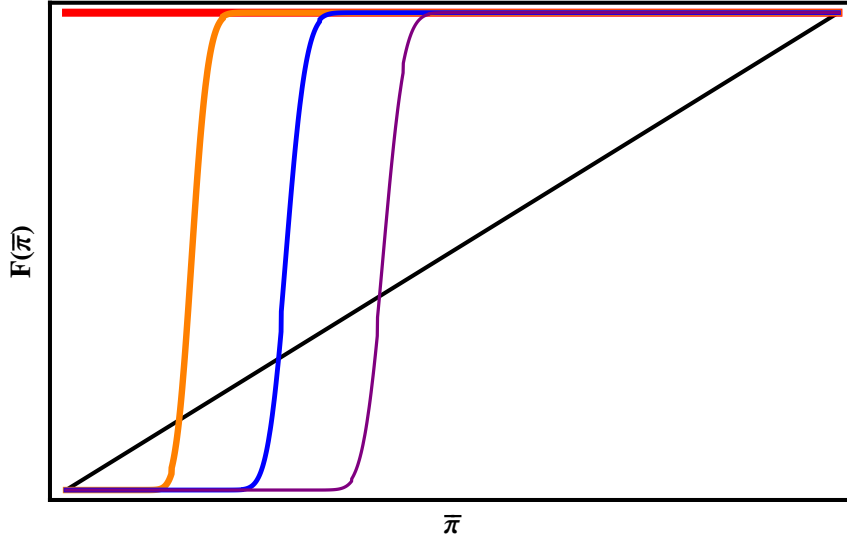


Figure 3: Solutions to the fixed-point equation (13) for different values of  $\gamma$  (reading counter-clockwise the different curves represent  $\gamma$  values 0.001, 0.03, 0.04 and 0.06). Additional exogenous parameters are set as  $\phi = 0.7$ ,  $\delta = 0.24$ ,  $g = 0.03$ ,  $\mu = 0.01$  and  $N = 500$ .

**Definition** The bond is “*readily acceptable*” whenever equation (13) has a unique Nash equilibrium,  $\bar{\pi} = 1$ , and all agents accept the bond without acquiring private information.

**Proposition 2.** *In the limit that the number of islands is large,  $N \gg 1$ , there is a unique Nash equilibrium in pure strategies where all agents trade without acquiring private information whenever*

$$\delta > -g - \left( \frac{1-\gamma}{\gamma} \right) \mu + (1+\gamma)\phi. \quad (14)$$

On the other hand, for lower values of  $\delta$  there are two Nash equilibria in pure strategies – (1) all agents trade without acquiring private information and (2) all agents decide to acquire private information active trading is curtailed.

*Proof.* See the appendix. □

Equation (14) provides a condition on the size of  $\delta$ , relative to the other model parameters, that is consistent with there being an unique Nash equilibrium in pure strategies where all agents trade without acquiring private information. For values of  $\delta$  on and below the locus,  $-g - (1 - \gamma)\mu/\gamma + (1 + \gamma)\phi$ , there are multiple equilibria. We thus interpret the bond as being readily acceptable whenever there is an unique Nash equilibrium where all agents trade without acquiring private information. Clearly, this equilibrium is stable to small perturbations. While, in the case of multiple equilibria, the path along which agents accept the bond without acquiring private information is no longer stable to perturbations.

Figure 4 illustrates the locus described in Proposition 2. It shows the degree of financial development,  $\delta$ , required to support a readily acceptable bond for any given growth rate,  $g$ . Intuitively, a store of value will be readily accepted in the case of a high-growth economy that is financially well developed (the upper right-hand quadrant). But other combinations are also feasible. Asset acceptability is also possible in low-growth – high-financial development cases, as well as situations where growth rates are high and financial development is low.

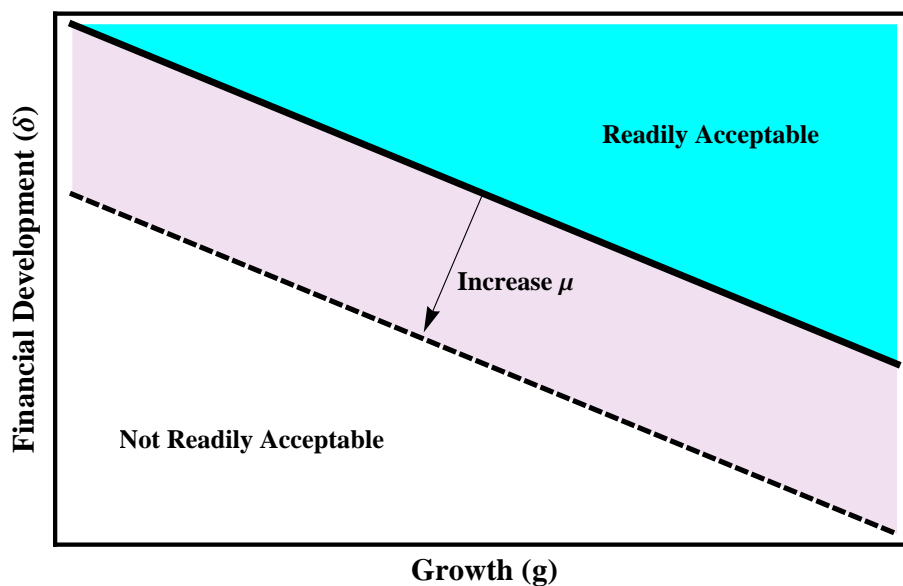


Figure 4: Combinations of  $g$  and  $\delta$  necessary to support bond acceptability.

The comparative statics for the locus are also clear from equation (14). The ratio  $(1 - \gamma)\mu/\gamma$  captures the opportunity cost of an additional unit of information relative to its noise. As Figure 4 shows, a rise in  $\mu$  (correspondingly, a decrease in  $\gamma$ ) makes the bond more acceptable, i.e., the locus shifts downwards.

A decrease in the fire-sale cost term,  $\phi$ , also has the effect of shifting the locus downward. This result is also intuitive – the more willing is the central bank to accept the bond at full price, the more acceptable a store of value is likely to be.

### 3. Acceptable stores of value in a two-region world

We now partition the economy into two distinct regions, Blue and Red. Let  $x^B = X_t^B / (X_t^B + X_t^R)$  be the share of the Blue region's output in the world economy and, correspondingly, let  $x^R = 1 - x^B$  be the share of Red output. We set initial conditions so that the Blue region is more financially developed, i.e.,  $\delta^B > \delta^R$ , while the Red region grows more quickly, i.e.,  $g^R > g^B$ . Moreover, we take  $g^R - g^B > \delta^B - \delta^R$ . Finally, without loss of generality, we assume the two regions are of equal size ( $x^R = x^B = 1/2$ ) in what follows.

#### 3.1. Trading environment

Each region issues its own bond and has its own long-lived central bank. The Blue bond is backed by a stream  $\{\kappa_t^B X_t^B\}$  of output from the Blue region, and the Red bond is backed by the stream  $\{\kappa_t^R X_t^R\}$ . At  $t = 0$  Nature draws  $\kappa_t^B = \delta^B$  and  $\kappa_t^R = \delta^R$  for all future periods. Critically, however, we suppose that the realization of  $\kappa_t^B$  is common knowledge – all potential buyers agree on the collateral backing the Blue bond. In contrast, for the Red bond, only the history  $h_t^R = \{\kappa_0^R, \kappa_1^R, \dots, \kappa_{t-1}^R\}$  is public information. Thus, buyers of Red bonds must decide whether to acquire costly private information or trade based on the public information only.<sup>4</sup>

As in Section 2, trade is facilitated in a market that matches potential buyers with sellers. We suppose, however, that a fraction  $\chi \in (0, x^R)$  of agents endowed with Red bonds are unable to trade. The parameter  $\chi$  thus reflects the extent of capital controls in the Red region. Since Blue bonds are readily acceptable, agents holding Blue bonds do not suffer any fire-sale losses. But the possibility that the market for Red bonds can turn

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<sup>4</sup>Our model thus corresponds to the current international economic situation, where the United States (Blue) is highly financial developed and occupies a role as provider of a global safe asset, while China (Red) is financial underdeveloped, growing rapidly and seeking a greater international role for the Renminbi. See Eichengreen (2011) for a detailed discussion.

illiquid means that Red bond-holders could face real costs  $C_t^R = \phi V_t^R$  if they are forced to sell their bonds to a central bank.

### 3.2. Interest rates and co-existing stores of value

The interest rates for Red and Blue bonds must equal the respective dividend price ratio plus the capital gains and minus, in the case of the Red bond, costs in the event of a forced sale. Thus

$$r_t^B = \frac{\delta^B X_t^B}{V_t^B} + \frac{V_{t+1}^B - V_t^B}{V_t^B}, \quad (15)$$

and

$$r_t^R = \frac{\delta^R X_t^R}{V_t^R} + \frac{V_{t+1}^R - V_t^R}{V_t^R} - \frac{\phi V_t^R \gamma (1 - \bar{\pi}_{t+1})}{V_t^R}. \quad (16)$$

Market clearing is given by the condition where aggregate wealth of all agents,  $W_t$ , is equal to aggregate output, which implies  $X_t = V_t$ . Consequently, the ratio  $X_t^B/V_t^B$  may be expressed as  $x^B X_t/(v^B V_t)$ , where  $v^B = V_t^B/V_t$  is the relative value of the Blue bond. If all potential buyers of Red bonds decide to check the collateral then, in the long-term limit, all Red bonds will be rejected and only Blue bonds will be demanded. Accordingly,  $v^B = x^B + (1 - \bar{\pi})(x^R - \chi)$ , where  $(1 - \bar{\pi})$  is the fraction of agents who decide to check the collateral underlying the Red bond. We thus obtain in the stationary state that

$$r^B = \delta^B \left( \frac{1}{1 + (1 - \bar{\pi})(1 - 2\chi)} \right) + g^B, \quad (17)$$

and

$$r^R = \delta^R \left( \frac{1}{1 - (1 - \bar{\pi})(1 - 2\chi)} \right) + g^R - \gamma (1 - \bar{\pi}) \phi \quad (18)$$

Equations (17) and (18) can be readily compared to equation (4), the closed economy expression for the equilibrium real interest rate. If  $\bar{\pi} = 1$ , and all agents readily accept the Red bond, then  $r^B = \delta^B + g^B$ . But, if  $\bar{\pi} = 0$ , then the demand for the Blue bond in the world economy increases, implying a lower interest rate for the Blue region, namely  $r^B = \delta^B/2(1 - \chi) + g^B$ . Likewise for the Red region, when  $\bar{\pi} = 1$ , there are no potential fire-sale losses and  $r^R = \delta^R + g^R$ . But when  $\bar{\pi} = 0$ , there are two effects on the Red interest rate: On the one hand, fire-sale losses lower the interest rate. At the same time, the relative demand for Red bonds drops to  $1/2\chi$ , where  $\chi$  is the fraction of Red bond holders barred from trading with others, placing an upward pressure on the interest rate. When  $\delta^R(1/2\chi - 1) > \gamma\phi$  the demand-side effect dominates, implying an increase in the Red region's interest rate.

Figure 5 characterizes the information acquisition problem confronting agents in the two-region economy. At time  $t$ , the young agent  $j$  is randomly matched with the old agent  $i$  to trade with. If the old agent is selling a Blue bond, then agent  $j$  will readily accept it without acquiring costly private information, since  $j$  knows that all agents in the future will also readily accept the Blue bond without acquiring costly private information. But if the old agents is selling a Red bond then, as before, agent  $j$  must decide whether to accept the bond without acquiring costly private information about collateral in the Red region.

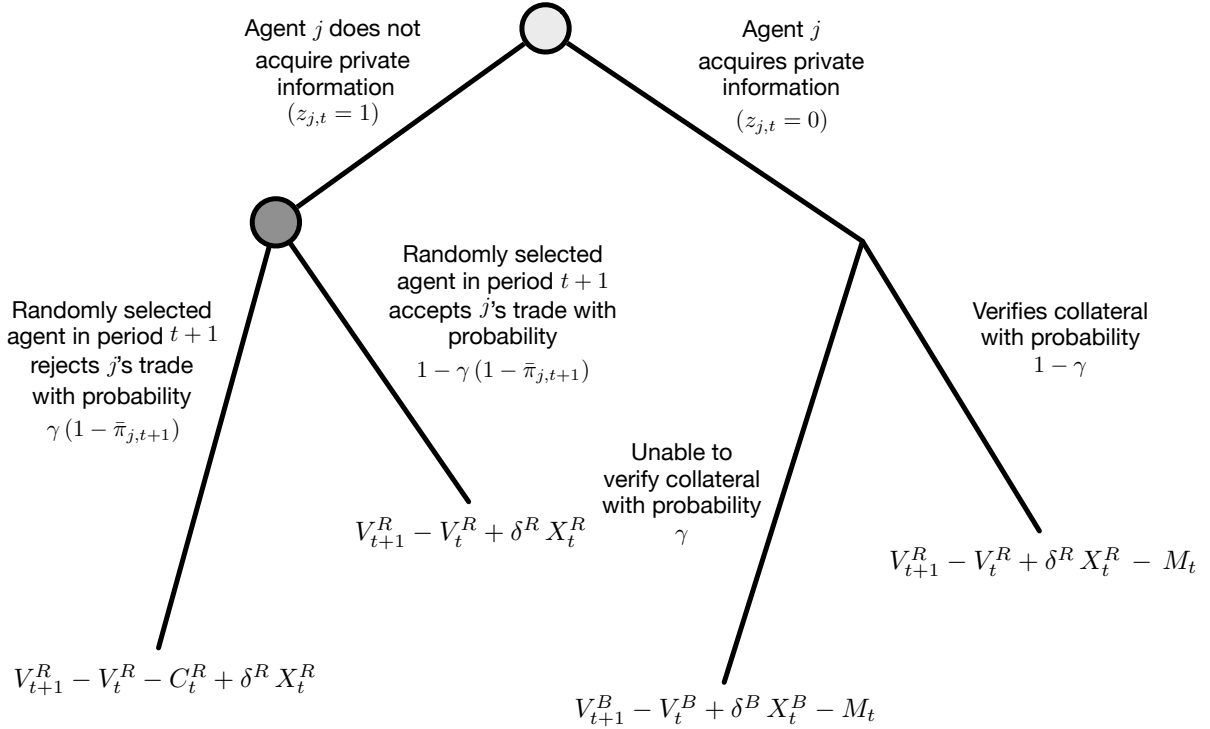


Figure 5: Game tree for investors in the two-region economy

If agent  $j$  decides to gather private information ( $z_{j,t} = 0$ ) then with probability  $1 - \gamma$ , the agent correct verifies that  $\kappa_t^R = \delta^R$  is all future periods purchases the bond. The payoff to  $j$  is

$$V_{t+1}^R - V_t^R + \delta^R X_t^R - M_t = V_t^R \left[ r^R - \frac{\mu}{v^R} \right], \quad (19)$$

where the cost of monitoring is  $M_t = \mu V_t = \mu V_t^R / v^R$ . But, with probability  $\gamma$ , agent  $j$  cannot verify the collateral backing the bond and rejects the trade. Agent  $j$  subsequently



purchases a Blue bond from the central bank. The payoff to agent  $j$  is<sup>5</sup>:

$$V_{t+1}^B - V_t^B + \delta^B X_t^B - M_t = V_t^R \left[ \frac{v^B}{v^R} r^B - \frac{\mu}{v^R} \right]. \quad (20)$$

If agent  $j$  opts not to gather costly private information and, instead, trades based on public information,  $h_t^R$ , the final payoff depends on whether a buyer in period  $t+1$  is willing to trade based on the public information only. If  $\bar{\pi}_{j,t+1}$  is the probability that a randomly selected young agent in period  $t+1$  is willing to trade based on the public information only, then the conditional probability that a young agent in period  $t+1$  rejects the trade is  $\gamma(1 - \bar{\pi}_{j,t+1})$ . In this event, agent  $j$  is forced into a distress sale of the Red bond and incurs a loss  $\phi V_t^R$  to his consumption. The payoff to  $j$  is

$$V_{t+1}^R - V_t^R - \phi V_t^R + \delta^R X_t^R = V_t^R [r^R - \phi].$$

While, with probability  $1 - \gamma(1 - \bar{\pi}_{j,t+1})$ , agent  $j$  is successful in selling the Red bond to a young agent in period  $t+1$  for a payoff:

$$V_{t+1}^R - V_t^R + \delta^R X_t^R = V_t^R r^R.$$

We now characterize the conditions under which the two stores of value co-exist in the world economy, i.e., when all agents are willing to accept both Blue and Red bonds without monitoring.

**Proposition 3.** *The minimum  $\delta^R$  consistent with the unique Nash equilibrium in pure strategies, where all agents readily accept both Blue and Red bonds without acquiring costly private information is given by the solution to the implicit function*

$$H(\delta^R, \chi, \phi, \mu) \equiv \gamma \left[ - (1 + \gamma) \phi + g^R - g^B \frac{(1 - \chi)}{\chi} + \frac{\delta^R - \delta^B}{2\chi} \right] + \frac{\mu}{\chi}. \quad (21)$$

*Proof.* See the appendix. □

In our model, the Red region's policy-maker has three potential instruments with which to promote the acceptability of the Red bond: (a) influence the pace of financial reform by varying  $\delta^R$ ; (b) control the extent to which the Red central bank is able to

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<sup>5</sup>The payoffs in equations (19) and (20) must be consistent with  $j$  having a strictly positive levels of consumption. This is satisfied whenever  $\mu < \chi r^R(\chi)$ .

cushion distress sales of the Red bond by varying  $\phi$ ; and (c) liberalize capital controls by lowering  $\chi$ . Figure 6 depicts the combinations of the instruments required to support the co-existence of both stores of value in the global economy. Below the plane only Blue bonds are readily acceptable. While, for combinations of  $\phi$ ,  $\chi$  and  $\delta^R$  on and above the plane, both Blue and Red bonds are readily acceptable and co-exist in the world economy. When capital controls are strict,  $\chi$  is large, and fire-sale losses are adverse,  $\phi$  is large, then a high level of financial development is needed for the Red bond to be readily acceptable. However, as capital accounts are liberalized, and fire-sale losses are mitigated by decreasing  $\phi$ , a lower level of financial development is needed for the Red bond to be readily acceptable. Corollary 1 formalizes these insights.

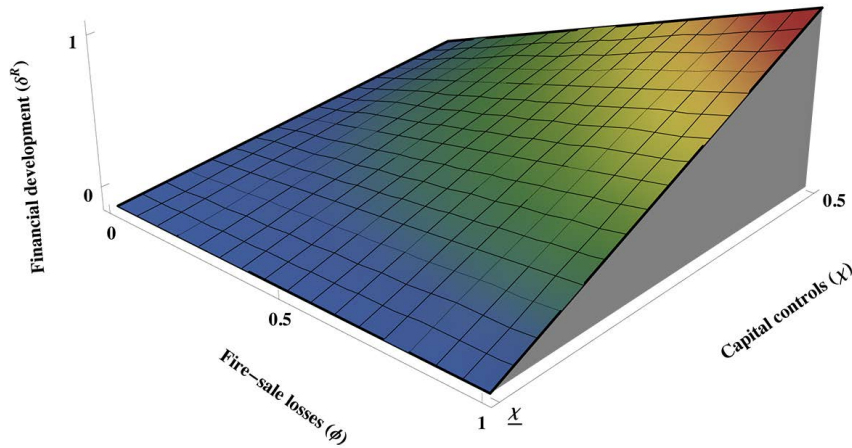


Figure 6: Combinations of  $\chi$ ,  $\phi$  and  $\delta^R$  necessary to support co-existing stores of value. Lighter colors indicate larger values of  $\delta^R$ , while darker colors imply smaller values of  $\delta^R$ . The parameter  $\chi$  is decreasing in the direction towards the bottom of the figure, while  $\phi$  is decreasing as one approaches the left-hand corner of the figure.

**Corollary 1.** *A marginal decrease in  $\phi$  lowers the minimum  $\delta^R$  necessary for both bonds to be readily acceptable. If the cost of information is high,  $\mu/\gamma > g^B + (\delta^B - \delta^R)/2$ , then a marginal decrease in  $\chi$  also lowers the minimum  $\delta^R$  required for both bonds to be readily acceptable. Finally, a marginal increase in  $\mu$  decrease the minimum  $\delta^R$  necessary for both bonds to co-exist as acceptable stores of value.*

*Proof.* See the appendix. □

### 3.3. Multipolar world and strategic complementarities

A multipolar world in which stores of value co-exist implies that small changes in fundamentals, or in the perception of these fundamentals, can have important implica-

tions for capital flows (see Gourinchas et al. 2011; Eichengreen, 2011). For example, a negative shock to the capacity of the Blue region to stand behind the Blue bond could trigger capital flight as some investors switch to the Red bond if it is perceived as readily acceptable.

Our model is able to shed light on how large the shock to fundamentals would need to be in order to propel the Red bond to a position of being readily acceptable to investors. If initial conditions are such that only Blue bonds are readily acceptable to investors, then the total demand for Blue bonds will be the sum of demands in both regions, excluding Red islands that are prohibited from asset trades, namely,

$$X_t \left[ \frac{1}{2} + \left( \frac{1}{2} - \chi \right) (1 - \delta^R) \right], \quad (22)$$

where  $X_t = X_t^B + X_t^R$ . This value, however, is greater than the Blue region's wealth,  $X_t/2$ . So the net foreign asset position of the Blue region – the difference between the wealth of islands in the Blue region and the total value of its assets – is strictly negative, i.e.,

$$\frac{X_t}{2} - X_t \left( \frac{1}{2} + \left( \frac{1}{2} - \chi \right) (1 - \delta^R) \right) < 0. \quad (23)$$

Moreover, when only Blue bonds are acceptable,  $\bar{\pi} = 0$ , the world interest rate<sup>6</sup> at which the Blue region can borrow is low,

$$r = \frac{1}{2} [g^B + \delta^B] + \frac{1}{2} [g^R + \delta^R] - \left[ \left( \frac{1}{2} - \chi \right) (g^R - g^B) + \chi \gamma \phi \right]. \quad (24)$$

Equations (23) and (24) make clear the advantage to the Blue region arising from its role as sole provider of international liquidity to the world economy. The relaxed external constraint implied by these equations is consistent with the ‘exorbitant’ privilege of the global safe asset issuing country highlighted by Obstfeld and Rogoff (2005), Gourinchas and Rey (2007) among others.

Now consider a permanent shock  $\Delta$  to the Blue region that adversely affects the Blue region's capacity to back stop the Blue bond i.e.,  $\kappa^B = \delta^B - \Delta$ , while the wealth of the Blue region remains proportional to  $1 - \delta^B$ . To the extent that only the Blue bond is readily acceptable to all investors, the effect of the shock is two-fold. First, the shock lowers the

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<sup>6</sup>See the Appendix for the derivation of the world interest rate.

value of Blue bonds. On the demand side, however, there is no change in the demand for Blue bonds, both within the Blue region and from the Red region. This implies that the net foreign asset position of the Blue region remains negative at the value given by equation (23).

These dynamics persist as long as the  $\Delta$ -shock is small. However, once the Blue region's capacity to back its bond reaches  $\kappa^B = \delta^B - \Delta^*$ , Red bonds become readily acceptable, where

$$\Delta^* = -\frac{2\mu}{\gamma} + 2\chi \left( (1+\gamma)\phi - g^R \right) + 2(1-\chi)g^B + \delta^B - \delta^R \quad (25)$$

The critical  $\Delta^*$  is influenced by all three of our policy variables –  $\delta^R$ ,  $\chi$  and  $\phi$ . As the Red region becomes more financially developed, a smaller shock to the Blue region is needed for the Red bond to become readily acceptable,  $\partial\Delta^*/\partial\delta^R < 0$ . Likewise, marginal decreases in the fire-sale losses,  $\phi$ , and capital controls,  $\chi$ , imply that smaller  $\Delta^*$  are required for the Red bond to become readily acceptable.

In this multipolar world, where both Blue and Red bonds are readily acceptable, the world interest rate increases to

$$r = x^B \left[ g^B + \delta^B \right] + x^R \left[ g^R + \delta^R \right]. \quad (26)$$

Since investors are indifferent between purchasing Blue and Red bonds, fraction of Blue bonds demanded falls from  $1 - \chi$  to  $1/2$ , while the fraction of Red bonds demanded increases from  $\chi$  to  $1/2$ . In this new equilibrium, the demands for the Blue and Red bonds are exactly matched by the supplies of the two regions, implying that both regions have balanced accounts, with their net foreign asset positions' being exactly zero.

#### 4. Discussion

Our stylized model contributes to the policy debate on the process of renminbi internationalization.<sup>7</sup> This process began in 2009 as a conscious policy move by the Chinese authorities (Yu, 2014). As noted by Eichengreen (2014), the policy has followed three main 'pathways'. The first emphasizes domestic financial development, notably the strengthening of contract enforcement, reform of the banking system, and the creation of deep and

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<sup>7</sup>The reader is referred to Cockerell and Shoory (2012), Hooley (2013), Eichengreen (2014), and Yu (2014) for detailed discussion of the reforms underpinning China's financial integration and the international use of the renminbi.

liquid securities markets. The second prioritizes capital account liberalization, allowing Chinese residents to diversify their portfolios towards foreign assets and foreigners to participate more actively in renminbi-denominated business activities. Finally, a third route charts a middle way. In this multi-pronged approach, domestic financial reform and capital liberalization takes place selectively, while offshore financial centres (e.g. Hong Kong) and special onshore financial zones (e.g. Shanghai) are deployed as experimental platforms, cultivating expertise and clientele for the renminbi. These are complemented by renminbi swap lines negotiated with central banks of other countries that encourage foreign banks and firms to take positions in the renminbi.<sup>8</sup>

The three policy parameters of our model,  $\delta^R$ ,  $\chi$ , and  $\phi$ , correspond to domestic financial reform, capital account liberalization, and the panoply of policies that promote pools of liquidity through swap lines and special financial centres. Figure 6 thus illustrates combinations of these policies that are compatible with an international currency – in the sense that the renminbi co-exists with the US dollar as a global store of value. It is important to note that the plane depicted in Figure 6 illustrates combinations of  $\delta^R$ ,  $\chi$  and  $\phi$  that are *just* compatible with currency internationalization. For renminbi internationalization to be robust to small shocks, the policy combinations must be sufficient to place the economy well above the plane. Thus, for example, rapid capital liberalization and extensive swap lines, absent domestic reform, are not sufficient to sustain an international currency – the economy would be located at the (relatively fragile) bottom-left-hand corner of the plane. Similarly, domestic reform, without complementary relaxation of capital restrictions and promotion of offshore markets, would be insufficient on its own to cement the status of an international currency.

These implications of our model, thus, temper the arguments of some commentators (e.g. Sheng, 2012) who favor renminbi internationalization through rapid capital liberalization in the hope that it will catalyze the (inevitably slow) process of domestic financial sector reform. Our model is more supportive of views of those such as Ju and Wei (2010) and Yu (2014) who counter that domestic financial reform is a critical pre-requisite if currency internationalization is to be sustained into the medium-term.<sup>9</sup> But emphasizing

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<sup>8</sup>McCauley (2011) describes this approach as “internationalization within capital controls.”

<sup>9</sup>Ju and Wei (2010) extend the model of Holmström and Tirole (1997) by allowing the returns on capital to be endogenously determined by a country’s characteristics. In doing so, they provide a micro-foundation for the trade-off between capital account liberalization and domestic financial reforms. Their results suggest that, although rapid capital account liberalization has an ambiguous welfare effect on emerging economies, these countries are better served by prioritizing financial sector reform and improved corpo-

the first ‘pathway’ of domestic financial reform at the expense of other pathways would mean that renminbi internationalization could take a very long time. It is therefore unsurprising that Chinese policymakers appear to be taking a holistic approach towards currency internationalization, simultaneously pursuing elements of all three pathways in an attempt to hasten progress.

While a rapid rise of the renminbi to international currency status is not impossible, Eichengreen (2014) suggests that it would require a confluence of circumstances, notably a shock that undermines confidence in the US dollar and rapid policy reform in China. In addition to this, our model suggests that take up of the renminbi will depend critically on the willingness of investors to experiment with a new store of value. If investors are too cautious about the actions of their counterparties and do not believe that others will readily accept the renminbi, internationalization will take a very long time. Conversely, if agents do not harbor such concerns, then take-up will likely be rapid. The ‘petri dish’ approach of creating special financial zones in which agents develop expertise with renminbi-based transactions can be viewed, in large part, as an attempt to accelerate such learning dynamics.

Figure 7 illustrates. The solid line depicts the analysis of Section 4, in which the Red bond becomes readily acceptable following an adverse shock to the capacity of the Blue region to backstop the Blue bond. The outcome is non-linear and, following the critical realization of the shock, the Red bonds tips from being not accepted to being readily accepted.

Critically, in our model, when overlapping generations of agents interact, the agent on island  $j$  is certain about the play of generations that are yet unborn – he uses the expected utility criterion to rank payoffs. In producing the dashed line in Figure 7 we relax this strong assumption and generalize our model to permit ambiguity about the future play of unborn agents.<sup>10</sup> Under these circumstances, it can take significantly longer for the Red bond to become readily accepted. Ambiguity about the actions of investors’ counterparties and the counterparties of those counterparties prompts a ‘flight to safety’ – and the Blue bond remains the safe asset of choice for much longer than might be warranted by its

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rate governance.

<sup>10</sup>The reader is referred to Anand and Gai (2012) for a formal model in which investors have multiplier preferences in the spirit of Hansen and Sargent (2007). In the model, investors allow for the possibility that their counter-parties use very different models to their own and attach a weight (which serves as an index of ambiguity) to the probability that their model is the true model.

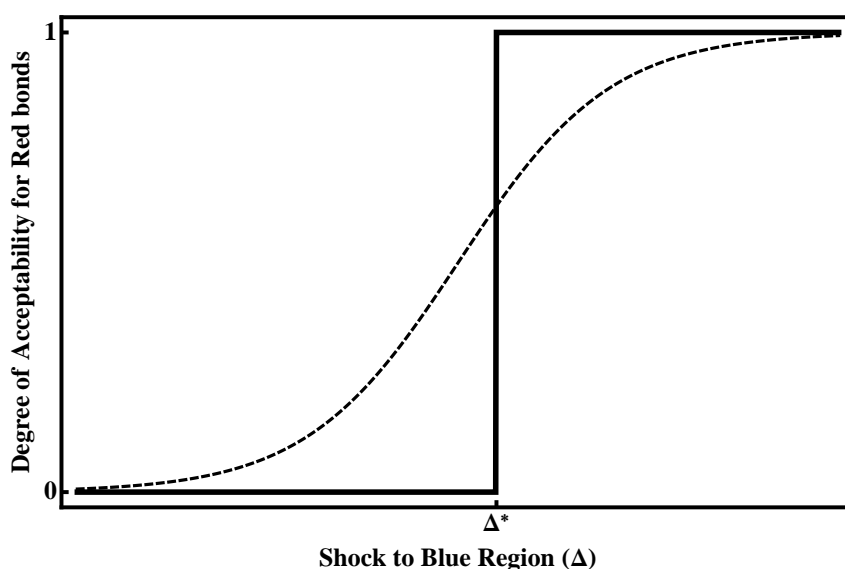


Figure 7: Demand for Red bonds as a function of the shock  $\Delta$  to the Blue Region. The solid line depicts the pure Nash equilibrium solution, while the dashed shows how when one permits ambiguity, as in Anand and Gai (2012), the tipping-point result is smoothed due to slow learning dynamics.

fundamentals.

## 5. Concluding remarks

Traditional models of international currencies emphasize economies of scale as a key driver in determining which currencies agents use. Transaction costs scale with a country’s size, suggesting that the future of the international monetary system will remain unipolar, with the US dollar reigning as the de-facto currency within international markets.

In re-examining the ascent of the dollar during the interwar years, Eichengreen and Flandreau (2009, 2012), and Chițu et al. (2013) question the traditional view. These authors argue that financial development and market liquidity may have been more important than size in propelling the dollar’s use. This “new view” suggests that a multipolar international monetary system is plausible. Moreover, policies aimed at sustainable financial deepening and integration could promote the international currency status of currencies other than the dollar.

In this paper we formalize some of the intuition behind this “new view”. In doing so we explore how a financial asset – bond – can emerge as a global store of value. This, in turn, depends on the issuing region’s growth rate and financial development. A fast-growing region needs a relatively low level of financial development for its asset to emerge as the global store of value. Conversely, a slow-growing country requires a high level of financial

development to achieve the same.

We extend this basic model to a two-region (Red and Blue) setting, where both regions issue bonds. Assuming that Blue bonds have already achieved an international status, we examine the prerequisites for both Red and Blue bonds to co-exist as global stores of value. Our findings inform the current debate on ways of enhancing the international role of the renminbi. They suggest that deep financial reforms should precede capital account liberalization if the internationalization of the renminbi is to be sustained over the medium-term.

A key assumption in our extended model is that the Blue bond is perfectly acceptable to all agents (there are no frictions between buyers and sellers). Consequently, we only focus on measures that would promote the Red bond's acceptability. An area for future work is to have the acceptability of both Blue and Red bonds being determined endogenously. This opens important questions on the role of cooperation and coordination of monetary and fiscal policies of the regions issuing bonds. Equilibria where each region unilaterally decides on its policies are likely to be sub-optimal with overly tight policies. Instead, if one allows for cooperation, better outcomes may be achievable.

Finally, our analytical results point to a testable hypothesis highlighting the role of financial development and macroeconomic growth as important determinants of the international acceptability of stores of value. Empirical analysis of the model along these lines would complement existing studies (e.g., Cecchetti et al. 2010), and is left for future research.



## 6. Appendix

### Proof of Proposition 1.

In the stationary state, where  $\bar{\pi} = \bar{\pi}_{j,t} = \bar{\pi}_{i,t+1}$ , by the law of large numbers,  $\bar{\pi}$  is the probability that a randomly selected agent will trade without monitoring. We now solve for  $\bar{\pi}$  by the following fixed-point argument. Let  $\ell$  be the number of trading partners who accept the bond without acquiring costly private information. Consequently, agent  $j$  will also accept the bond without acquiring private information whenever

$$\ell > \frac{N-1}{\phi} \left[ \phi - r - \frac{1-\gamma}{\gamma} \mu \right]. \quad (\text{A1})$$

What matters for agent  $j$  is the absolute number of trading partners who agree, rather than their individual identities. With  $N-1$  potential trading partners, the number of different combinations of  $\ell$  agents who agree is  $\binom{N-1}{\ell}$ . The probability that these  $\ell$  agents trade without acquiring private information is  $\bar{\pi}^\ell (1-\bar{\pi})^{N-1-\ell}$ . Summing over  $\ell$  and combining this with equation (A1), where  $r \equiv r(\bar{\pi}) = \delta + g - (1-\bar{\pi})\phi$ , we obtain the result in equation (13).  $\square$

### Proof of Proposition 2.

For  $N \gg 1$ , we can apply the de Moivre-Laplace Central Limit Theorem (Papoulis and Pillai, 2002) and approximate the Binomial distribution in equation (13) by a Normal distribution that is sharply peaked around its mean, i.e.,

$$\lim_{N \rightarrow \infty} \binom{N-1}{\ell} \bar{\pi}^\ell (1-\bar{\pi})^{N-1-\ell} = \frac{1}{2\pi N \bar{\pi} (1-\bar{\pi})} e^{-\frac{(\ell - N\bar{\pi})^2}{2N\bar{\pi}(1-\bar{\pi})}} = \mathbf{D}(\ell - N\bar{\pi}),$$

where  $\mathbf{D}(x)$  is the Dirac-delta function – a degenerate Normal distribution function that has value 1 for  $x = 0$ , and is zero everywhere else. Denoting  $s = \ell/N$ , the fixed-point equation simplifies to

$$\begin{aligned} \bar{\pi} &= \int_0^1 \mathbf{D}(s - \bar{\pi}) \mathbb{1}\{\gamma(\delta + g - \gamma(1-\bar{\pi})\phi - (1-s)\phi) + (1-\gamma)\mu\} ds \\ &= \mathbb{1}\{\gamma(\delta + g - (1+\gamma)\phi(1-\bar{\pi})\phi) + (1-\gamma)\mu\}. \end{aligned} \quad (\text{A2})$$

Clearly, equation (A2) has only two-possible fixed-points, i.e.,  $\bar{\pi} = 1$  and  $\bar{\pi} = 0$ . Let us first investigate the conditions for  $\bar{\pi} = 1$  to be a fixed-point. The argument of the indicator function simplifies to  $\gamma(\delta + g) + (1-\gamma)\mu$ , which is always positive. Hence,  $\bar{\pi} = 1$  is always a fixed-point.

On the other hand, for  $\bar{\pi} = 0$  to be a solution, we must have that  $\gamma(\delta + g - (1+\gamma)\phi) + (1-\gamma)\mu < 0$ . Consequently, whenever the inequality is reversed, we have the unique solution  $\bar{\pi} = 1$ . Solving for  $\delta$ , we obtain the condition in equation (14).  $\square$

### Proof of Proposition 3.

Comparing payoffs, we obtain that the expected payoffs to agent  $j$  from monitoring and not monitoring are

$$V_t^R \left[ r^R - \gamma \left( r^R - r^B \frac{v^B}{v^R} \right) - \frac{\mu}{v^R} \right], \quad (\text{A3})$$

and

$$V_t^R \left[ r^R - \gamma(1 - \bar{\pi}_{j,t+1})\phi \right] \quad (\text{A4})$$

respectively. The best response for agent  $j$  is thus

$$z_{j,t}^* = \begin{cases} 1, & \text{if } \gamma \left[ \phi \left( \frac{1}{N-1} \sum_l z_{l,t+1}^* - 1 \right) + r^R - r^B \frac{v^B}{v^R} \right] + \frac{\mu}{v^R} \geq 0 \\ 0, & \text{otherwise} \end{cases}, \quad (\text{A5})$$

where  $z_{l,t+1}^*$  are the best responses of agents born in period  $t+1$ .

Defining the number of future trading partners who accept by  $\ell$ , we have that it is a best response for  $j$  to accept the Red bond without monitoring whenever

$$\ell > \frac{N-1}{\phi} \left( \phi - \frac{\mu}{\gamma v^R} + r^B \frac{v^B}{v^R} - r^R \right). \quad (\text{A6})$$

Since it is only the absolute number of trading partners who accept that matters for agent  $j$ , following an identical line of reasoning to that used in Proposition 1, we obtain that the Nash equilibrium in pure strategies for the fraction of agents who accept the Red bond without monitoring,  $\bar{\pi}$ , is given by the fixed-point solution to

$$\bar{\pi} = \sum_{\ell=0}^{N-1} \binom{N-1}{\ell} \bar{\pi}^\ell (1-\bar{\pi})^{N-1-\ell} \mathbf{1} \left\{ \gamma \left[ r^R - r^B \frac{v^B}{v^R} - \phi \left( 1 - \frac{\ell}{N-1} \right) \right] + \mu \right\}. \quad (\text{A7})$$

Finally, in the limit  $N \gg 1$ , we can apply the de Moivre-Laplace Central Limit Theorem and approximate the Binomial distribution in equation (A7) by a Normal distribution that is sharply peaked around its mean, yielding a new fixed-point equation

$$\bar{\pi} = \mathbf{1} \left\{ \gamma \left[ r^R(\bar{\pi}) - r^B(\bar{\pi}) \frac{v^B(\bar{\pi})}{v^R(\bar{\pi})} - \phi(1-\bar{\pi}) \right] + \frac{\mu}{v^R(\bar{\pi})} \right\}. \quad (\text{A8})$$

When  $\bar{\pi} = 1$ , the argument of the indicator function is

$$\frac{\gamma}{2} \left[ g^R - g^B - (\delta^B - \delta^R) \right] + \mu > 0,$$

implying that  $\bar{\pi} = 1$  is always an equilibrium. For  $\bar{\pi} = 0$  to be a fixed point, we must have that the argument of the indicator function is negative, i.e.,

$$\underbrace{\gamma \left[ - (1 + \gamma) \phi + g^R + \frac{\delta^R}{2\chi} - \left( g^B + \frac{\delta^B}{2(1-\chi)} \right) \left( \frac{1-\chi}{\chi} \right) \right] + \frac{\mu}{\chi}}_{H(\delta^R, \chi, \phi, \mu)} < 0. \quad (\text{A9})$$

Therefore, the unique  $\bar{\pi} = 1$  solution is obtained whenever the inequality in equation (A9) is violated, which gives us the implicit function of equation (21).  $\square$

**Proof of Corollary 1.**

The partial derivative of the implicit function  $H(\delta^R, \chi, \phi, \mu)$  are as follows:

$$\frac{\partial H}{\partial \delta^R} = \frac{\gamma}{2\chi} > 0, \quad (\text{A10})$$

$$\frac{\partial H}{\partial \chi} = \frac{1}{\chi^2} \left[ \gamma \left( g^B - \frac{\delta^R - \delta^B}{2} \right) - \mu \right] < 0, \quad (\text{A11})$$

$$\frac{\partial H}{\partial \phi} = -\gamma(1 + \gamma) < 0, \quad (\text{A12})$$

$$\frac{\partial H}{\partial \mu} = \frac{1}{\chi} > 0. \quad (\text{A13})$$

The sign of the derivative with respect of  $\chi$  follows from the assumption that  $\mu/\gamma > g^B + (\delta^B - \delta^R)/2$ . Finally, by the implicit function theorem we get:

$$\frac{\partial \delta^R}{\partial \chi} = -\frac{\partial H / \partial \chi}{\partial H / \partial \delta^R} > 0, \quad (\text{A14})$$

$$\frac{\partial \delta^R}{\partial \phi} = -\frac{\partial H / \partial \phi}{\partial H / \partial \delta^R} > 0, \quad (\text{A15})$$

$$\frac{\partial \delta^R}{\partial \mu} = -\frac{\partial H / \partial \mu}{\partial H / \partial \delta^R} < 0. \quad (\text{A16})$$

□

**Derivation of the world interest rate.**

The values for the bonds issued by the Red and Blue regions are

$$r V_t^i = V_{t+1}^i - V_t^i - (1 - \bar{\pi}_{t+1}^i) C_t^i + \delta^i X_t^i, \quad (\text{A17})$$

where  $i \in \{R, B\}$ . Summing up across the two regions and using that the Blue bond is always readily acceptable,  $\bar{\pi}^B = 1$ , while for the Red bond  $\bar{\pi}^R = \bar{\pi}$  and  $C^R = \phi V_t^R$ , we obtain

$$r V_t = \left[ g^B + v^R (g^R - (1 - \bar{\pi}_{t+1})\phi - g^B) \right] V_t + \left[ \delta^B + \frac{1}{2} (\delta^R - \delta^B) \right] X_t,$$

where

$$V_t = V_t^R + V_t^B, \quad X_t = X_t^R + X_t^B, \quad (\text{A18})$$

and

$$v^R = \frac{V_t^R}{V_t}, \quad x^R = \frac{X_t^R}{X_t}. \quad (\text{A19})$$

In equilibrium, the outputs from the two regions must be equal to the wealth of all agents, which must be the same as the value of all bonds, i.e.,  $X_t = W_t = V_t$ , which yields

$$r = \frac{1}{2} (g^B + \delta^B) + \frac{1}{2} (g^R + \delta^R) - (1 - \bar{\pi}) \left[ \left( \frac{1}{2} - \chi \right) (g^R - g^B) + \chi \gamma \phi \right]. \quad (\text{A20})$$

□

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