# Jumpstarting an International Currency*

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April 2025

**Abstract**

While the USD dominates cross-border transactions today, a few other currencies are also used internationally. This paper shows that central bank policies that reduce the volatility of borrowing costs for foreign firms in domestic currency can trigger a jumpstart of the currency's international status, because firms' choices of the currency of their working capital complement their sales invoicing. Empirically, the creation of swap lines by the People's Bank of China between 2009 and 2018 supports this theoretical claim. Signing a swap line with a country is associated with an increase in the probability that the country would use the RMB at all by 12%, and a four-fold increase in the value of the country's RMB payments.

*Contact: s.bahaj@ucl.ac.uk and r.a.reis@lse.ac.uk. First draft: February 2020. We are grateful to multiple seminar and conference audiences for feedback, to Giancarlo Corsetti, Paul De Grawe, Martina Fazio, Lu Han, Kalina Manova, Dmitry Mukhin, Christoph Trebesch, and Adrien Verdelhan for useful comments, and to Sasha Abraham, Francisco Cocco, Jose Alberto Ferreira, Xitong Hui, Andrea Sisko, and Xiaotong Wu for research assistance. This project received funding from the European Union's Horizon 2020 research and innovation programme, INFL, under grant number No. GA: 682288. Bahaj thanks the Institute for Monetary and Economic Studies, Bank of Japan and the Hong Kong Institute for Monetary and Financial Research for their hospitality during part of this research. Data relating to SWIFT messaging flows is published with permission of S.W.I.F.T. SC SWIFT ©2020. All rights reserved. Because financial institutions have multiple means to exchange information about their financial transactions, SWIFT statistics on financial flows do not represent complete market or industry statistics. SWIFT disclaims all liability for any decisions based, in full or in part, on SWIFT statistics, and for their consequences. The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the Bank of Japan, the Hong Kong Monetary Authority or the Bank of England.

# 1 Introduction

An international currency is a monetary unit that is used significantly in cross-border transactions. The few currencies that qualify today are the euro, the yen, pound sterling, the Swiss franc, the yuan and, of course, the US dollar, which dominates invoicing, issuance of financial assets, sovereign reserves, and almost any measure of international use. A significant literature has modeled the complementarities that make one currency dominant and has studied the privileges afforded to a country from its currency dominating.[1] But before a currency can dominate, it has to become international. Fewer studies have investigated how a currency achieves that status, and almost none have asked which government policies assist (or hinder) that jumpstart. Why have the euro, yen, sterling, and franc survived in international use despite the dollar's dominance? Why did the yuan join this group in the last decade when the Brazilian real, or the Indian rupee, have not done so? Did the deliberate policies of the People's Bank of China (PBoC) a decade ago play a role, and if so, how large was it? This paper investigates these questions.

It makes two contributions. First, in section 2 and 3, it offers an empirical analysis of the PBoC's swap lines, signed over 2009-18, that provided RMB lending of last resort to foreigners. The PBoC's publicly stated objective for providing this RMB liquidity was to support RMB-denominated trade finance and settlement.[2] We describe their properties and characterize their rapid growth. We combine them with monthly SWIFT data on payments across borders, broken down by currency and usage, for the entire globe. These data have the advantage of covering many countries over a decade, so we can exploit the cross-country variation to estimate the consequences of signing the swap lines.

Our main finding is that there was significant growth in the use of the RMB after entering a swap agreement. Comparing 21 countries that signed a RMB swap line with those that did not, while controlling for a series of confounding factors, we find that a swap line is associated at the extensive margin with an increase in the probability that the country uses the RMB for international payments by approximately 14%. At the intensive margin, RMB use rises by between 220 and 450% across specifications. Most of the effect of the swap lines on using the RMB happens within 12 months of the signature of the agreement and persists long after. The effect is visible in RMB payments that do not involve China itself, and it is not explained by the rising economic integration with China,

[1] See Prasad (2015), Gopinath (2015), Eichengreen *et al.* (2017), Ilzetzki *et al.* (2020) among many others.

[2] See Zhou (2017) for an official PBoC statement on the aims of the swap facilities. It explicitly mentions currency internationalization and the stabilization of markets for trade finance.

including under the Belt and Road initiative. Finally, this policy has spillovers: when a country enters an agreement, its neighbors' use of the RMB increases by 10%, even if they do not have a swap line.

The paper's second contribution is a model in section 4 that explains why a currency becomes international (as opposed to dominant) and, most importantly, how a central bank's lender-of-last-resort policy directed at trade finance can influence that process. In the theoretical framework, import-export firms choose the currency in which to invoice their goods in their export markets *and* the currency of denomination of their trade finance for imported inputs. While the literature has focussed on the currency of the sales and of the assets of economic agents, we focus on the currency of firms' liabilities. This provides a link to the effect of central bank policies on borrowing costs for firms, matching the policies associated with the rise in RMB in the data.

In the model, firms face uncertainty over the interest rate on trade finance. By cutting the right tail of the distribution of borrowing costs, a swap line makes finance in that currency more attractive. Sticky prices then generate a complementarity between the currency of liabilities and the currency of invoicing. The model predicts the existence of a threshold on the distribution of borrowing costs that, when cleared, leads a currency to jumpstart into international use. According to the model, the RMB was close enough to this threshold in many countries before the swap lines were signed, justifying the extensive margin effects that we estimate.

This mechanism predicted by the model comes with further predictions that we look for in the data in section 5. First, we find that the signing of a swap line stabilizes offshore RMB borrowing costs, as postulated by the theory. Second, we show that the volatility in the offshore borrowing costs affects RMB use, by looking at the 2015-16 RMB crisis, when the PBoC's attempts to manage the RMB exchange rate by draining liquidity in the offshore market caused a sharp rise in the private cost of borrowing RMB outside of China. As our model predicts, this event lowers the use of the RMB by countries without a swap line, but not by those with a swap line, which insulated them from the fluctuations in the private cost of borrowing. Third, the swap lines are associated with an increase in trade finance in the SWIFT data, which was the focus of the theory. Moreover, the effect is heterogeneous in line with the theory's predictions: stronger in countries with a higher trade share with China, that import more intermediate goods, and whose export industries require more working capital. Fourth and finally, again in line with the model, the RMB has replaced existing vehicle currencies like the USD and the EUR in

denominating payments, as opposed to the local currencies.

We conclude in section 6 by noting the strong parallels between the rise of the RMB and the rise of the USD one century earlier, and speculating on the future role of the RMB.

**Related literature.** A large literature has studied international currencies, mostly focussing on the causes and consequences of USD dominance (Maggiori, 2017, Gourinchas *et al.*, 2019, Gopinath *et al.*, 2020). We contribute by analyzing the early stages of adoption, when a currency goes from zero to positive use, well before it becomes dominant.

Like us, several papers put trade at the centre of the mechanism that leads to dominance (Gopinath & Stein, 2021, Chahrour & Valchev, 2022, Mukhin, 2022). Currency choice in trade has several complementarities that incentivize using relatively few currencies. There are firm complementarities in matching the currency of costs and revenues (Engel, 2006, Gopinath *et al.*, 2010), demand complementarities for firms in the same market (Bacchetta & van Wincoop, 2005, Goldberg & Tille, 2008), and complementarities between the denomination of exports and imports (Chung, 2016, Mukhin, 2022). Empirically, the literature has used microdata on invoicing to confirm that complementarities in currency choice are present in invoicing decisions (Goldberg & Tille, 2016, Chen *et al.*, 2022, Corsetti *et al.*, 2022, Amiti *et al.*, 2022), including more recently for trade denominated in RMB (Chowdhry, 2024). Our focus is on the complementarities between invoicing and trade finance, and especially on how they create a role for central bank policies that stabilize the cost of finance in a currency and jumpstart its use.

In that regard, our work is closest to the models of currency choice in Corsetti & Pesenti (2002, 2015) where self-validating currency areas can emerge depending on the policy rule for the nominal rate. Similarly, Drenik *et al.* (2021) ask how a central bank's control of inflation influences the denomination of contracts. We study a different central bank policy, the lender of last resort function extended to trade finance abroad.[3]

Using firm-level data, Salomao & Varela (2022) characterize which Hungarian firms borrow in foreign currency. Their findings support the mechanisms guiding the choices of the firms in our model. Benguria & Novy (2024) use Argentinian data on firm invoicing to study our model's predictions on the impact of the RMB swap lines. Closest to our paper is Eichengreen *et al.* (2017), which asks whether central bank's policies can jumpstart the international use of a currency in the historical context of the Federal Reserve (Fed). For

[3]Bruno & Shin (2023) also emphasize the importance of the currency of firms' working capital. Their focus, however, is on how changes in the exchange rate transmit to costs of production. Drenik & Perez (2021) also introduce a working capital channel, but their focus is on the domestic, rather than cross-border, use of an international currency.

the internationalization of the USD, it is difficult to separate the effect of policy from other factors, including World War I or rapid US growth. We provide an analogy with the PBoC, and use its swap lines as a way to test for the effects of policy.

Returning to theoretical mechanisms, Gopinath & Stein (2021) study a different complementarity between finance and invoicing for firms. They focus on the problem of local banks, who lend domestically in foreign currency in order to match the deposits of domestic households in foreign currency. In our application, there is no significant volume of RMB deposits in almost all of the countries in our sample. Moreover, because the foreign currency deposit base gives an abundant supply of foreign currency funding to banks in the model of Gopinath & Stein (2021), an international lender of last resort is unnecessary.[4] Therefore, this model does not explain our empirical results. Consistent with our focus instead on trade finance and the availability of bank loans to firms in foreign currency, di Giovanni *et al.* (2021) shows that this funding is important, volatile, and exposed to shocks from the foreign economy. Empirically, Bahaj & Reis (2024) document the sources of volatility in RMB-denominated offshore borrowing, further raising the relevance of lender-of-last-resort policies while, theoretically, Cristoforoni & Errico (2024) extend our model to study asymmetric shocks across currencies.

The role of depositors in Gopinath & Stein (2021) ties with a related literature on how international currencies act as a store of value. A currency can dominate others as an asset if it offers a hedge against consumption risk (Hassan, 2013, Gourinchas *et al.*, 2022) or if it has special features in terms of its safety or convenience (Farhi & Maggiori, 2018, Jiang *et al.*, 2021). In the data, the USD also dominates the denomination of debt securities (Maggiori *et al.*, 2019, 2020).[5] Farhi & Maggiori (2019) propose a model where the denomination of payments intersects with the denomination of reserve assets, specifically in the context of competition between the US and China. The policy we study does not directly tie into the role of the RMB as a store of value. Swap lines alter the cost of borrowing

[4]Das *et al.* (2022) extend the model to include banking crises, which creates a role for a lender of last resort in foreign currency to fund bailouts. However, the lender of last resort is the local central bank, and the relevant policy trade-offs are with reserve accumulation and macroprudential policy, unlike the borrowing costs for trade finance that we emphasize.

[5]As shown in Maggiori *et al.* (2020), access to the international bond market is relatively rare among firms, and the policy we study focuses primarily on supporting the banking system. Several papers study determinants of the denomination of bond issuance, including hedging (Coeurdacier & Gourinchas, 2016), safety and convenience premia (Caramichael *et al.*, 2021, Jiang *et al.*, 2024), carry trades and speculation (Bruno & Shin, 2017, Huang *et al.*, 2024), and signalling (Eren *et al.*, 2024). More broadly, Eren & Malamud (2022) propose that the dominance of the USD arises from its role in denominating credit and study the resulting global impact of US monetary policy.

RMB rather than the returns on holding it. Several other Chinese policies are designed to internationalize the RMB as a store of value (Naef *et al.*, 2022), including the opening up of the stock market (He *et al.*, 2023), the bond market (Clayton *et al.*, 2023), and the establishment of an offshore banking system (Bahaj & Reis, 2024). Clayton *et al.* (2023) discuss this aspect of the internationalization strategy, rationalizing China's policies as trying to build credibility as an issuer while reducing the cost of capital flight.

There is a growing literature studying swap lines (Bahaj & Reis, 2022b, 2023), but it has focused almost entirely on the swap lines established by the Federal Reserve or the ECB. Their features and aims are different from the PBoC lines studied in this paper, since they: (i) have shorter maturities, (ii) involve only a handful of advanced economies as opposed to the diverse set of countries with RMB swap lines, (iii) were designed to address the dollar funding needs of foreign banks with substantial dollar-denominated assets, in contrast to the PBoC's focus on trade finance in the context of limited RMB cross-border banking, and (iv) were needed because of the USD's dominance, as opposed to the RMB swap lines that were deployed to start the internationalization of the RMB. While the RMB's swap lines are different, they are no less economically important: their notional limit of approximately RMB 3tr is comparable to the USD 600bn of peak drawings from the Fed's swap line. Horn *et al.* (2023) aggregate public sources and argue that around half the lines have been tapped and, in keeping with the lender of last resort function, drawings are associated with times of external distress.

# 2 Data on RMB payments and swap lines

This section describes our two sources of data: the PBoC and multiple central banks on their swap agreements, and the Society for Worldwide Interbank Financial Telecommunication (SWIFT) on cross-border payments by currency. Formal definitions and sources are in appendix B. After discussing how many lines were signed and when between 2009 and 2018, we build an aggregate series for cross-border RMB payments, and discuss the appropriate sample of countries to connect the two.

**The PBoC swap lines.** A RMB swap line is an agreement between the PBoC and a foreign central bank enabling the latter to borrow RMB in order to provide RMB-denominated credit in the foreign economy to local banks. The typical agreement sets out a renewable 3-year period during which the foreign central bank can choose to activate the line. Like other central bank lending programs, swap lines put a ceiling on interest rates, thereby reducing the interest rate risk faced by commercial banks (and by extension their cus-

tomers) in dealing in RMB.[6] Therefore, the lines provide insurance against excessively high borrowing costs; we will empirically confirm this effect for the RMB in Section 5.

Appendix A describes the operational aspects of the RMB swap lines and explains how they are an extension of the PBoC's lender of last resort function abroad to support the provision of RMB-denominated trade finance by foreign banks. It also discusses the usage of the facilities. On the one hand, there is no systematic usage data, but there is scattered evidence that it is positive. On the other hand, even if a line is unused most of the time, its presence still caps interest rate risk for firms reliant upon RMB trade finance.

We collect data on each swap line agreement signed or renewed by the PBoC starting from 2009.[7] We compiled this information from the PBoC's news releases, validated against the counterparty's communications. By 2018, 38 countries had signed an agreement. The variable $\text{SwapLine}_{i,t}$ takes a value of one if country $i$ first signed a PBoC swap agreement at or before month $t$. Because swap line agreements sometimes lapse and are usually renewed right away or within a few months, we keep the indicator at 1 if the agreement lapses, since the potential for renewal would maintain its insurance aspect. Hence, $\text{SwapLine}_{i,t}$ is a binary absorbing treatment variable with staggered adoption.

Figure 1a shows the evolution of the number of outstanding swap lines and the sum of their notional limits. The trend is upward-sloping. Most of the growth happened in the decade's first half, with a slowdown after 2016. Since 2018, only Saudi Arabia, Macau, and Laos signed new agreements, but many swap lines were renewed and the amount outstanding increased.

Figure 1b shows a map of outstanding lines. Large financial centres have large swap lines, as expected since their financial systems supply credit in RMB to firms around the world. Some countries with significant trade or investment relations with China also have a line. For the other swap lines, there is no obvious pattern driven by economic fundamentals. This likely reflects that the lines were partly a political endeavor. It also means that the timing in which the agreements were signed is not clearly linked to fundamentals.

**SWIFT data on RMB payments.** SWIFT provides a network for banks to send and receive secure and standardized messages about financial transactions. SWIFT does not settle payments, but its messages are mostly cross-border payment orders that are settled via correspondent accounts that banks hold with each other. These messages account for a

[6] See Bahaj & Reis (2022a) on this mechanism and evidence for its effectiveness.

[7] Subsequent work has expanded this data collection to cover all swap lines around the world (Bahaj *et al.*, 2024).

large share of cross-border transactions (see Rice *et al.*, 2020) across currencies, including RMB payments (see Appendix A.3).

Our data is the monthly value of messages (measured in USD) in a balanced panel between October of 2010 and October of 2018, excluding within-country messages, aggregating by country-pair (there is no information on the bank or client sending the message), and broken down by currency and message type. For most of what follows, we focus on payment orders: these are message types MT103 and MT202 in SWIFT, covering single customer and bank-to-bank payment message types, respectively. We also consider message types MT400, which are advices of payment, and MT700, which confirm the issuance of a letter of credit.[8] These messages arise directly from trade finance (the payments backing MT400 and MT700 are recorded separately as message types MT202 or MT103). However, not all international trade involves an MT400 or MT700, and not all trade finance is communicated via SWIFT. Hence, these message types have incomplete coverage and may not be representative.

Our main measure of interest is the value of RMB cross-border payments sent and received per month per country (or, equivalently, the messages related to trade finance). The aggregated series for the RMB share of payments computed from the microdata is displayed in figure 2. We show message types from payments in panel (a) and those from trade finance in panel (b). While our microdata stops in 2018, we add aggregate public data published by SWIFT on RMB payments to show more recent trends.[9]

The upward trend in the use of the RMB for payments since the PBoC started its internationalization strategy is visible. As with the number of swap lines, there is a leveling off in 2015-16 and a slight decline after, which we will discuss in detail in Section 5.2. The RMB recovered ground in 2018-22, and there was a further jump in use following the invasion of Ukraine that cannot be accounted for solely by Russia, which is too small in the global payment system.[10] In the final quarter of 2023, the RMB was the fourth most commonly used currency for payments, between the GBP and JPY, and the second most commonly used for trade finance at a similar level to the EUR. A decade prior, in 2013,

[8]Specifically, an MT400 is a message from a bank acting on behalf of an importer, confirming to a bank acting on behalf of an exporter that the importer has made payment. An MT700 is a message from a bank acting on behalf of an importer to a bank acting on behalf of the exporter that it will pay the exporter once required documents are supplied, typically upon receipt of proof of shipping.

[9]Our aggregate series differs from SWIFT's due to us consolidating jurisdictions – the Euro Area, the US and its outlying territories, the UK and the crown dependencies, and others.

[10]In subsequent work, Chupilkin *et al.* (2023) shows that the swap lines are associated with an amplification of the switch to the RMB among Russia's trading partners after 2022.

the RMB was the 12th most used currency for payments, just below the Thai Baht.

**A first look at the data.** Figure 3 plots the sample average RMB share of payments per country against the share of goods trade for each country with China. Three points stand out. First, there are outliers in the data. Some heavy users of RMB are large financial centres that process RMB payments, like Hong Kong or Singapore. Macau and Iran are also special cases: the former is a special administrative area of China, while the latter is under economic sanctions. Mongolia is another outlier as a neighboring country with strong links to China.

Second, the observations are above the 45-degree line: the RMB as a payment currency has punched below China's weight in international trade. By comparison, the USD has a weight of around 50% in global payments relative to a US trade share of around 15%. The USD is a dominant, as opposed to merely international, currency. The correlation in the figure is small, as some economies that are highly integrated in trade use the RMB little.

Third, for most country-month observations, the use of the RMB is zero.[11] Figure A2 in the appendix presents equivalent scatter plots for the start and end of the sample, in 2010 and 2018. A significant change between the two dates is countries starting to use the RMB in the first place, alongside an overall increase in the share of payments.

Let $\text{Rpayment}_{i,t}$ denote the value of RMB payments (MT103 and MT202) from country $i$ in month $t$. Reflecting the extensive margin, our initial variable of interest is an indicator that takes a value of 1 if, in a month, the country sends or receives an RMB payment, $1(\text{Rpayment}_{i,t} > 0)$. We then turn to the share of cross-border payments in RMB, $\text{Rshare}_{i,t}$, scaled so a unit change is equivalent to one percentage point, together with other measures to assess the intensive margin.

**Sample selection.** Developed economies have sophisticated financial sectors that generate domestic trade finance and are often hubs for international payments. This can lead to double counting transactions in SWIFT: a payment can appear as multiple messages if routed through several jurisdictions. A payment from Chile to China may pass through New York, London, and Singapore, so payment flows to and from financial centres can be misleading.

We deal with financial centres and the concern over the outliers highlighted by Figure 3 in a few ways. First, we consolidate Hong Kong and Macau into China. Second, we

[11] SWIFT reports a zero for a country pair if there were less than four payments across all currencies in that month. So, if a country makes many payments to China, but all are in dollars, we would accurately observe RMB payments as a precise zero. If the country only makes two payments to China, but all are in RMB, then the observation would be zero as well.

drop Iran from the sample given its sanctioned status, and we consider the robustness of our results to the inclusion of Mongolia's swap line. Third, in the baseline, we exclude the financially developed countries that are hubs and focus on developing countries (average below 30,000 PPP dollars of GDP per capita over the sample) and likely rely on foreign currency credit.[12]

Finally, we exclude four countries that had a swap line before the start of the sample, as well as countries with an average population of less than half a million, and countries with missing values for our control variables to keep a balanced panel. This leaves 11,058 observations on 114 countries, of which 21 are treated during the sample period. Table 1 shows the date each country signed an agreement with the PBoC, and appendix table A1 presents summary statistics for the variables used in our baseline specification.

# 3 The impact of swap lines on RMB payments

This section investigates whether signing a swap line is associated with an increase in RMB usage, along both the extensive and the intensive margins, and judges how robust this relation is to controlling for several covariates.

## 3.1 The evolution of RMB use

Panels (a) and (b) in Figure 4 plot the mean and median RMB share of cross-border payments for all countries that signed a swap agreement against the number of months before and after the line was introduced. Noticeably, the typical country that entered a swap agreement made little use of the RMB before the policy. Afterwards, the RMB was used persistently, at a rate that grew over time.

One year prior to signing the agreement, these countries used the RMB at similar rates to other countries. Mean usage increases just a few months before the announcement, but it turns out that Mongolia drives this as an outlier: excluding Mongolia, there is no pre-trend (see Figure A4 in the appendix). It is still possible that the signing of the swap line is anticipated, since the negotiations are not always secret, and some official announcements are made in the build-up to an agreement. Considering the role of these facilities as an insurance mechanism, it would not be surprising that behavior starts to change even before the agreement is finalized.

[12] We treat the euro area's countries at the start of the sample in 2010 as a single consolidated entity, which is dropped because its per capita income exceeds the threshold. Countries that joined the euro area after 2010 are separate, but we do not treat their adoption of the euro, and resulting access to the ECB's swap line, as equivalent to signing an agreement.

Panels (c) and (d) in the Figure show the average of $1(\text{Rpayment}_{i,t} > 0)$ and $\text{Rshare}_{i,t}$, respectively, before and after a swap line is signed for each country in our sample that has an agreement. For completeness, we also add the data points for the developed countries that we excluded from our baseline estimates. Almost all the data points are above the 45-degree line, indicating that the swap line is associated with a rise in RMB use, consistent with panels (a) and (b).

The bottom line from the Figure 4 is that the swap lines are associated with a jumpstart in the use of the RMB as an international currency for payments. The rest of this section investigates whether this effect is statistically significant, and whether it may driven by other observables. We discuss RMB trade finance in particular in Section 5.

## 3.2 Statistical specification

Our baseline specification is a panel linear probability regression:

$$1(\text{Rpayment}_{i,t} > 0) = \varsigma_i + \tau_t + \beta \times \text{SwapLine}_{i,t} + \gamma \times \text{Controls}_{i,t} + \text{error}_{i,t}, \qquad (1)$$

An estimate of $\beta > 0$ indicates that the swap lines have a positive association with RMB use at the extensive margin. This is a difference-in-differences model with a staggered, absorbing, binary treatment. Because a recent literature has noted that there might be a bias if the treatment effect is heterogeneous across time, we use the imputation methodology from Borusyak *et al.* (2024), clustering standard errors at the country level and averaging treatment effects by cohort.

There is a causal interpretation of $\beta$ if there is conditional independence: in the absence of the swap lines agreement and conditional on our control variables, the countries in our sample would have similar trends in the use of the RMB. This would be true if the countries were comparable and the swap lines were randomly assigned. Anecdotally, the agreements' timing were primarily the result of political forces in China and the counterparty rather than economic forces. However, RMB usage in a country could increase due to factors that also prompt the signature of a swap line with the PBoC. The obvious confound is rising economic, financial and political integration with China. We address this concern with a combination of controls, zooming in on payments less closely linked to economic activity with China, and looking for spillover effects on other countries. Still, to be clear, none of these are watertight identification strategies so our results should be read as documenting an association between the policy and RMB use.

**Covariates.** Our controls fall into three categories, reflecting different confounds. First, a swap line may be signed to facilitate trade with China and, in turn, more trade with China could encourage RMB use independently of the policy. To control for this, we include as covariates: the log of dollar exports and imports from the country to China, the ratio of Chinese imports and exports in the country's GDP, and a dummy for whether the country has a trade agreement with China. Note, however, that in the data there is no increase in trade with China following the introduction of a swap line (see appendix C.2).

Second, non-trade-related integration may lead to increased RMB payments thanks to policies distinct from, but correlated with, the swap lines. The RMB swap lines are sometimes part of a package of policies between China and other countries, and it may be these other policies that spurred the use of the RMB. To address this issue, we add four measures of Chinese economic policy towards county $i$ as another set of controls: whether the country has a RMB clearing bank,[13] whether it is a member of the Asian Infrastructure Investment Bank, the size of infrastructure investment flows from China as ratio of GDP (both the monthly flow and the cumulative flow since the start of the sample),[14] and the similarity of the country's voting patterns to China in the UN General Assembly, to proxy for the country's overall geopolitical alignment with China.

Third, region-specific trends in RMB usage may correlate with signing a swap line, perhaps because of political or economic developments in the region and its relations with China. We control for the proportion of the country's neighbors that use the RMB in a given month. A country's neighbors are defined as all countries within 1,000km of country $i$ if at least five are within that distance (if there are fewer than five countries, we include the nearest five countries to country $i$).[15] A related issue is that signing a swap agreement can spill over across borders. If an individual country signs an agreement and starts pricing trade in RMB, nearby countries that trade with it may also start using the currency. Such spillovers would reject the null hypothesis that the swap line has no effect, but they would violate the assumption of a stable unit treatment value. Appendix C.2 uses a spillover model to explore the association between a swap line and RMB use

[13] See appendix A.1 for discussion of the role played by clearing banks.

[14] Infrastructure investment forms a key pillar of China's global development strategy under the country's Belt and Road Initiative (BRI), and we dig deeper into the role played by the BRI in appendix C.1

[15] Formally, let $\mathcal{N}_i$ denote the set of country $i$'s neighbors. The control variable for neighbors RMB use is:

$$\text{Neighbor Use}_{i,t} = \frac{1}{|\mathcal{N}_i|} \sum_{j \in \mathcal{N}_i} 1(\text{Rpayment}_{j,t} > 0).$$

We measure distance capital to capital using great circle distance. Alternative measures and thresholds give similar results.

in neighboring countries.

### 3.3 Estimates

**The extensive margin.** Table 2 reports estimates for the extensive margin of RMB use. The first column has no covariates and shows that the swap line is associated with an 11% increase in the country's likelihood of using the RMB in a given month. The following three columns show that this finding is unaffected by incrementally adding our three sets of covariates. Column (5) confirms our coefficient of interest is similar if we use a two-way fixed effects estimator.[16]

Columns (6) and (7) split payments into those sent versus those received: for payments related to trade, the former would correspond to imports and the latter to exports. The relationship is stronger for payments sent than received, which will be consistent with our model, where the response of exports is a second-round effect. The coefficient on payments received is not distinguishable from zero in the table, but this is not true across alternative specifications, and when we consider only trade finance payments received, the coefficient is statistically significant (see appendix Table A4).

Figure 5a shows an event study plot for the specification in column (4), which has all the covariates. Most of the effect is in the vicinity of the signing of the swap line, with the coefficient stabilizing after 12 months. There is no reversion.

In line with our previous discussion of pre-trends, the event study plot suggests an effect just prior to the agreement. The formal pre-trend tests in Borusyak *et al.* (2024) reject the null of no pre-trend up to two months prior, but not for further lags. It is unlikely that an unobserved pre-treatment shock triggered both the RMB use and the signing of a swap line since it takes more than two months to negotiate an agreement. More likely, this reflects anticipation, as news about the agreement may be available before the announcement. Column (8) of Table 2 accounts for an anticipation period by shifting the treatment timing 6 months prior. This raises the coefficient estimate by 6 percentage points.

Finally, columns (9) and (10) consider the robustness of the results to sample selection. Column (9) excludes Mongolia as an outlier; this has minimal impact on our results at the extensive margin (the same is not true at the intensive margin, as we will discuss below).

[16]The number of countries that sign a swap agreement is small, so there is a large pure control group of never-treated countries. Hence, a two-way fixed effects estimator will still primarily deliver an estimate of $\beta$ based on comparisons between treated observations and the never-treated and down weight "forbidden" comparisons that motivate the literature on staggered adoption. As a result, the imputation and standard least squares estimates deliver similar results.

Column (10) relaxes the selection criteria on excluding developed economies, which has little impact on the coefficient estimate.

**The intensive margin.** Table 3 considers the association between the swap line and the intensive margin of RMB use. This requires taking a stance on Mongolia, because it is an outlier with a large and volatile RMB usage. To be conservative, we drop Mongolia for all the specifications presented here, while appendix Table A5 includes it leading to larger estimates, since Mongolian use of the RMB rose sharply after it signed a swap agreement.

Columns (1)-(2) of Table 3 replace the left-hand side of equation (1) with $\text{Rshare}_{i,t}$, showing estimates with or without controls. Signing a swap line agreement is associated with an increase in the share of the RMB in international payments of 0.13 percentage points. Figure 5b presents the equivalent of column (2) as an event study plot. In contrast to Figure 5a, when accounting for the intensive margin, there is no evidence of pre-trends in the months immediately prior to signing an agreement. Column (3) considers the average treatment effect at different time intervals. The effect compounds over time, rising to 0.3 percentage points between years 3 and 4, or approximately one-fifth of the overall rise in RMB payments between 2010 and the end of our sample.

To reinforce the point regarding a lack of pretrends, in columns (4)-(5) we employ the synthetic control approach of Arkhangelsky *et al.* (2021) that reweights observations to ensure the pre-agreement trends are the same in the treated and control countries. This synthetic difference-in-differences methodology is also robust to staggered adoption and is well-suited for settings with relatively few treated units (as in our case).[17] The coefficient estimates are robust to this alternative approach.

Even after dropping Mongolia, it is still the case that, across countries, the volatility of $\text{Rshare}_{i,t}$ is increasing in its level. Hence, the estimates in columns (1)-(5) are weighted towards the countries that use the RMB the most. In columns (6)-(9) we present results using $\ln(1 + \text{Rpayment}_{i,t})$ as the outcome variable. This is a common and simple way to transform data that can handle zeros, retains a log-like interpretation of the coefficients, is compatible with synthetic control methods, and is more robust to volatile outliers (the inclusion of Mongolia has a minimal impact in this specification, see Table A5).[18] Across the difference-in-differences estimators, the coefficients are positive and statistically sig-

[17] Applying synthetic control methods to a binary outcome variable is problematic, so we did not use this approach for the extensive margin regressions.

[18] This log-like transformation has been criticised by Chen & Roth (2023) as not being invariant to the scaling of the data so the size of the coefficients in columns (5)-(8) lack a meaningful interpretation. Note also that, given the log-like interpretation of the outcome variable, we control for country size by augmenting the control set with the logarithm of the country's GDP and its total cross-border payments, both in USD.

nificant. In columns (10)-(11), we instead use a Poisson model (Santos Silva & Tenreyro, 2006). Interpreting the point estimates from this specification, as in Chen & Roth (2023), suggests that countries that signed a swap agreement had RMB usage between 250%-440% higher than the control countries following the policy's introduction.[19]

**Additional results.** Appendix C presents additional empirical exercises. First, we show that rising economic or political integration between the country and China does not explain our results. Specifically, the swap lines' association with RMB payments: (i) is present for non-Chinese counterparties; (ii) is not explained by the membership of the Belt and Road Initiative; and (iii) does not extend to trade between the country and China.

Second, we consider the association between the swap line and RMB payments in neighboring countries. Distance is a key determinant of the size of trade flows. When a country's neighbor signs a swap line with the PBoC, the country is more likely to import more inputs invoiced in RMB from this neighbor, increasing the likelihood that the country jumpstarts its own use of the RMB. A neighboring country signing a swap line is also arguably orthogonal to local economic or political confounds that simultaneously drive RMB use. In appendix C.2 we confirm this effect on neighboring countries and offer an evaluation of potential spillovers.

# 4 A model of currency choices

This section proposes a model to explain the association we found between RMB use and the swap lines. The setting is a small open economy where firms choose their invoicing currency, as in Engel (2006) and the literature that followed. Novel, we consider import-export firms that also choose the currency of trade finance to study the complementarity between the two currency choices and how central-bank policy can influence the cost of borrowing.

## 4.1 The environment

There is a continuum of firms indexed by $j \in [0, 1]$. Each firm sells to a continuum of markets with zero mass, each with its own currency, indexed by $i \in [0, 1]$. The firm

[19]The Poisson model does not include countries where all values for RMB payments are zero, so the control group is restricted to countries that use the RMB at least once throughout the sample. Another caveat of this model is that, unlike in the trade literature, where country-pair data is used, our specification is aggregated at the country level. Therefore, there is still an incidental parameters problem when including country-level fixed effects, which could bias the estimates. Finally, the issues surrounding a staggered difference-in-differences design in Poisson regression models have still not been thoroughly studied.

also sells to the market of the issuer of the current dominant currency, denoted with the subscript $d$, and to the market of a rising international currency, subscript $r$. These two markets have positive mass in the sales of each firm, reflecting the size of their economies.

There are three periods, distinguishing between three stages of choices that each firm must make. In period 0, the firm chooses the currency in which it pays for imported inputs. These are purchased in advance, so they require working capital, and the firm chooses a matching currency for its trade finance. Imported inputs and trade finance are available in the two international currencies, $d$ or $r$. The interest rate that will later be charged for recurring finance in each currency is uncertain and can differ across firms, reflecting their reputation or (out-of-equilibrium) temptation to default.

In period 0, the firm also chooses the price in a specific currency at which it will sell its goods in each market. Prices are nominally sticky, so currency choice affects the volatility of firm sales. The firm can choose the currency of its price from: its own currency, the local currency of the market to which it is selling, the dominant currency $d$, or the rising international currency $r$.[20] The exchange rates and the level of demand in each market are uncertain.

In period 1, the firm produces using imported and local inputs. All uncertainty is resolved. The price of inputs, exchange rates, and borrowing costs are all exogenous, while the period-0 choices generate an endogenous joint distribution of future revenues and costs of production.

Finally, in period 2, each firm $j$ satisfies demand in each market $i$ given its sticky price. It collects revenues, pays off loans, and realizes its profits.

**Functional assumptions in production.** Firm $j$'s production technology in period 0 is:

$$x^j = \min\left\{\frac{x_r^j}{\eta^j}, \frac{x_d^j}{1-\eta^j}\right\}. \tag{2}$$

The firm can choose $\eta^j \in [0,1]$ to pin down the relative shares of the input $x^j$ denominated in currency $r$, $x_r^j$, and the share $x_d^j$ paid for in currency $d$.

[20] In the model, firms choose the currency of their borrowing and their invoicing, but in the data we only observed the currency of cross-border payments. In principle, the currency used for invoicing and settling payments could differ, and the currency of credit could not be the currency used for repayment. However, studies in this topic (e.g., Friberg & Wilander, 2008) find that, in 99% of the cases, the currency used to settle payments is the same as the currency of invoicing or the one denominating the debt.

The production function in period 1 uses input $x^j$ and other local inputs $l^j$:

$$y^j = (x^j)^\alpha (l^j)^{1-\alpha}. \tag{3}$$

Appendix E.4 allows for a generic, linear, homogeneous production function.

The input $l^j$ is paid for in period 2, while the $x^j$ input must be paid for ahead of production. Thus, the firm must borrow to finance these inputs. Using a different currency to pay for and to finance the imported inputs generates exchange-rate risk. We assume that the firm will never bear this risk, so $\eta^j$ pins down both the currency of the input and the currency of its trade finance. Appendix E.3 allows these two choices to differ and shows that, in general, it is optimal for them to be the same.

**Cost of finance and production.** For firm $j$, in period 1, borrowing $b_d$ units of $d$ currency requires repayment of 1 unit of $d$ currency in period 2. Borrowing $b_r$ of $r$ currency requires a payment of $\varepsilon^j$. Therefore, the interest rate on a $d$ loan is $1/b_d$, while the interest rate on a $r$ loan is $\varepsilon^j/b_r$. Both rates are known in period 1, but in period 0, firm $j$ faces uncertainty on $\varepsilon^j$, which is drawn from a distribution $G^j(\varepsilon^j)$.

The difference in the cost of finance plays a role in the firm's choice of currency. For a start, a higher mean of $\varepsilon^j$ makes it more expensive on average to use $r$ credit than $d$ credit. This may be the case if the dominant currency enjoys a convenience premium. Second, the larger spread of possible $r$ interest rates relative to $d$ rates makes $r$ credit more risky and is a reflection of the more liquid, stable, and efficient capital markets in $d$ currency. In our model, this is what defines $d$ as the dominant currency. Assuming that the cost of borrowing in $d$ is known and homogeneous is for simplicity, since it is the spread between $d$ and $r$ credit that matters.

In period 1, the inputs in each currency, $x_d^j$ and $x_r^j$, cost $\rho_d$ in $d$ currency and $\rho_r$ in $r$ currency, respectively. Both $\rho_d$ and $\rho_r$ are known in period 0, so we can focus on the cost of credit. The local input costs $w$, which is paid in domestic currency in period 2. Also uncertain is the exchange rate $s_i$ between domestic currency and the currency of market $i$. (A higher $s_i$ is an appreciation of the foreign currency.)

The marginal cost of production for firm $j$ depends on the choice of $\eta^j$ and on all the shocks that are realized in period 1:

$$C(\eta^j, \varepsilon^j, s_r, s_d, w) = \left[\frac{\eta^j s_r \rho_r \left(\frac{\varepsilon^j}{b_r}\right) + (1-\eta^j) s_d \rho_d \left(\frac{1}{b_d}\right)}{\alpha}\right]^\alpha \left(\frac{w}{1-\alpha}\right)^{1-\alpha}. \tag{4}$$

**Currency of pricing.** In period 0, each firm $j$ chooses the currency of its sticky price in market $i$ from four options:

$$\mathcal{P}_i^j \in \{PCP, LCP, DCP, RCP\}. \tag{5}$$

Under producer currency pricing (PCP), the firm chooses a price $p_i^j$, in domestic currency. Under local currency pricing (LCP), $p_i^j$ is the price in market $i$, so $p_i^j s_i$ is the domestic currency revenue per unit sold. Pricing in the dominant currency (DCP) in market $i$ yields a unit revenue $p_i^j s_d$, and doing so in the rising currency (RCP) gives $p_i^j s_r$.

The firm faces a demand curve in each market with a constant elasticity $\theta$. Its sales depend on the currency in which it sets its price. Under LCP, demand is given by: $y_i^j = (p_i^j/q_i)^{-\theta}$ where $q_i$ is a stochastic market-specific demand shifter that realizes in period 1. Under PCP, changes in the exchange rate cause changes in the price facing consumers, and thus in their demand for the firm's product: $y_i^j = (p_i^j/(q_i s_i))^{-\theta}$. Under DCP, changes in the exchange rate between the $i$ market and $d$, so $s_d/s_i$, shift demand: $y_i^j = (p_i^j s_d/(q_i s_i))^{-\theta}$. Symmetrically, with RCP: $y_i^j = (p_i^j s_r/(q_i s_i))^{-\theta}$.

**The goal of each firm.** We gather the shocks to exchange rates, $s_i$, and the demand shifters, $q_i$, into vectors $S$ and $Q$, respectively. These contain the analogues in the $r$ and $d$ markets. The non-credit stochastic variables that realize in period 1 have joint density $H(S, Q, w)$.

The ex-post profits of a firm in period 2 are given by the difference between revenues and costs. In the case of choosing LCP in market $i$, they are:

$$\pi^{LCP}(p_i^j, \eta^j, \varepsilon^j, S, Q, w) = (p_i^j s_i)(p_i^j/q_i)^{-\theta} - C(\eta^j, \varepsilon^j, S, w)(p_i^j/q_i)^{-\theta}. \tag{6}$$

Similar expressions hold for the other three pricing cases (see appendix E.1).

Combining profit functions with the marginal cost function, the firm's problem is:

$$\max_{\eta^j} \left( \int_0^1 \max_{\mathcal{P}_i^j} \max_{p_i^j} \left( \int \int \pi^{\mathcal{P}}(p_i^j, \eta^j, \varepsilon^j, S, w) dH(S, Q, w) dG^j(\varepsilon^j) \right) di + ... \right) \tag{7}$$

The first inner maximization is over the optimal price in each market. The second is over the pricing currency for each market. The outer maximization is over the currency of credit at the firm level. The expression omits the equivalent expressions for the $d$ and $r$ markets that have positive mass (the whole expression is in the appendix).

## 4.2 The predictions of the model

We now solve the firm's problem in (7) and study how a swap line affects equilibrium.

**The forces in the model.** With full information, a firm would choose a price equal to a constant markup over marginal cost. The pricing currency would be irrelevant since, knowing the exchange rates, prices could adjust to deliver the optimal constant markup. As for the choice of credit, firms with $\varepsilon^j > (\rho_d/\rho_r)(b_r/b_d)(s_d/s_r)$ would choose to use $d$ since its cost is lower, accounting for the cost of inputs, the cost of credit, and the appreciation of the currency in the three terms in parentheses, respectively.

With uncertainty, firms must form expectations of the costs of choosing a different currency. Firms are not averse to uncertainty per se: they maximize expected profits and are risk neutral, as in the standard microeconomic theory of the firm. Therefore, access to fairly priced financial hedges would not alter the firm's problem.[21] However, ex-post deviations from a constant markup over marginal cost lead to lower profits in expectation, as do ex-post changes in the costs of credit and inputs. Therefore, the firm is averse to positive co-movement between the marginal costs and demand, and between the components of marginal costs. This is the key force in the model.

To expose the mechanisms driven by this force, we start by making the simplifying assumption that the distribution $H(S, Q, w)$ is log normal with mean $\mu$ and $\Sigma$.[22] We use subscripts to indicate its elements: mean and variances of the currency of country $i$ are $\mu_i$ and $\sigma_i^2$, covariance with currency of $k$ is $\sigma_{ik}$, and subscripts $w$ and $q$ refer to domestic input costs and demand shifters. Appendix F.1 proves the following result:

**Proposition 1.** *The solution to the firm's problem in equation* (7) *has the following properties:*

*(a) The firm will choose either to use entirely r- or d-credit and inputs, $\eta^j \in \{0, 1\}$.*

*(b) Consider a particular market $i$ where the firm chooses RCP. If $\varepsilon^j = 1$ and the $d$ and $r$ currencies are otherwise identical in terms of mean, variance and costs, the firm's profit in market $i$ will increase following a switch from d-credit to r-credit if:*

$$\theta\left(\sigma_r^2 - \sigma_{rd}\right) > (1-\alpha)(\sigma_{rw} - \sigma_{dw}) + \theta\left(\sigma_{ri} - \sigma_{di}\right) + \theta\left(\sigma_{rq_i} - \sigma_{dq_i}\right). \tag{8}$$

[21] An alternative way of interpreting risk neutrality is to assume that the firm has already engaged in sufficient financial hedging from a competitive risk neutral intermediary such that it is indifferent between cash flows received in different states of the world.

[22] We obtain equivalent results using a second-order approximation with a general distribution in Appendix E.4). Log-normality provides simple analytical solutions.

(c) *If the firm chooses r-credit, and the d and r currencies are otherwise identical in terms of mean and variance, then RCP is preferred to LCP in market i if the variance of the local exchange rate is sufficiently high:*

$$\sigma_i^2 - 2\alpha\sigma_{ir} - 2(1-\alpha)\sigma_{iw} \geq \Phi \equiv \sigma_r^2 - 2\alpha\sigma_r^2 - 2(1-\alpha)\sigma_{rw}. \tag{9}$$

Proposition 1(a) follows from the quasi-convexity of profit functions in input prices. The firm wants to pick the currency with the lowest expected cost, and diversification is not beneficial since the marginal cost of imported inputs is linear in the two currencies. Hence, a corner solution is optimal, since one currency will (weakly) dominate the other.

Proposition 1(b) shows how the choice of the currency of credit allows the firm to hedge different risks. The firm wishes to maintain a constant mark up over marginal cost. If it uses RCP in a particular market, switching to $r$-credit brings the benefit of aligning one component of costs to the currency of revenues. This benefit is captured by the left-hand side of proposition 1(b), as $\sigma_r^2 - \sigma_{rd}$ is weakly positive, and reflects the alignment of prices and marginal costs in switching from $d$ to $r$-credit. On the right-hand side, the first term captures the hedge for domestic input costs, which will be higher for $r$-credit if $\sigma_{rw}$ is low relative to $\sigma_{dw}$. The second and third terms capture the hedging of shifts in demand, as the firm wishes to avoid having high marginal costs when it needs to meet high demand. Since this could happen either because $s_i$ appreciates or because $q_i$ is large, then $r$-credit is less attractive than $d$-credit if $\sigma_{ri} > \sigma_{di}$ or $\sigma_{rq_i} > \sigma_{dq_i}$.

Finally, proposition 1(c) considers the choice of pricing currency. Unlike the previous two results, this one follows existing well-known findings in the literature. Taking $\eta^j = 1$ as given: (i) a higher $\sigma_i^2$ relative to $\sigma_r^2$ makes choosing LCP less attractive as prices would be more volatile, (ii) a higher covariance $\sigma_{ir}$ makes LCP more attractive as it would better hedge the $r$-component of costs, and (iii) a higher $\sigma_{iw}$ relative to $\sigma_{rw}$ provides a further incentive for LCP since marginal cost also depends on the local input price $w$.[23]

**A simplification on the shocks.** This paper focuses on how access to trade finance alters a firm's pricing decisions. To keep expressions more straightforward, from here onwards

[23]By assuming constant elasticity demand curves, we have ruled out demand complementarities in price setting, since the firm's optimal flexible price is unrelated to those of other firms. Therefore, neither $\sigma_{rq_i}$ and $\sigma_{iq_i}$ appear in proposition 1(c). Demand complementarities provide an additional force for currency dominance, as firms have an incentive to price in the same currency as their competitors. Appendix E.4 shows that, up to a second-order approximation, the main insights of our main analysis are unchanged. Novel, if the demand complementarities are sufficiently strong, this can provide a new force pushing the firm to use the rising currency following the introduction of a swap line.

we abstract from some of these hedging channels by making the following assumption:

**Assumption 1.** *The elements of $\mu$ and $\sigma$ that relate to the currencies $d$ and $r$ are symmetric such that $\mu_d = \mu_r$, $\sigma_r^2 = \sigma_d^2$, $\sigma_{rw} = \sigma_{dw}$, and $\sigma_{ri} = \sigma_{di}$ and $\sigma_{rq_i} = \sigma_{dq_i}$ for all $i \in [0,1]$. The covariances between $r$ and $q_r$ and $d$ and $q_d$ are also symmetric and are restricted such that profits in the $r$ market are higher under $r$-credit if borrowing costs are the same across currencies (symmetric for the $d$ market).*

This assumption ensures that neither the $r$ nor the $d$ currency has an innate advantage over the other beyond the cost (and uncertainty) of borrowing in each currency. If one of the currencies is expected to depreciate relative to the other, or if it is less volatile, the firms will favor it. These effects are mostly isomorphic to altering the relative interest rates ($b_d$ and $b_r$), so carrying the extra terms offers little extra insight. Moreover, in our empirical application, $r$ stands for the RMB and $d$ for the USD, currencies which, during our sample period, were partially pegged, so this restriction approximately held, with the USD dominance coming from its deeper financial markets in the model. The last part of assumption 1 ensures that the alternative currency is not a sufficiently good hedge against demand shocks that it overcomes the complementarity of matching currencies.

**The currency of borrowing.** Appendix F.2 proves the following result:

**Proposition 2.** *The firm will choose $r$-credit ($\eta^j = 1$) if:*

$$\left( \int \left( \varepsilon^j \right)^{\alpha} dG^j(\varepsilon^j) \right)^{1/\alpha} \leq \left( \frac{b_r}{b_d} \right) \left( \frac{\rho_d}{\rho_r} \right) \Psi(\mu, \Sigma, \mathcal{P}^j). \tag{10}$$

*Otherwise, it will choose $d$-credit. Under assumption 1, $\Psi(\mu, \Sigma, \mathcal{P}^j)$ equals one if the $r$ and $d$ markets are the same size. Starting from here, $\Psi(\mu, \Sigma, \mathcal{P}^j)$ increases with the size of the $r$-market.*

For intuition, consider the case where $\Psi(.) = 1$. The proposition shows that if the expected value of a concave function of the excess credit costs in $r$ currency is below the relative interest rates and input costs in the $r$ and $d$ currencies, then the firm chooses $r$ credit. The threshold is whether the cost of $r$-credit is low relative to $d$-credit.

Now, $\Psi(.)$ captures how the distribution of exchange rates (captured by $\Sigma$ and $\mu$) interacts with the endogenous choice of invoice pricing (captured by $\mathcal{P}^j$). This includes the complementarities between the currency of pricing and credit, as well as any advantages that a choice of credit has as a hedge. The exact functional form of $\Psi$ is convoluted, and we present it in the appendix. If $r$ and $d$ are symmetric in every way, including market

size, and only differ in the cost of borrowing and inputs, then all these interactions cancel between the two currencies and $\Psi = 1$. However, if the $r$ market becomes larger (or the firm prices in the $r$ currency for another exogenous reason), the above complementarities kick in and raise $\Psi$, thus making $r$-credit more attractive.

**Central bank policies to jumpstart the currency.** The distribution of credit costs in the $r$ currency, $G^j(\varepsilon^j)$, plays a central role in Proposition 2. If the expected cost and volatility of $r$-credit is low, the firm is likelier to borrow and price in $r$ currency. A swap line provides a way to borrow foreign currency at a pre-announced interest rate, placing a ceiling on borrowing costs. Hence, we model its introduction as giving firms the option to always borrow $r$ currency at a rate $\varepsilon^{\text{swap}}/b_r$, where $\varepsilon^{\text{swap}}$ is within the support of $\varepsilon^j$ for some $j$. Appendix F.3 proves the following result on the impact of introducing a swap line:

**Proposition 3.** *The introduction of a swap line that allows firms to obtain r-credit from the central bank at a known rate $\varepsilon^{swap}/q_r$ has the following effects:*

*(a) It shifts the effective distribution of borrowing costs to*

$$\tilde{G}^j(\varepsilon^j) = \begin{cases} 1 & \text{if } \varepsilon^j \geq \varepsilon^{swap} \\ G^j(\varepsilon^j)/G^j(\varepsilon^{swap}) & \text{if } \varepsilon^j < \varepsilon^{swap} \end{cases} \tag{11}$$

*so that $\tilde{G}^j(\varepsilon^j)$ is first-order stochastically dominated by $G^j(\varepsilon^j)$ under the new distribution.*

*(b) Keeping fixed the $\mathcal{P}^j$ decision, some firms switch from $\eta^j = 0$ to $\eta^j = 1$ if the threshold on $\Psi(.)$ in proposition 2 is crossed when computed using $\tilde{G}^j(\varepsilon^j)$.*

*(c) For firms that switch to $\eta^j = 1$, then RCP is always preferred to DCP as long as the correlation between $s_d$ and $s_r$ is smaller than one, and RCP is preferred to LCP if the condition in proposition 1(c) involving the threshold $\Phi$ is met. RCP is preferred to PCP if the covariance of the country's non-credit marginal costs with the r exchange rate is high enough:*

$$\sigma_{rw} \geq \Omega \equiv \sigma_r^2 \left( \frac{0.5 - \alpha}{1 - \alpha} \right). \tag{12}$$

By only cutting the right tail of the distribution of $\varepsilon^j$, the swap line may end up only being used infrequently and in small volumes. Nonetheless, result (a) notes that remov-

ing rare high rates affects firms' inclination to borrow in the $r$ currency ex-ante.[24]

Result (b) shows that $\int \left(\varepsilon^j\right)^{\alpha} d\tilde{G}^j(\varepsilon^j)$ is a sufficient statistic to assess the effectiveness of the policy that shifts the distribution of credit costs on currency choices. The firms that cross the new threshold switch from $d$ credit to $r$ credit.[25]

Once a firm switches the currency of its credit from $d$ to $r$, the first part of result (c) notes that it will always want to switch out of the $d$ currency for its pricing. Since its marginal costs are now partly denominated in the $r$ currency but not in $d$, the firm has no reason to use DCP. The second part recalls proposition 1(c)'s result that the firm will not choose LCP as long as $\sigma_r^2$ is small enough. The third part shows that the firms will adopt RCP in some markets if $\sigma_{rw}$ is high enough, crossing a third threshold $\Omega$, which is common across markets. If $\alpha > 1/2$, the condition always holds as $s_r$ makes up a large enough share of the firm's marginal cost that it wants to set its price in the $r$ currency. For a smaller $\alpha$, even though $w$ makes up a more significant portion of marginal costs, as long as $\sigma_{rw}$ is large enough, RCP will achieve higher expected profits.

**Discussion.** The model explains why the majority of the currencies in the world are not international for three complementary reasons associated with each of the three thresholds: $\Psi$, $\Phi$, and $\Omega$.[26] First, a stable exchange rate is a pre-condition for the currency's international use, but for most currencies, $\sigma_r^2$ is large, so the currency will not be used for invoicing according to proposition 1. Second, credit is expensive and illiquid in most currencies, and a distribution $G^j(.)$ skewed to the right will fail to pass the threshold in proposition 2 . Third, most countries are not large enough in international trade as export markets or as sources of intermediate imports so their $\Omega$ threshold in proposition 3 is small and hard to clear. If these countries were to try policies to jumpstart their currencies, proposition 3 predicts they would fail as the thresholds would not be overcome.

The policies of the PBoC in the 2010s had a chance to succeed because they also came with sound monetary policy, growing capital markets, and a considerable weight

[24]The same result could be achieved through a direct government subsidy of trade finance in the rising currency. This would directly shift the $G^j(\varepsilon^j)$ distribution to the left. However, this would come with potentially large costs if the subsidy is paid on all overseas credit. Instead, the swap line serves as a backstop, ex-ante lowering the risk of very high rates, but only used infrequently ex-post.

[25]One result from the empirical analysis is that the swap line does not increase trade with China. This is consistent with the model, since the swap line lowers the cost of RMB credit but not of Chinese trade. Further, in the model, we hold the size of each market, including the $r$-market, fixed so there is no change in trade by assumption, only a change in the denomination of prices.

[26]For example, in October 2018, the final month in our sample of Swift data, 89% of international payments were made in just six currencies: USD, EUR, JPY, GBP, CHF and CNY.

in trade.[27] Consider an initial situation where the $r$ currency is not used outside the r-market, as was the case with the RMB before 2009. All firms use $d$-currency credit, and each firm uses DCP in some markets and LCP in others. If the swap line lowers expected borrowing costs enough that some firms cross the threshold in proposition 2, a mass of firms starts borrowing in $r$-currency. Because in some markets, the volatility of the bilateral exchange rate is above the $\Phi_i$ threshold in proposition 1(c), these firms move away from invoicing in the $d$ currency for those markets as well. They will choose RCP instead of PCP if the country itself satisfies the $\Omega$ threshold in proposition 3(c).[28]

In the end, both payments sent and received in the $r$ currency rise, as the two complement each other. This happens not just with respect to the $r$ country but also to the other countries with which it trades. The currency has jumpstarted into international status, as we saw in the data with the RMB after the signature of a swap line with the PBoC.

# 5 Evidence on four mechanisms in the model

The model has predictions beyond a jumpstart in RMB payments. This section states them and looks at the evidence to test them.

## 5.1 Swap lines reduce RMB borrowing costs

The mechanism in our model relied on the distribution of borrowing costs under the swap line, $\tilde{G}^j(\varepsilon^j)$, being first-order stochastically dominated by $G^j(\varepsilon^j)$. In expectation, RMB-denominated borrowing costs should fall following the agreement of a swap line.

To our knowledge, there is no comprehensive data on country-specific interest rates for RMB-denominated trade or wholesale finance. However, instead of borrowing RMB directly in interbank markets, a local bank wishing to extend RMB-denominated trade finance to a local firm can obtain the RMB by converting local currency in the FX spot market while using an FX swap to hedge the mismatch between the RMB loan and the local currency deposit. This synthetic RMB borrowing is nearly equivalent in its cash flow to wholesale finance, so its cost should give a proxy for the cost of RMB funding for the local banking system. Since the swap line caps the cost of direct RMB borrowing, they

[27] This insight allows us to elaborate on what may initially seem a critical assumption in our model: that the firm can only buy inputs in $r$ and $d$ currencies. We could have allowed the firm to source inputs denominated in any of the other currencies in the model. However, the firm would never choose to do so if the threshold in proposition 2 was not satisfied. The assumption that the firm is picking between $r$ and $d$ inputs is simply equivalent to assuming the thresholds are not satisfied for other currencies.

[28] Appendix D displays these predictions of the model using a simple graph.

should, through competition and arbitrage, cap the cost of synthetic borrowing as well.[29]

We measure synthetic 3-month borrowing costs at a daily frequency between June 2007 and June 2021 for 23 currencies issued by central banks that enter a swap agreement with the PBoC, using data from Datastream. We consider four different potential ways of synthetic borrowing based on using onshore or offshore RMB markets, or on swapping the RMB directly or using the USD as a vehicle, and take the minimum rate as if banks always opted fot the cheapest option.[30] Appendix B has full details.

The cross-currency average of synthetic borrowing costs is shown in figure 6a, together with direct RMB borrowing costs onshore in China (the 3-month SHIBOR rate) and offshore in Hong Kong (the 3-month HIBOR rate). Outside of the period between August 2015 and April 2017, which we will discuss further below, the average synthetic rate closely tracks the offshore borrowing rate, consistent with the idea that borrowing RMB in offshore money markets is an alternative to synthetic borrowing. At the same time, there is significant cross-sectional dispersion. Even after accounting for time and currency fixed effects, the standard deviation across countries is around 100bp on a typical day, rising to around 400bp when RMB rates are volatile.

Table 4 tests for the impact of swap lines on borrowing rates using the same staggered difference-in-differences methodology. Column (1) shows that signing a swap agreement is associated with a 115bp fall in RMB borrowing rates. Figure 6b considers monthly averages and presents the equivalent specification as an event study plot. There is an immediate and sustained downward movement after the agreement, and we cannot reject the null of no pre-trends. Column (2) uses a least-squares estimator. Since now there is no never-treated group, the issues with staggered adoption are severe, and the OLS estimator delivers a materially smaller coefficient. Column (3) uses the spread between local borrowing costs and the relevant RMB interest rate as the dependent variable. This way, we control for all time variation in the underlying level of RMB borrowing costs. The result is unaffected. Column (4) uses a 1-year, as opposed to 3-month, maturity, and the results are almost unchanged. Finally, column (5) looks only at a sample of emerging market currencies in line with the sample selection criteria in the main analysis. The effect rises to 205bp, consistent with these countries experiencing more volatile funding

[29]The relevant interest rate in the model is the cost of trade finance for firms. Instead, we measure banks' wholesale funding costs, and rely on there being significant interest rate passthrough. Note, however, that the effectiveness of the swap lines themselves also rely on this passthrough. After all, the PBoC provides RMB to the local central bank, which will lend to the local banking system, who, finally, lend to firms.

[30]Markets may be segmented such that a relatively cheap option is not available and the swap line may be capping the cost of more expensive options. Our results, therefore, are a lower bound.

conditions, so that the swap line is more likely to be a valuable backstop.

## 5.2 Swap lines reduce tail risk of RMB use

In early 2015, macro-financial forces led the RMB-USD exchange rate to depreciate. The PBoC managed this exchange rate via a trading band with a central parity rate and, on August 11th 2015, it adjusted that rate. The RMB depreciated by 3% over the next two days, and would continue doing so for the next 18 months. Because China operates parallel offshore and onshore currency systems in order to enforce its capital controls, this devaluation caused the offshore currency to be worth less than the onshore currency. To keep the peg between the two currencies, the PBoC intervened by draining liquidity from the offshore financial system. This intervention raised the level and volatility of offshore RMB borrowing costs, visible in Figure 6a. The volatility continued until the introduction of a new currency management regime around April 2017. McCauley & Shu (2018) and Bahaj & Reis (2024) elaborate on these events.

This episode has useful features to test our model. First, the shock was primarily financial, coming with no economic slowdown in China's economy or in its global trade share. Second, the shock had its source in China, rather than being related to a specific counterparty economy. Third, the policy change in August 2015 was unanticipated; there was no movement in offshore prices beforehand. And fourth, the volumes drawn from the swap line are dwarfed by the net flows in or out of China and by Chinese FX reserves, so they are not a source of pressure on the RMB-USD exchange rate. Hence, the 2015-16 episode can be interpreted as an unexpected rightward shift in $G^j(\varepsilon^j)$. Figure 6a validates this interpretation: offshore borrowing costs were unusually volatile in 2015-16.

The model predicts that this shock would stall the use of the RMB for payments, as countries near the threshold would move away from it. Figure 2 already showed this was the case. For countries that have a swap line though, the relevant distribution, $\tilde{G}^j(\varepsilon^j)$, is capped on the right. Therefore, it will experience a smaller outward shift, and borrowing costs will not rise, so the use of the RMB would be preserved. Figure 6a supports this prediction of the model, as most of the countries in the sample had a swap line by 2015 and the mean synthetic RMB borrowing cost did not track the rise in offshore rates. Finally, figure 7 plots the average quarterly RMB usage for countries with and without a swap line before and after the crisis. (Appendix B.2 describes the sample; the key selection criteria being that all countries already used the RMB prior to 2015.) As expected, countries with swap agreements tend to use the RMB more, but the trends were parallel prior to 2015-Q4, both visually and confirmed by formal test from Borusyak *et al.* (2024).

Consistent with the predictions of the model, countries without a swap line experienced a sharp decline in RMB usage in 2015Q4 that countries with a swap line did not emulate.

Table 5 establishes this via difference-in-differences estimates of the effect of the swap line on RMB usage after 2015Q3. The first column presents a simple two-way fixed effects model with a coefficient of 2.2 log points. Column (2) includes controls for the logarithm of the country's overall payments, its nominal GDP, and its trade with China, which raises the point estimate somewhat. In columns (3) and (4), we push the event date back one quarter to 2015Q2. The crisis started at the end of Q3 and the policy change may have led to outflows from China, which would explain the uptick in payments in 2015Q3 among the control group. Shifting the event date back by one quarter lowers the point estimate but does not alter the overall message of the results. Finally, reflecting the small cross-section, columns (5)-(8) repeat the analysis using a synthetic difference-in-differences estimator. The results are similar. To conclude, since the swap line insures its recipients from spikes in private borrowing costs, we find that countries with swap lines maintained their use of the RMB relative to non-recipients.

## 5.3 Swap lines work through trade finance

Our model's predictions relate to the choice of currency for international trade and trade finance, as opposed to for trading financial assets. We now focus on the subset of messages that are due to bank-financed international trade (message types 400 and 700).

Table 6 shows the association between swap lines and RMB-denominated messages for trade at the extensive margin (columns (1) and (2)) and for the share of messages related to trade-finance denominated in RMB (column (3)). The coefficient estimates are quite similar to those obtained when looking at all payments. Appendix table A4 replicates our baseline table 2 in full using messages related only to trade, confirming this is true across a broad sweep of specifications. These findings are consistent with our model's predictions that stabilizing offshore funding costs can lead to a redenomination of trade finance with knock-on effects on international payments.

The focus on trade finance also ties the model's predictions to a set of country characteristics that make it more likely for the policy to be effective. We formalize these in appendix E.5. First, the larger is the $r$ market for a country, the more likely the swap line will jumpstart RMB use. In the model, since the firm prices in RCP in the $r$-market, more sales to that economy lowers the threshold $\Psi$, and boost the relative attractiveness of using $r$-credit. Columns (4)-(5) in table 6 test this prediction. We split our sample into observations where the country's goods trade share with China is above or below the

sample median. While the variation for this specification is limited, the extensive margin effect is quite different between the two groups, with almost all the effect concentrated in countries with above-average trade with China.

Second, the swap line is effective in the model by altering the cost of working capital and imported inputs. Therefore, countries that consume more intermediates or that produce in sectors that rely more heavily on working capital should see a stronger association between RMB use and the introduction of the policy. In the model, all imported inputs need working capital, so these two concepts are captured by the parameter $\alpha$. In the data, we can separate them. Using the BEC trade classification, we measure reliance on imported inputs as the average share of imports that correspond to intermediates. We measure reliance on working capital by classifying a country's exports to industries by ISIC and then matching ISIC industries to their reliance on liquidity needs measures using average inventory-to-sales ratios in US Compustat firms from 1980-1999.[31] Combining this series with the trade data, we produce an export-weighted measure of a country's industrial reliance on working capital and divide countries depending on whether they are above or below the sample median. Columns (6)-(7) and (8)-(9) of Table 6 show that the relationship between RMB use and the swap line is generally increasing in both intermediate input intensity and reliance on working capital. These differences are quantitatively large and statistically significant.

## 5.4 Swap lines boost RMB use relative to other international currencies

A final prediction of the model is that the switch to the RMB should primarily come from existing international currencies, like the USD or the EUR, and not from the local currencies. The RCP choice replaces DCP as opposed to PCP or LCP according to Proposition 3c.

In the data, different countries trade in different markets. In some of them, the USD might be the usual vehicle, while in others it is the EUR or the JPY. To compare countries' payments with a common counterparty, we focus on payments to and from China. Table 7 presents results from our staggered adoption difference-in-differences estimator, where our outcome variable is the share of payments to/from China in different currencies. Column (1) shows that signing a swap agreement is associated with a rise in the RMB share of payments to and from China of 14 percentage points. Columns (2)-(5) decompose this increase: 8 percentage points are accounted for by a fall in the USD share (column

[31] This follows Manova *et al.* (2015). US public firms likely have access to finance and working capital, so this measure should capture technological differences rather than financial frictions.

(2)), 2.5 percentage points by a fall in the EUR share (column (3)), a further 0.5 percentage points is a fall in the combined share of GBP, JPY and CHF (column (4)) and the remaining three percentage points is accounted for by a decline in other currencies (mostly HKD, AUD, CAD and SGD, column (5)). As predicted by the model, the home currency of the country that receives the swap agreement (column (6)) does not experience a statistically significant decline in usage.

# 6 Conclusion

By extending its lender of last resort function to stabilize the supply of trade finance abroad, a central bank can influence the international status of its currency. We put forward a model of the currency choice for trade finance and invoicing. It predicts that there will be thresholds for key economic variables that a currency must meet before it becomes international. Most currencies do not meet these thresholds, explaining why so few are used internationally. However, for some, policy can shift the thresholds and jumpstart the currency. Empirically, the RMB swap lines support these theoretical mechanisms and the role of these thresholds. We estimated that a swap line is associated with a 14 percentage point increase in the probability of a country making or receiving RMB payments.

There have been so few instances of currency rising to international status that it is impossible to know if these results are specific to the RMB. However, an analogy from economic history is informative. In 1912, the United States was the world's largest exporter, but US firms used financial markets in London to access trade finance denominated in GBP. The Federal Reserve Act of 1913 allowed US banks to open branches abroad, and the first president of the FRB, New York, Benjamin Strong, had an explicit goal of internationalizing the USD. One notable measure he took was to give US banks the ability to discount USD-denominated trade acceptances—a form of trade finance— at the Federal Reserve. The Fed was aggressive in backstopping the market for USD trade finance: by some estimates, between 1923 and 1929, the Fed owned as much as half of all issued trade acceptances (Eichengreen, 2011). By 1925, the USD had become an international currency, and by World War II it had become the dominant currency.

A century later, China was also the world's largest exporter and largely reliant on foreign currency trade finance. It pursued a similar policy agenda, this time using swap lines to backstop the provision of RMB-denominated trade finance. Is it a coincidence that similar policies succeeded one century apart? The theory and empirics in this paper suggest that the answer is no. Rather, these policies and the Chinese experience with

them provide valuable lessons for why some currencies rise to international status. At the same time, this comparison suggests that China must go well beyond the swap lines for the RMB to rise further in international usage and challenge the dominant USD's status. Further policies to remove capital controls in China and some luck in a shock to the USD dominance (like World War I was for sterling) are likely required.

Is this internationalization strategy optimal? Whether the swap lines were the best tool to trigger the jumpstart and whether the costs of policies outweigh the benefits of having an international currency are questions that we did not ask or answer. Neither did we address whether the central bank is the right agent to pursue this promotion, how it should interact with fiscal authorities, and what the implications are for the exchange rate regime and capital flows. We leave these questions for future work.

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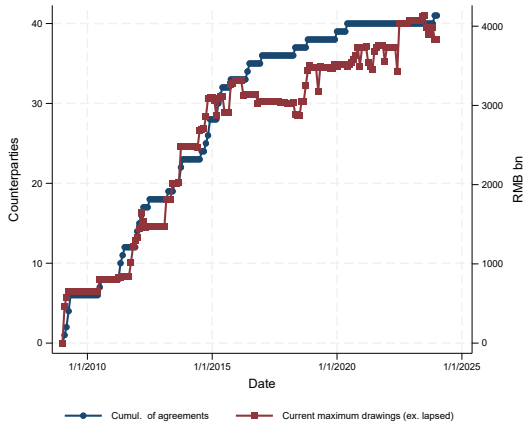
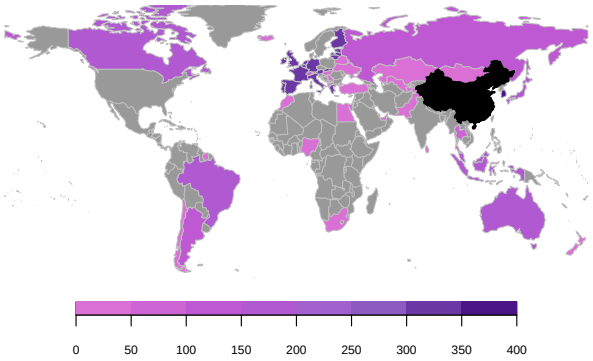
## Figure 1: The PBoC swap lines

(a) Swap lines: number and amounts



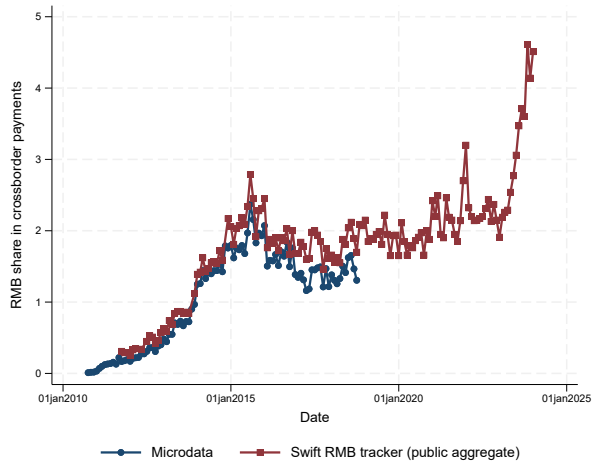

(b) The network of swap lines in 2018



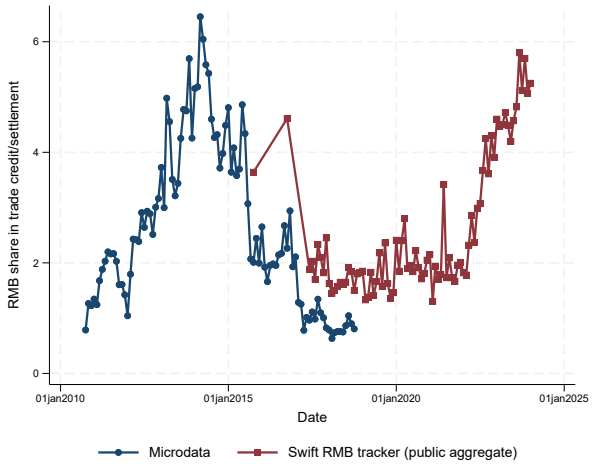

Notes: In Panel (a) the navy line shows the cumulative number of countries/central banks that had signed at least one swap agreement with the PBoC; burgundy line shows the current notional limit on all active PBoC swap lines where lines that have lapsed and have not been renewed receive a zero value. Panel (b) shows swap lines active at the end of 2018, the shade of color indicates the maximum amount the PBOC is willing to lend in RMB bn.

## Figure 2: RMB share in global payments and trade finance

(a) Payments (MT103 & MT202)

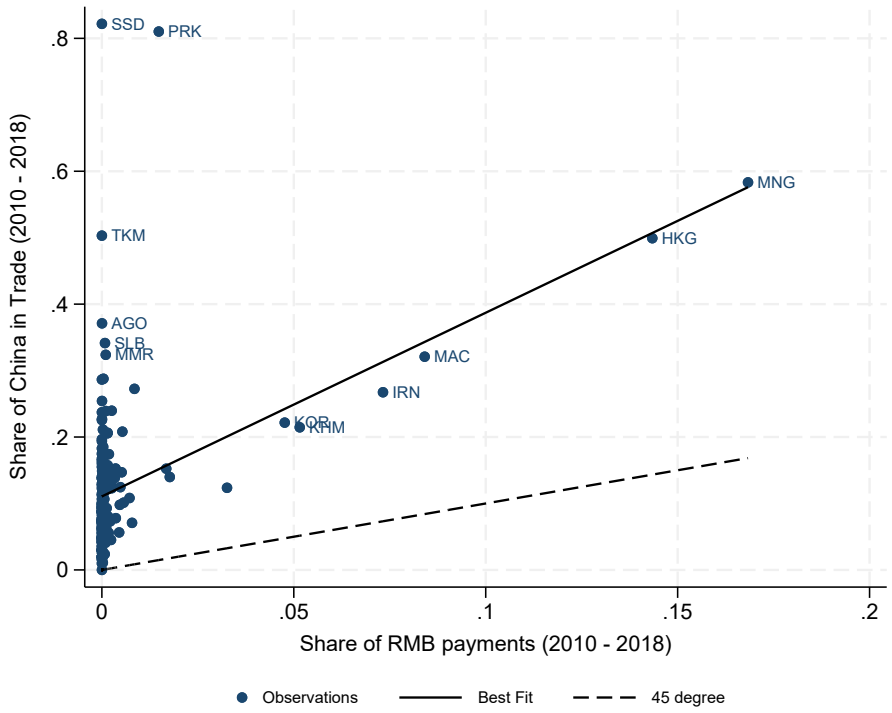



(b) Trade finance/settlement (MT400 & MT700)




Notes: In panel (a), the burgundy line shows the percentage of SWIFT messages MT102 and MT202 denominated in RMB as reported by the SWIFT RMB tracker, the navy line shows the equivalent for our microdata. Panel (b) is the equivalent but for message types MT400 and MT700, i.e. those related to trade finance. The navy and burgundy lines do not align precisely due to differences in how jurisdictions have been consolidated.

Figure 3: RMB payments per country vs. trade with China




Notes: Scatter plot showing the average share of a country's good trade with China (sum of imports and exports) on the y-axis and the equivalent share of payments in RMB (MT103 and MT202) on the x-axis. The dashed line is a 45 degree line and the solid black line is a line of best fit. Data on trade shares is from the IMF direction of trade statistics.

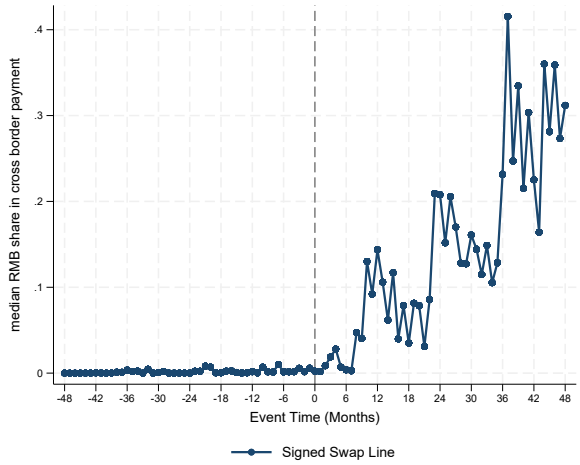
Table 1: The PBoC's swap line agreements as of end 2018

| Country | In Baseline Sample | Date of 1st Agreement | Notional Amount (RMB mn) as of 1st Agreement | Country | In Baseline Sample | Date of 1st Agreement | Notional Amount (RMB mn) as of 1st Agreement |
|---|---|---|---|---|---|---|---|
| Albania | ✓ | 12/09/2013 | 2000 | Malaysia | | 08/02/2009 | 80000 |
| Argentina | | 02/04/2009 | 70000 | Mongolia | ✓ | 06/05/2011 | 5000 |
| Armenia | ✓ | 25/03/2015 | 1000 | Morocco | ✓ | 11/05/2016 | 10000 |
| Australia | | 22/03/2012 | 200000 | New Zealand | | 18/04/2011 | 25000 |
| Belarus | | 11/03/2009 | 20000 | Nigeria | ✓ | 27/04/2018 | 15000 |
| Brazil | ✓ | 26/03/2013 | 190000 | Pakistan | ✓ | 23/12/2011 | 10000 |
| Canada | | 08/11/2014 | 200000 | Qatar | | 03/11/2014 | 35000 |
| Chile | ✓ | 25/05/2015 | 22000 | Russia | ✓ | 13/10/2014 | 150000 |
| ECB | | 08/10/2013 | 350000 | Serbia | ✓ | 17/06/2016 | 1500 |
| Egypt | ✓ | 06/12/2016 | 18000 | Singapore | | 23/07/2010 | 150000 |
| Hong Kong | | 20/01/2009 | 200000 | South Africa | ✓ | 10/04/2015 | 30000 |
| Hungary | ✓ | 09/09/2013 | 10000 | Sri Lanka | ✓ | 16/09/2014 | 10000 |
| Iceland | | 09/06/2010 | 3500 | Surinam | ✓ | 18/03/2015 | 1000 |
| Indonesia | | 23/03/2009 | 100000 | Switzerland | | 21/07/2014 | 150000 |
| Japan | | 26/10/2018 | 200000 | Tajikistan | ✓ | 03/09/2015 | 3000 |
| Kazakhstan | ✓ | 13/06/2011 | 7000 | Thailand | ✓ | 22/12/2011 | 70000 |
| Korea | | 20/04/2009 | 180000 | Turkey | ✓ | 21/02/2012 | 10000 |
| Malaysia | | 08/02/2009 | 80000 | Ukraine | ✓ | 26/06/2012 | 15000 |
| Mongolia | ✓ | 06/05/2011 | 5000 | UAE | | 17/01/2012 | 35000 |

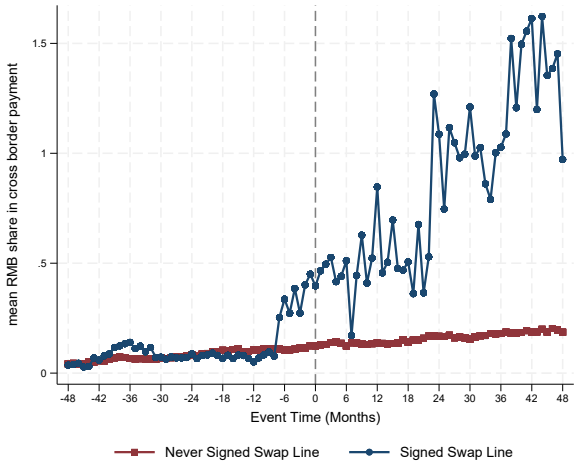
Notes: This shows all the countries that signed swap agreements with the PBoC until the end of our sample in 2018. The second column indicates whether the country enters our baseline regression sample (i.e. column (4) of Table 2); countries can be excluded if they signed an agreement before the start of our sample in October 2010 or are above the per capita income threshold. Column (10) of Table 2 relaxes this income threshold filter for the main empirical analysis.

Figure 4: RMB payments before and after a swap line is signed

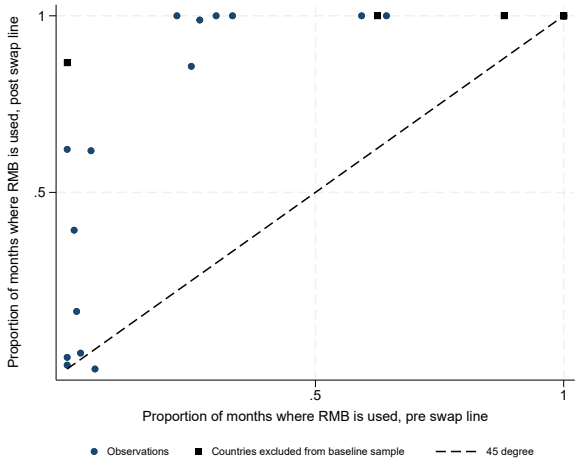
(a) Median of $\text{Rshare}_{i,t}$



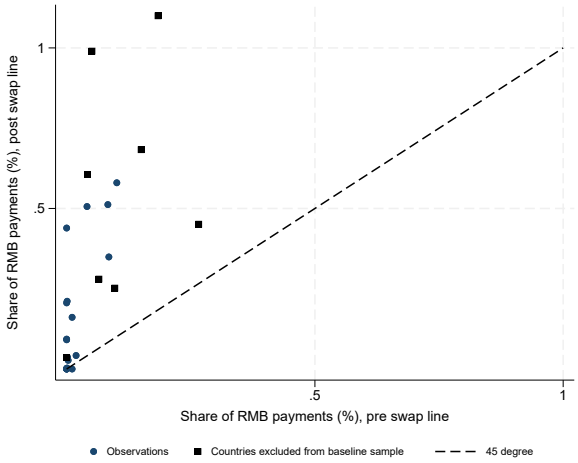

(b) Mean of $\text{Rshare}_{i,t}$




(c) Country means of $1(\text{Rpayment}_{i,t} > 0)$ before and after first swap line agreement



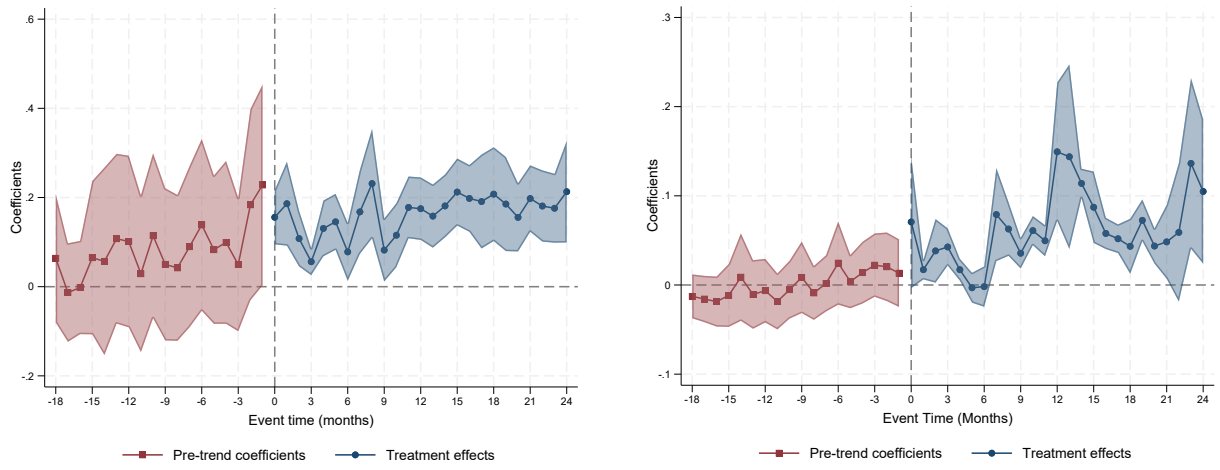

(d) Country means of $\text{Rshare}_{i,t}$ before and after first swap line agreement




Notes: Panels (a) and (b) plots of $\text{Rshare}_{i,t}$ against event time. Event time is defined such that month zero corresponds to the month when the country first signs a PBoC swap line. Panel (a) plots, for each event time period, the median value of $\text{Rshare}_{i,t}$ for all countries that have signed a swap agreement in our sample. The navy line in panel (b) presents the equivalent value for the mean of countries that have signed swap line agreements. The burgundy line in panel (b) corresponds to a control group based on countries that have never signed swap agreements. To produce it, for each country that signed an agreement, we take a mean of $\text{Rshare}_{i,t}$ for the countries who never entered an agreement in the same event time period. This forms a control group for each country that entered an agreement. We then take a second mean of these control series across the swap line countries for each event time period. This second mean is the burgundy line. The median RMB usage for countries that have not signed a swap line is nil for all time periods so we do not present an equivalent series for panel (a). Panel (c) plots, for each country that has signed an agreement, the average level of $1(\text{Rpayment}_{i,t} > 0)$ before and after signing a swap line. Navy circles indicate countries that enter our baseline sample, burgundy squares indicate developed economies and financial centres that we drop in the baseline specification. Panel (d) plots the equivalent for $\text{Rshare}_{i,t}$.

## Figure 5: Event study plots

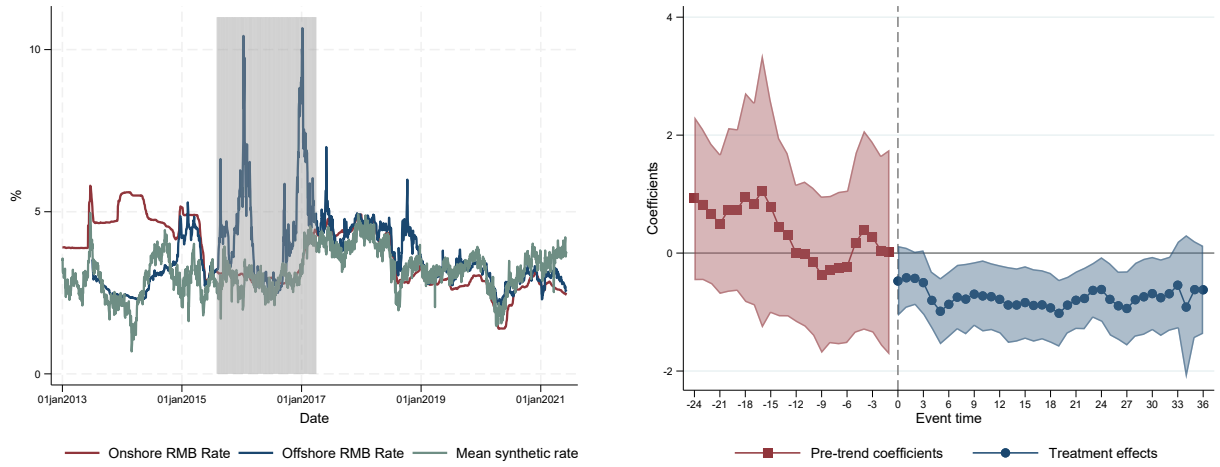
(a) $1(\text{Rpayment}_{i,t} > 0)$ (b) $\text{Rshare}_{i,t}$




Notes: Event study plots using the methodology of Borusyak *et al.* (2024). Panel (a) present event study plots between horizons -18/+24 months for the specification in column (4) of table 2. Panel (b) presents to equivalent for column (2) of table 3. The shaded areas represent 95% confidence intervals.

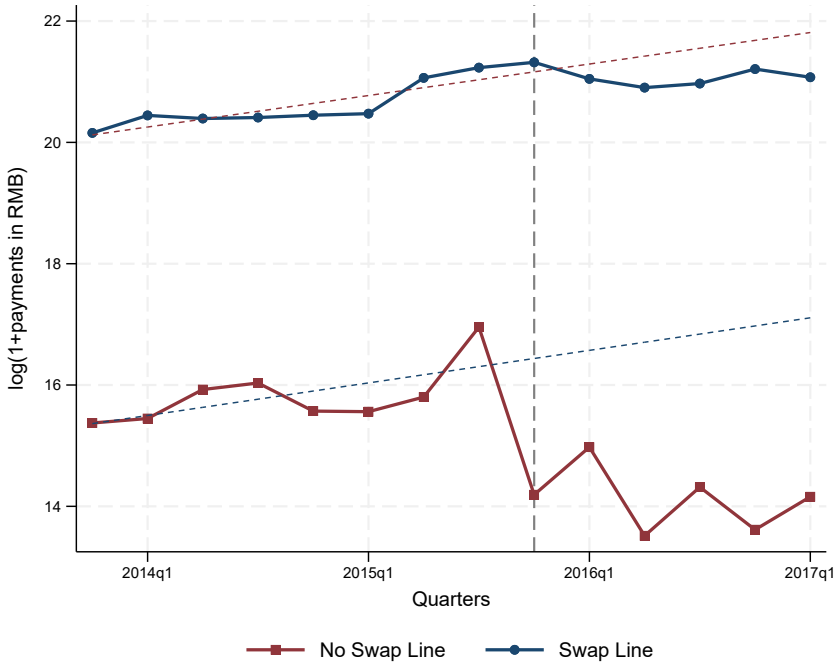
## Figure 6: RMB borrowing costs

(a) Time series of borrowing costs (b) Event study around swap agreements




Notes: Panel (a) presents times series plots of the 3-month RMB SHIBOR rate, the 3-mth HIBOR rate and the average of the synthetic RMB borrowing costs we compute for countries in our sample as discussed in appendix B. Panel (b) is an event study plots using the methodology of Borusyak *et al.* (2024) based on the equivalent specification to column (1) of table 4 with observations aggregated to a monthly frequency by taking averages. Shaded areas represent 95% confidence intervals.

Figure 7: RMB payments before and after the 2015-2016 RMB crisis




Notes: The figure plots $ln(1 + \text{Rpayment}_{i,t})$ for countries with and without swap agreements as of August-2015. $\text{Rpayment}_{i,t}$ has been aggregated to a quarterly frequency. To be included in the sample a country must make positive RMB payments in all quarters between 2013-Q4 and 2015-Q3 as well as meet our standard sample selection criteria. Dashed lines show linear trend lines computed over 2013-Q4 and 2015-Q3. Lines colored in navy relate to countries with a swap agreement, lines burgundy to those without.

Table 2: Swap lines and the prob. the RMB is used

| | Baseline Specification | | | | Robustness | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time & Country f.e. | Incl. China Trade | Incl. China Policy | Incl. Neigh Share | Least Squares | Payments Sent | Payments Rec'd | 6 Month Shift | Ex Mongolia | Incl. Developed |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $\text{SwapLine}_{i,t}$ | 0.1065** | 0.1069** | 0.1229*** | 0.1179*** | 0.1548** | 0.1168** | 0.0551 | 0.1780*** | 0.1479*** | 0.0983** |
| | (0.046) | (0.045) | (0.044) | (0.046) | (0.071) | (0.046) | (0.039) | (0.048) | (0.047) | (0.049) |
| $N$ treated | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 20 | 29 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 107 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Trade Controls | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Policy Controls | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Neighbor Control | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Method | BJS(24) | BJS(24) | BJS(24) | BJS(24) | OLS | BJS(24) | BJS(24) | BJS(24) | BJS(24) | BJS(24) |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates of equation (1). In all specifications the outcome variable is an indicator variable for whether the country makes a payment denominated in RMB in a particular month where payment is defined by SWIFT message types MT 103 and MT 202. The treatment variable is a dummy variable indicating whether the country's central bank, as of month $t$, has ever signed a swap line agreement with the PBoC ($\text{SwapLine}_{i,t}$). Sample period is October 2010 to October 2018. BJS(24) refers to the did imputation method from Borusyak *et al.* (2024). Column (1): includes only country and time fixed effects and no further controls. Column (2): as previous, as but includes as controls a Chinese FTA dummy and trade flows with China. Column (3), as previous, but includes as extra controls dummies for membership of the AIIB and the presence of an RMB clearing bank and Chinese investment flows into the country. Column (4): as previous, but includes Neighbor $\text{Use}_{i,t}$ as an extra control. Column (5): as column (4), but uses a two way fixed effects estimator. Column (6): as column (4), but only considers payments sent. Column (7): as column (4), but only considers payments received. Column (8): as column (4), but shifts treatment back by six months. Column (9): as column (4), but shifts treatment back by six months. Column (10): as column (4), but relaxes sample selection criteria based on country GDP per capita.

## Table 3: Swaplines and the intensive margin of RMB use

| Outcome Variable: | Rshare$_{i,t}$ | | | | | $ln(1+\text{Rpayment}_{i,t})$ | | | | Rpayment$_{i,t}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| SwapLine$_{i,t}$ | 0.1289*** | 0.0948*** | | 0.1106** | 0.1003** | 3.7154*** | 3.4019*** | 3.2354** | 2.4507* | 1.6831*** | 1.2454*** |
| | (0.019) | (0.011) | | (0.043) | (0.045) | (0.720) | (0.773) | (1.482) | (1.449) | (0.298) | (0.318) |
| 0-11 months | | | 0.0391*** | | | | | | | | |
| | | | (0.009) | | | | | | | | |
| 12-23 months | | | 0.0839*** | | | | | | | | |
| | | | (0.007) | | | | | | | | |
| 24-35 months | | | 0.0894* | | | | | | | | |
| | | | (0.054) | | | | | | | | |
| 36-48 months | | | 0.2951*** | | | | | | | | |
| | | | (0.015) | | | | | | | | |
| $N$ treated | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 58 | 58 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Trade Controls | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Policy Controls | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Neighbor Control | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Log Controls | No | No | No | No | No | No | Yes | No | Yes | No | Yes |
| Method | BJS(24) | BJS(24) | BJS(24) | SDID | SDID | BJS(24) | BJS(24) | SDID | SDID | PPML | PPML |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates of equation (1) with different outcome variables reflecting the intensive margin of RMB use, i.e. the value of RMB payments in particular month where payment is defined by SWIFT message types MT 103 and MT 202. The treatment variable is a dummy variable indicating whether the country's central bank, as of month $t$, has ever signed a swap line agreement with the PBoC (SwapLine$_{i,t}$). Sample period is October 2010 to October 2018, Mongolia is excluded from the set of treated countries. BJS(24) refers to the did imputation method from Borusyak *et al.* (2024). SDID corresponds to a synthetic difference in differences estimator from Arkhangelsky *et al.* (2021), in which case bootstrapped standard errors are reported. PPML corresponds to a psuedo Poisson maximum likelihood estimator (Santos Silva & Tenreyro, 2006). Trade Controls are a Chinese FTA dummy and goods imports and exports from/to China in log terms and as a share of country total. Policy Controls are dummies for membership of the AIIB and the presence of an RMB clearing bank and variables capturing Chinese investment flows into the country. Neighbor control captures the share of neighboring countries using the RMB. Log Controls are the logarithm of the country's GDP and the logarithm of its total cross border payments, both in USD. Column (1): $Rshare_{i,t}$ is the outcome variable, specification includes only country and time fixed effects and no further controls. Column (2): as previous, but includes all controls. Column (3) as previous, but shows treatment effects after years 1, 2 and 3. Column (4)-(5): as columns (1) and (2) but uses a synthetic difference in differences estimator. Column (6)-(9): as column (1)-(2) and (4)-(5), but uses a two way fixed effects estimator but the outcome variable is $ln(1+\text{Rpayment}_{i,t})$. Column (9): uses a PPML estimator on the value of payments with no control variables and time and country fixed effects. Column (10): as column (9) but augments specification with controls. Since the outcome variable has a log interpretation, to control for country size we augment the control set to include the logarithm of the country's GDP and the logarithm of its total cross border payments, both in USD.

Table 4: Swap lines and RMB borrowing costs

| | Baseline | Least Squares | Spread v China Rate | 1 year Tenor | Emerging Markets Only |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $\text{SwapLine}_{i,t}$ | -1.1539*** | -0.4953* | -1.1967*** | -0.9415*** | -2.0505* |
| | (0.425) | (0.288) | (0.425) | (0.321) | (1.090) |
| $N$ | 23 | 23 | 23 | 23 | 13 |
| $T$ (trading days) | 3506 | 3506 | 3506 | 3506 | 3506 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes |
| Method | BJS(24) | OLS | BJS(24) | BJS(24) | BJS(24) |

Standard errors clustered by country in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Sample covers 23 currencies in a balanced panel covering trading days from 1st June 2007-8th June 2021. The outcome variable is the country specific estimate of the synthetic RMB borrowing cost as computed in Appendix B. The treatment variable is a dummy variable indicating whether the country's central bank, as of trading day t, has ever signed a swap line agreement with the PBoC. Column (1): baseline specification estimated using the imputation method of Borusyak *et al.* (2024). Column (2): uses a two way fixed effects estimator rather than a the imputation method. Column (3): redefines the the outcome variable to be the spread over the equivalent offshore or onshore Chinese borrowing cost. Column (4): uses a one year tenor rather than a three month tenor. Column (5): restricts the sample only to the emerging markets countries used in the main analysis sample reduced to 13 currencies.

Table 5: Swap lines and RMB payments during the August 2015 episode

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Swap Line Aug-$15_i$ | 2.2141* | 2.9380** | 1.7645* | 2.4037* | 2.5698** | 2.7251** | 1.9584* | 2.1613 |
| $\times \text{Post}_t$ | (1.181) | (1.399) | (1.068) | (1.243) | (1.203) | (1.341) | (1.095) | (1.331) |
| $N$ treated | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| $N$ control | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| $T$ | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Controls | No | Yes | No | Yes | No | Yes | No | Yes |
| Event Date | 2015Q4 | 2015Q4 | 2015Q3 | 2015Q3 | 2015Q4 | 2015Q4 | 2015Q3 | 2015Q3 |
| Method | OLS | OLS | OLS | OLS | SDID | SDID | SDID | SDID |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Difference-in-differences estimates based on an outcome variable of $ln(1 + \text{Rpayment}_{i,t})$, where $\text{Rpayment}_{i,t}$ is the total value of payments in RMB made by country $i$ in quarter $t$. The treatment variable is a dummy that takes a value of one if the country has a PBoC swap line in August 2015. The sample period is 2013:Q4 - 2017:Q1. The sample applies the same selection criteria as in the main analysis, in addition all included countries must have made use of the RMB in every quarter between 2013:Q4 and 2015:Q2. Column (1) presents results with country and time fixed effects and event date of 2015 Q3; Column (2) adds controls equivalent to Column (4) in table 2. Column (3) and (4) repeat prior two columns with an event date of 2015 Q4. Columns (5)-(8) repeat the prior estimation using a synthetic differences-in-differences estimator (Arkhangelsky *et al.*, 2021).

Table 6: Swaplines, RMB trade finance and country characteristics

| Partition | | | | China Trade Share | | Intermediate Imports | | Export Working Capital Needs | |
|---|---|---|---|---|---|---|---|---|---|
| | $1(\text{Rtradecredit}_{i,t} > 0)$ | | $\text{RtradecreditShare}_{i,t}$ | below median | above median | below median | above median | below median | above median |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\text{SwapLine}_{i,t}$ | 0.1496*** | 0.1262*** | 0.1313** | 0.0234 | 0.1804*** | 0.0523** | 0.1670*** | 0.0772*** | 0.1445*** |
| | (0.009) | (0.022) | (0.055) | (0.016) | (0.025) | (0.024) | (0.021) | (0.023) | (0.022) |
| Difference in coefficients | | | | 0.1571*** | | 0.1146*** | | 0.0673*** | |
| | | | | (0.010) | | (0.006) | | (0.004) | |
| $N$ treated | 21 | 21 | 21 | 21 | | 21 | | 21 | |
| $N$ control | 93 | 93 | 93 | 93 | | 93 | | 93 | |
| $T$ | 97 | 97 | 97 | 97 | | 97 | | 97 | |
| Time f.e. | Yes | Yes | Yes | Yes | | Yes | | Yes | |
| Country f.e. | Yes | Yes | Yes | Yes | | Yes | | Yes | |
| Trade Controls | No | Yes | Yes | Yes | | Yes | | Yes | |
| Policy Controls | No | Yes | Yes | Yes | | Yes | | Yes | |
| Neighbor Control | No | Yes | Yes | Yes | | Yes | | Yes | |
| Method | BJS(24) | BJS(24) | BJS(24) | BJS(24) | | BJS(24) | | BJS(24) | |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates of equation (1) with different outcome variables reflecting the intensive margin of RMB use, i.e. the value of RMB payments in particular month. In this table, payments are defined as messages related to trade finance and or settlement, that is message types MT400 and MT700 in SWIFT. The treatment variable is a dummy variable indicating whether the country's central bank, as of month $t$, has ever signed a swap line agreement with the PBoC ($\text{SwapLine}_{i,t}$). Sample period is October 2010 to October 2018. BJS(24) refers to the did imputation method from Borusyak *et al.* (2024). Columns (1) and (2) consider the extensive margin effect with and without the control variables defined in the main text. Column (3) repeats the exercise with the share of messages related to trade finance that are denominated in RMB as the outcome variable. If the country reports no MT400 or MT700 messages in any currency we code the outcome variable to nil. Column (4)-(5), as column (3) but averages treatment effects depending on whether a country is above or below the sample median in terms of its trade share with China. Columns (6)-(7) repeats the exercise for the intermediate import share and columns (8)-(9) for the working capital of exports. See B for exact definitions of these variables.

Table 7: Swap lines and currency choice in payments with China

| | RMB | USD | EUR | GBP/JPY/CHF | Other | Home |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\text{SwapLine}_{i,t}$ | 14.046*** | -7.898*** | -2.627** | -0.493*** | -2.796** | -1.527 |
| | (2.29) | (2.49) | (1.04) | (0.09) | (1.25) | (1.19) |
| $N$ treated | 20 | 20 | 20 | 20 | 20 | 20 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes |
| Method | BJS(24) | BJS(24) | BJS(24) | BJS(24) | BJS(24) | BJS(24) |

Standard errors clustered by country in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates of equation (1) with the outcome variable being the currency composition of payments made to China (inclusive of Hong Kong and Macau). A payment is defined by SWIFT message types MT 103 and MT 202. The treatment variable is a dummy variable indicating whether the country's central bank, as of month $t$, has ever signed a swap line agreement with the PBoC ($\text{SwapLine}_{i,t}$). Sample period is October 2010 to October 2018, Mongolia is excluded from the set of treated countries. BJS(24) refers to the did imputation method from Borusyak *et al.* (2024). Column (1): the outcome variable is the share of payments in RMB. Column (2)-(5): the outcome variable is the share of payments in USD; EUR; GBP, JPY and CHF; all other currencies. The coefficients on columns (1)-(5) must by definition sum to nil. Column (6) is the share of payments in the currency of the counterparty.

# Appendix – For Online Publication

## A Institutional Background

Appendix A.1 discusses how the swap lines work from an operational and contractual perspective, appendix A.2 discussed evidence on usage on the facility and appendix A.3 discusses how different methods of RMB crossborder payments will manifest in the SWIFT data.

### A.1 How the RMB swap lines work

The contract works as follows (see Bahaj & Reis, 2023, for more details). The foreign central bank initiates the transaction by requesting to borrow RMB from the PBoC up to the notional amount of the contract, for a maturity that potentially goes from overnight to up to 2 years. If the PBoC approves and sends the RMB, the foreign central bank gives the PBoC a deposit in its own currency as collateral; this is what makes the transaction a swap. At the end of the swap, the foreign central bank cancels the deposit, so its own currency never enters circulation, and pays back to the PBoC the RMB borrowed plus a pre-agreed interest rate.[32] Since no currency gets exchanged in the spot market, and the interest rate is fixed, the swap line has (sovereign) credit risk for the PBoC, but, outside of default, no exchange-rate risk nor interest-rate risk for either party.

With this agreement in place, a commercial bank that provides credit in RMB to a firm in the foreign country has the option to go to its central bank to obtain the RMB paying the swap line interest rate. The foreign central bank typically distributes the RMB via a collateralized loan to its commercial banks. In some countries, like Singapore and Korea, there are standing RMB liquidity facilities that are financed by the swap line, but other countries have ad hoc arrangements. In this set up, the foreign central bank monitors the bank and its trade finance, and bears the private credit risk associated with the loans to the commercial banks.

Figure A1 is an illustration of the financial flows associated with swap line financed trade credit based on the example of an Egyptian importer buying goods from a Chinese exporter. One operational feature of the PBoC's swap lines arises due to capital controls in

[32] If the foreign central bank defaults on repaying the RMB, then the PBoC can lay claim to the deposit foreign currency to recoup the RMB in the spot market. However, the value and convertibility of the deposit when the central bank is in default will likely be limited.

China: the RMB is exchanged through an RMB clearing bank either locally (if the country has one), in Hong Kong, or in another offshore RMB centre. The foreign central bank will have an account with the clearing bank, which itself has an account at the PBoC backing it. For a discussion of how the offshore RMB payment system works see Bahaj & Reis (2024).[33] The figure illustrates that a necessary condition for the swap line to be effective in the first place is that the correspondent banking relationships required for international RMB payments exist. Other steps taken by the PBoC to internationalize the RMB for payments, including establishing the offshore RMB (CNH) market, the trade settlement scheme of 2009, and connect schemes in financial markets, are not country specific, and have developed the financial plumbing of the RMB offshore financial network to any country in the world.

One exception to policies not being country specific is the offshore network of clearing banks. As we will describe below, these are the plumbing via which offshore payments flow to the onshore banking system and vice versa. However, the location of a clearing bank is not critical. So long as an agent who wishes to make an RMB payment is a customer of a bank which has a clearing bank somewhere in the world in its correspondent network then the payment can be made. In practice, almost all offshore RMB clearing happens in Hong Kong, London and Singapore.

In the data, only 4 countries in our baseline line sample have received both a swap line and a clearing bank. One country received a clearing bank without a swap line. Given this limited variation it is hard to make strong statements about the effect of clearing banks. However, controlling for the presence of a clearing bank make makes no difference to our main regression results. There is also no association between RMB clearing banks and RMB payments.

## A.2 Usage of the RMB swap lines

The PBoC does not disclose data on the bilateral usage of the lines nor the interest rate charged (although anecdotes suggest these are above typical market rates, in line with lines capping market rates). The China Monetary Policy report contains information on end of year outstanding balance aggregated across all counterparties: the amount has fluctuated between $5bn and $10bn over the course of 2014-2020 (Perks *et al.*, 2021). The time series is short but the year-end balances for the PBoC exceeded the equivalent

[33] In this example, both the Central Bank of Egypt and the Egyptian commercial bank have the same RMB clearing bank acting as as correspondent. This does not need to be the case and there could be further flows within the RMB payment system.

aggregate drawings from the Federal Reserve's swap lines over the course of 2014-2019. 2020 is an exception: at year end, the Fed provided $17bn of swap line loans compared to $8bn for the PBoC. Given the potential maturity of the lines and their role as a back stop, there is likely to be significant fluctuations within year for both central banks. Indeed, the outstanding balance on the Federal Reserve's swap lines peaked at $450bn in May 2020. Drawings of an equivalent order of magnitude from the PBoC seem highly unlikely as they would be detectable from other sources.

In terms of the counterparties, in a extensive review of public sources, Horn *et al.* (2023) reports 17 countries have drawn on a PBoC swap line.[34] Other drawings may have been kept confidential. The exact use of the drawn funds is unknown. Public statements suggest the funds have been used in operations related to RMB trade settlement, in the cases of Korea, Nigeria, Singapore, Turkey, Thailand and Russia. Other countries, Pakistan, Argentina, Ukraine and Mongolia used the funds instead to pay for imports from China which would otherwise be funded in USD, or just swapped the RMB directly into USD to pay others or to pad their reserves. The central banks of Singapore, Russia and Korea publicly disclosed dedicated facilities to lend RMB for trade settlement purposes. Other central banks appear to operate on an ad hoc basis.

Horn *et al.* (2023) also describe that in many cases swap line drawings are coincident with times of external economic distress (FX depreciations, depleted reserves, rating downgrades). In line with a lender of last resort function of swap lines, this aligns with countries relying of the facilities when they cannot access private alternatives. This pattern of drawings is similar to that seen with the Federal Reserve's swap lines which have been drawn of times of economic distress where obtaining private dollar credit is difficult. This ties into the point we made above that the swap line does not need to be frequently used to generate effects. The line's existence insures trading firms against fluctuations in borrowing costs thereby altering incentives even if that insurance is never called upon.[35]

Horn *et al.* (2023) argue that the pattern of drawings, especially after 2020, reflects the bail out other countries with high indebtedness to China as part of the expansion of Chinese borrowing under the Belt and Road Initiative. In our view, swap line drawings being correlated with external distress is insufficient grounds to make that claim. But

[34] McDowell (2019) corroborates 9 of the 17 cases of countries drawing based on direct enquiries to the borrowing central banks.

[35] Evidence of the insurance role of the lines exists elsewhere in the literature. Albrizio *et al.* (2021) document that the introduction of EUR liquidity lines by the ECB had a significant impact offshore EUR funding costs despite the lines' rare use.

the swap line's role may have morphed after the end of our sample in 2018 away from being just vehicles to promote RMB internationalization and also as a means to provide external financial support. During our sample, controlling for inflows of capital from China or membership of the Belt and Road initiative do not play a role in explaining our results. We do find an association between the lines and trade finance so our results extend beyond payments linked to longer term debt. And it is difficult to square what would amount to ex-post bailouts with an immediate jump in RMB use.

### A.3 RMB payments in SWIFT

In general there are three payment systems for actually settling international transactions in RMB. First, two agents can exchange RMB if they are both customers of banks with a correspondent network that can access China's National Advanced Payments System (CNAPS): in which case the onshore Chinese payments system can be used in a similar manner to a convertible currency. However, Chinese capital controls place barriers to accessing CNAPS for foreign financial institutions. A second method involves using an offshore clearing bank to clear transactions, in which case both banks would require having the clearing bank in the correspondent network. Most offshore RMB transactions are cleared using this second method via the clearing bank in Hong Kong. In both these cases the messages between correspondents would typically be sent via the SWIFT network.

In 2015, China introduced a third method: its Cross-Border Interbank Payment System (CIPS). In function it is similar to a clearing bank where foreign financial institutions can hold RMB accounts for settlement. A relevant difference is that CIPS can be communicated with both via SWIFT, which we observe, and its own indigenous messaging system, which we do not. This potentially is a concern for measurement. However, note at the end of our sample in 2018 CIPS was still developing with a small network and transaction volumes. Moreover, and more importantly, the vast majority of messages to CIPS still rely on SWIFT partly due to the fixed costs of an extra messaging system (see Eichengreen (2022) and Cipriani *et al.* (2023)).

## B Data Sources and Manipulations

Below we describe and provide sources for the variables we use in our empirical analysis sections 2, 3 and 5. Table A1 presents summary statistics for the different variables in our baseline regression sample.

**SWIFT data on cross-border financial messages.** These data were provided by the SWIFT Institute and last received by us on the 5th of December of 2019. We use SWIFT message types MT 103, MT 202, MT 400 and MT 700 for the analysis. Our definition of payment corresponds to the sum of MT 103 (Single Customer Credit Transfers) and MT 202 (General Financial Institution Transfers). We consolidate message types MT 103+ and MT 103R into MT 103. We omit message type MT 202COV to prevent the double counting, as covered messages have corresponding MT 103 or MT 202 transactions.

The raw data has the total value of the messages sent and received by any two jurisdictions within SWIFT, broken down by the month that the message was sent or received, the message type, and the currency of the message. The value is converted in USD by SWIFT using the prevailing exchange rates on the day of the transactions. We convert our data into a balanced panel, replacing country-pair, message-type, month observations where no information is recorded into zero for the value of the messages.

We consolidate some jurisdictions within the SWIFT dataset together, such as the UK and its offshore dependencies, or the US and its overseas territories. This is to prevent the grossing up of cross-border transactions (sterling flows between the UK and the channel islands are substantial for example) and to ensure that the cross-sectional units we focus on are truly independent states. The complete list of consolidated jurisdictions is provided in the replication code.

**Monthly trade data.** We use the IMF direction of trade statistics to measure monthly bilateral goods trade between countries (last accessed on the 16th of September of 2019). The monthly trade data are used as controls in our specifications and are the dependent variable in table A2. Exports are measured as the value of goods free on board. Imports include the cost of insurance. The data is denominated in USD using prevailing market exchange rates and we consolidate certain jurisdictions in the same manner as the SWIFT data above.

**Data on composition of trade.** We use data from BACI on the composition of trade flows. These are used to sort countries into different groups in table 6 and in no other specification. The BACI data is sourced from the UN comtrade database, 2021 vintage. The data is annual, from 2007-2019, and covers goods trade only, at the country-pair-flow-product level. Product codes are defined using the UN Harmonised System (HS) at the six digit level; we use the HS 2007 classification as it is both available from the start of our sample and has the required concordances. To compute a country's intermediate inputs share, we first match HS codes to their Broad Economic Catergory (BEC) code, fourth revision,

using UN concordances. The UN defines BEC codes 111, 121, 21, 22, 31, 322, 43 and 53 as intermediates.[36]. Given the import data and matched product codes, it is straightforward to compute the average intermediate share of inputs by country. For exporters' reliance on working capital, we match export HS codes to International Standard Industry Classification codes, revision 2. This provides the industry composition of exports. An index of industrial reliance on working capital is provided in Kroszner *et al.* (2007), using the median inventory to sales ratio for US Compustat firms over the course of 1980-1999. Our final measure at the country level is the industry composition of exports-weighted version of the this index.

**GDP data.** We use the April 2019 vintage of the IMF world economic outlook to source cross country GDP data (last accessed on the 23rd of September of 2019). Nominal GDP in USD at market exchange rates is WEO code NGDPD, nominal GDP at PPP exchange rates is WEO code PPPGDP and we convert the later into per capita terms using the country's population (WEO code LP).

**Distance data.** Data on distance between countries come from the CEPII GeoDist database described in Mayer & Zignago (2011). We downloaded these data from the CEPII website on 21st October of 2019. We use the location of the capital as the location of the country and calculate distance using the great-circle distance method.

**Swap line data.** The complete dataset on PBoC swap lines is provided in table 1.

**Chinese Investment.** Data on Chinese fixed investment projects in foreign countries comes from the Chinese Global Investment Tracker compiled by the American Enterprise Institute. We use the Spring 2019 vintage last accessed on the 30th December of 2019. We take the dollar figure of monthly investment flows recorded in each country and the cumulated since the start of the dataset and express both as a percentage of the country's nominal GDP.

**Membership of the AIIB.** Membership of the Asian Infrastructure Investment Bank was downloaded directly from this website, last accessed on the 30th December of 2019.

**Membership of the Belt and Road Initiative.** The date a country signed the memorandum of understanding to join the Belt and Road Initiative is sourced from Nedopil (2023). We do not treat the Euro Area as a member of the Initiative due to the limited participation of its member states.

[36]See https://unstats.un.org/unsd/tradekb/Knowledgebase/50090/Intermediate-Goods-in-Trade-Statistics (Last accessed April 4th 2022)

**Chinese Free Trade Agreements.** Data on the Chinese Free Trade Agreement network was downloaded from the Chinese ministry of commerce (see here, last accessed on the 16th April of 2020). We date free trade agreements from their effective dates. We count ASEAN members as having a FTA starting from when the ASEAN framework was agreed in November 2002.

**UN voting alignment .** Our the data on UN general assembly voting is sourced from Bailey *et al.* (2017). We use version 32 of the data covering UN sessions between 1946-2022, last accessed on 23rd January 2024 . As suggested by the authors we use the absolute difference in ideal point estimates as our measure of voting similarity as suggested by Bailey *et al.* (2017). UN general assembly sessions do not exactly align with years, however, for simpilicity we abstract from this and match our SWIFT data to the year of the session.

## B.1 Computing synthetic RMB borrowing costs

**Data Sources.** We use Refinitiv Eikon to obtain daily data on CNY and CNH FX swaps by counterparty, alongside the corresponding spot exchange rates. We use Refinitiv Datastream to obtain data on local currency interbank offered rates (or equivalent) and FX forward and spot prices versus USD. We separate these series into the bid price and the ask price to account for the transaction costs involved in synthetic borrowing. For comparability, when we use Eikon for the FX derivative rates, we use Eikon for the spot exchange rate and similarly for Datastream. The difference between the two sources when definitions overlap is minimal. The exact tickers are provided in the supplementary materials.

**Sample Currencies.** We obtain data on synthetic RMB borrowing costs for the following 23 currencies: AED, AUD, BRL, CHF, CLP, EUR, GBP, HKD, HUF, IDR, ISK, JPY, KRW, KZT, MYR, NZD, PKR, RUB, SGD, SRL, THB, TRY, ZAR where we were able to compute a high quality borrowing cost measure from the available data. This sample enables us to form a balanced panel starting 1st of June 2007. Note that CNH derivatives only started becoming available around 2011. Most of our earlier observations are constructing via a triangular trade of swapping into USD and then into CNY.

**Constructing RMB borrowing costs.** We calculate the synthetic borrowing costs in four ways for each country. All four start from the local currency borrowing cost measured by the interbank offered rate (or equivalent) at a three-month maturity since the start of 2007. The first uses the price of local currency to offshore RMB (CNH) FX swap contracts. The second uses instead swaps to the onshore currency, CNY. The trade settlement scheme that China operates effectively removes any constraints to converting between

CNY and CNH for cash flows linked to international trade or trade credit (HKMA, 2009). The Chinese banking system will exchange them one to one, so the two swaps would be equivalent for a bank providing trade credit. The same is not true for speculators which drives a possible wedge between the price of CNH and CNY derivatives.[37] Finally, and because there are no derivatives contracts between some local currencies and either CNH or CNY, we also consider a triangular trade where the bank borrows in local currency first, swaps the local currency into USD and then swaps the USD into CNH or CNY. This gives us two more synthetic borrowing costs. In all four cases, we account for the transaction cost by using the appropriate bid/ask prices.

We then assume banks will choose the cheapest of the four options, so our proxy at the country level is the minimum of the four synthetic borrowing costs. If no price information is available for one of the four routes, we assume that the contract is not quoted and the cost of borrowing is infinite.

To construct synthetic RMB rates directly from CNY or CNH FX swaps, for currency $k$ and on trading day $t$, we first calculate the implicit forward rate from the bid prices:

$$f_{r,t}^{k,bid} = s_{r,t}^{k,bid} + swap_{r,t}^{k,bid},$$

where $r$ denotes RMB, defined as either CNY of CNH, $swap_{r,t}^{k,bid}$ is the RMB vs currency $k$ swap rate in swap points and $s_{r,t}^{k,bid}$ is the spot exchange rates. All exchange rates are defined in terms of local currency $k$ per unit of $r$.

Define the gross interest rate on a loan denominated in currency $k$ for the same maturity as the swap as $1/q_k$. The synthetic cost of RMB borrowing using currency $k$ as base is then given by:

$$1/\tilde{q}_r^k = s_{r,t}^{k,ask}/(f_{r,t}^{k,bid} \times q_k).$$

Let $d$ denote USD. When going via the USD we observe $f_{d,t}^{k,bid}$ directly including for $k = r$. Hence, we can compute:

$$1/\hat{q}_r^k = (s_{r,t}^{d,ask}/f_{r,t}^{d,bid}) \times s_{d,t}^{k,ask}/(f_{d,t}^{k,bid} \times q_k),$$

as an alternative measure of RMB borrowing costs based on a triangular trade. For our

[37] Also, due to capital controls, CNY contracts that trade offshore are sometimes non-deliverable and settled in USD. A bank that uses a non-deliverable CNY derivative would have to purchase RMB in the spot market as well. However, since wholesale transaction costs in the spot market are low, for trade credit again this should be a minor issue.

empirical analysis, we have $r \in \{CNY, CNH\}$ and we define the RMB interest rate for the country issuing currency $k$ as

$$1/q^k_{RMB} = \min\left(1/\hat{q}^k_{CNY}, 1/\hat{q}^k_{CNH}, 1/\tilde{q}^k_{CNY}, 1/\tilde{q}^k_{CNH}\right).$$

### B.2 Sample for the evaluation of 2015-16 RMB crisis

Our sample is countries that used the RMB in all quarters between 2013-Q4 and 2015-Q3, i.e. the two years before the RMB crisis that started in 2015-Q4 (our event date). We also impose the same filters as in Section 3 and are left with 29 countries, of which 12 had a swap agreement in 2015-Q3 (our treated group). The following groups of countries enter our sample.

**Control:** Angola, Bangladesh, Bosnia and Herzegovina, DR Congo, Fiji, Ghana, India, Kenya, Latvia, Mexico, Mauritius, Philippines, Poland, Romania, Tanzania, Vietnam, Zambia.

**Treated:** United Arab Emirates, Brazil, Chile, Hungary, Kazakhstan, Mongolia, Pakistan, Qatar, Russia, Thailand, Turkey, South Africa.

We focus on countries that were already RMB users before 2015. As some countries occasionally do not make RMB payments in a given month, we consider payments at a quarterly frequency to preserve observations. We end our sample period in 2017-Q1 when the period of volatility ended with policy reform.

Since, for some of the countries without a swap line, the occasional country-quarter observation is nil in the post period, we define our outcome variable as $ln(1 + \text{Rpayment}_{i,t})$.

## C Additional Empirical Results

This appendix present additional empirical evidence to back our findings. In appendix C.1 we show that our results are not obviously explained by rising economic or political integration with China by showing the association between the swap agreement and RMB payments extends to non-Chinese counterparties. Nor does the association appear to be explained by the presence of the Belt and Road Initiative – neither controlling for the county's status as a Belt and Road initiative member or conditioning only on payments to non-initiative member countries affects the results. At the same time the swap lines are obviously associated with an increase in trade between the country and China.

In appendix C.2 we show that the swap line is also associated with RMB use among a country's neighbors. We also set up a formal spillover model to estimate the extent of

spillovers.

Last, appendix C.3 presents some additional robustness checks to the results presented in sections 2, 3 and 5.

## C.1 RMB use and integration with China

The potential confound that is foremost in the mind when interpreting our results is that the swap lines are simultaneously determined with economic and financial integration with China. Table A2 considers three alternative specifications designed to mitigate this concern. Columns (1) and (2) consider, with and without controls, a specification excluding payments to or from China itself. If the swap line is a by-product of financial integration with China, the agreement would coincide with the use of the RMB for payments to or from China specifically. Moreover, as figure A1 makes clear, merely activating the line generates cross-border payments in RMB between the country's central bank and the PBoC. However, we find an extensive margin effect looking at payments excluding those to China (inclusive of Hong Kong and Macau). That is, the swap line is also associated with the use of the RMB as a vehicle currency.

One of the most important policies to encourage real and financial linkages with China, particularly among emerging economics, is the Belt and Road initiative. The BRI is a development strategy designed to export Chinese financing, expertise and firms to countries that are in need of infrastructure development. We take no stance on the merits of the initiative but note it may also be a force encouraging the use of the RMB. For example, a Chinese firm operating in different countries as part of the BRI could exchange RMB with itself as an intragroup payment. Moreover, swap line agreements could be associated with the BRI. Indeed, Horn *et al.* (2023) argue that in recent years, largely after our sample ends, the swap lines may have been used to help refinance the loans associated with the BRI.

However, it turns out the overlap between the countries that part of the BRI and have a swap line is limited (see Figure A3). China has a more limited set of counterparties with its swap line than it has with its initiative members, perhaps due to the sovereign risk attached to the former. Even when a country has both a swap line and membership of the BRI the agreement dates do not coincide. Still, we can investigate the extent to which the BRI may explain our results. In columns (3) and (4) we exclude any payments a country makes with a BRI member (inclusive of China). This would address any association that may rise if recipients of the swap lines tend to have payment counterparties that are disproportionately BRI members. In column (4), alongside our previous controls, we

also explicitly control for whether the country making or receiving a payment is a BRI member. None of these adjustments materially affect our findings.

An alternative way to assess whether deeper economic links with China are confounding our estimate of the link between swap lines and RMB use is to directly test whether the signing of a swap line is associated with more trade between the country and China. If the effect is null, then this would reject the hypothesis that the swap agreements are only entered into in the anticipation of deepening economic ties with China. Columns (5) and (6) of Table A2 replace the left-hand side variable in equation (1) with the share of China in imports and exports. We also modify the control set to exclude the variables that capture the country's trade with China, included in the baseline specification, and define Neighbor Trade$_{i,t}$ to be the average of neighboring trade flows with China. The estimates show no association between trade and signing a swap line suggesting economic ties are not a relevant confound. This leaves open the question of why the swap lines are associated with RMB use but not an obvious increase in Chinese trade, we discuss of this feature of the data in section 4.

## C.2 Neighbors and Spillovers

When a country's neighbor signs a swap line with the PBoC, the country is more likely to import more inputs invoiced in RMB from this neighbor. In our model, this would raise $\sigma_{rw}$ as some of the $w$ costs are now invoiced in $r$ currency. It is more likely that the threshold in proposition 3c) is met, which in turn leads to a fall in $\Psi$ in proposition 2 and the jump-start of the RMB. The theory, therefore, matches the fact that when a country signs a swap line with the $r$-currency central bank, we should expect its neighbors to make and receive more payments in the $r$ currency, even if they introduced no policies of their own.

Columns (1)-(3) in Table A3 shows regressions where the outcome variable is now Neighbor Use$_{i,t}$ measuring the share of RMB usage among the neighbors of the country that signed a swap line. The first column shows the baseline specification. The second column excludes from the calculation of Neighbor Use$_{i,t}$ the neighboring countries that signed a swap line themselves at any point in the sample, to isolate the effect of the single country signing an agreement. For comparability with the rest of the Table column (3) The effect remains strikingly large, between 10% and 14%.

If the swap line effect spills over across borders, it will violate the SUTVA assumption, which could bias our estimates. To investigate this, we set up a spillover model (Berg

*et al.*, 2021) by defining the variable:

$$\text{Neighbor Swap}_{i,t} = \frac{1}{|\mathcal{N}_i|} \sum_{j \in \mathcal{N}_i} \text{SwapLine}_{j,t}, \tag{A1}$$

which is the proportion of neighbors that have signed a swap agreement. We then include as covariates Neighbor $\text{Swap}_{i,t}$ interacted with $\text{SwapLine}_{i,t}$ and $1 - \text{SwapLine}_{i,t}$. This accounts for spillovers varying depending on whether the country has an agreement in place, so they take the place of Neighbor $\text{Use}_{i,t}$ as a covariate.

Columns (3) and (4) in table A3 show that the baseline association between the probability of RMB usage and signing a swap line agreement is a little lower when accounting for spillovers: between 6%-10%, although with larger standard errors. However, this coefficient now measures the effect assuming no neighboring country has signed a swap line agreement. Accounting for spillovers, the effect of signing a swap line on the probability of RMB usage rises by an additional 60-65% if all neighbors had already signed an agreement, suggesting substantial amplification if multiple countries sign an agreement simultaneously. Similarly, even if a country does not sign an agreement, the effect of all of its neighbors signing an agreement is an increase in the probability of RMB use of 44-46% corroborating the result in columns (1)-(2).

Columns (6)-(9) present the same results using specifications in from table 3 that take into account spillovers at the intensive margin. Focusing on column (9), the Poisson model including controls, the point estimates suggets that signing a swap agreement when no neighbors have done so raises RMB usage by 150%; however, if one in ten neighbors also had a swap line (the mean and standard deviation of Neighbor $\text{Swap}_{i,t}$ are roughly 0.1) this raises the estimate threefold to 450%. Likewise, having one tenth of neighboring countries sign a swap agreement would raise RMB usage by 90% even if the country in question had not signed an agreement itself.

## C.3 Robustness of Baseline Results

Figure A2 presents the equivalent of Figure 3, for the start and end of the sample in 2010 and 2018. It shows that a major shift in the has been countries starting to use the RMB in the first place (alongside an overall increase in the share of payments).

Figure A3 shows the geographic prevalence of countries that have received a PBoC swap line and have signed up to the Belt and Road Initiative. As can be seen, these two groups do not perfectly overlap.

Figure A4 shows the equivalent to 4 excluding Mongolia from the sample and confirming that Mongolia appears to drive pretreatment trends.

Table A5 reestimates our extensive margin results including Mongolia, this increases the coefficient on the share of RMB payments substantially but has less of an impact on the estimates of a proportional increase in payments.

Table A4 re-estimates Table 2 using payments just for trade credit and confirms our main results. Note that to be conservative, when computing the RMB share of trade finance, we set the value to zero even if the country reports no messages of types 400 and 700 in any currency. Treating these observations as missing increases the coefficient estimates a little when using the unbalanced panel. Since MT400 and MT700 data are less well reported, we lack sufficient observations to estimate a count data model, so we do not fully explore the intensive margin.

# D A graphic display of the model

Figure A5 displays the main predictions of proposition 3 graphically using a box. Firms are shown on the x-axis, ordered so that the higher is $j$, the higher is the volatility of the firm-specific interest rate risk in $r$ currency, $\int \left(\varepsilon^j\right)^{\alpha} d\tilde{G}^j(\varepsilon^j)$. Thus, associated with the threshold $\Psi$ in proposition 2, there is a threshold $j^*$ such that firms $j \leq j^*$ choose $\eta = 1$, and firms $j > j^*$ choose $\eta = 0$.

The y-axis denotes markets where each firm sells. Export markets are indexed by the inverse of $\Phi_i$, as defined in 1(c), so that as we move up, the bilateral exchange rate is increasingly stable. This indexing means we can define a threshold market where for $i \leq i^*$, pricing in the currency of credit is preferred to pricing in LCP.

Finally, the rectangles at the top capture the $r$ and $d$ markets, which have positive mass.

Panel a) in the figure shows an $r$ currency that is not international as $j^* = 0$. The $r$ currency is not used outside the r-market.[38] All firms choose $d$ currency credit, and each firm uses DCP in some markets and LCP in others (with a threshold market $i_d^*$).

Panel b) shows the impact of introducing a swap line that lowers expected borrowing costs enough that some firms cross the threshold in proposition 2. A mass of firms borrow in $r$ currency and $j^* > 0$. In some markets, the volatility of the bilateral exchange rate is

[38]For the $r$ market, LCP is the same as RCP. Therefore, the $r$ currency is only used in trade with the $r$ country before the policy. This is by assumption. DCP could also be chosen in the $r$ market under $d$ credit. However, 1 guarantees RCP is chosen in the $r$ market if $\eta = 1$.

above the $\Phi_i$ threshold (proposition 1(c)) so the firms also start invoicing in the $r$ currency. This is true for a set of markets $i \in [0, i_r^*]$. The firms will switch to RCP instead of PCP as the country itself satisfied the $\Omega$ threshold in proposition 3(c). For markets $i \in (i_r^*, 1]$, the bilateral exchange rate is sufficiently stable, and the firms choose LCP instead.[39]

In the end, the area of the purple rectangle in figure A5 captures the usage of the $r$ currency. A further lowering of the swap line rate would increase the length of the rectangle. Both payments sent and received in the $r$ currency rise, as the two complement each other. This happens not just with respect to the $r$ country but also to the other countries with which it trades. The currency has jumpstarted into international status.

# E Additional Theoretical Results

For the baseline model, Appendix E.1 formally defines the profit functions and optimal price choices for a given firm $j$ in market $i$ under the different pricing regimes and Appendix E.2 defines formally the firm's profit function across difference choices of $\eta$. Appendix E.3 allows for a separate choice between the currency of borrowing and the currency of pricing of inputs. Appendix E.4 allows for variable mark-ups and potential demand complementarities in price-setting. Appendix E.5 derives a set of further predictions of the model on which countries would be more likely to see a jumpstart of the r-currency use after the introduction of a swap line, which we tested in section 5.3.

## E.1 Profit functions and optimal prices

The profits for firm $j$ in market $i$ under the different pricing regimes are:

$$\text{With LCP:} \quad \pi_i^{LCP}(p_i^j, \eta^j, \varepsilon^j, S, w) = \left[s_i p_i^j - C(\eta^j, \varepsilon^j, S, w)\right] (p_i^j / q_i)^{-\theta} \tag{A2}$$

$$\text{With PCP:} \quad \pi_i^{PCP}(p_i^j, \eta^j, \varepsilon^j, S, w) = \left[p_i^j - C(\eta^j, \varepsilon^j, S, w)\right] \left(\frac{p_i^j}{q_i s_i}\right)^{-\theta} \tag{A3}$$

$$\text{With RCP:} \quad \pi_i^{RCP}(p_i^j, \eta^j, \varepsilon^j, S, w) = \left[s_r p_i^j - C(\eta^j, \varepsilon^j, S, w)\right] \left(\frac{p_i^j s_r}{q_i s_i}\right)^{-\theta} \tag{A4}$$

$$\text{With DCP:} \quad \pi_i^{DCP}(p_i^j, \eta^j, \varepsilon^j, S, w) = \left[s_d p_i^j - C(\eta^j, \varepsilon^j, S, w)\right] \left(\frac{p_i^j s_d}{q_i s_i}\right)^{-\theta} \tag{A5}$$

[39] Under assumption 1, $i_r^* = i_d^*$ since the currencies are symmetric. Relaxing the assumption can cause the two threshold markets to differ, but this does not matter for the overarching logic of the results.

Firms choose prices to maximize the period-0 expectation of these expressions delivering:

$$\text{With LCP:} \quad p_i^{LCP}(\eta^j) = \frac{\theta}{\theta-1}\frac{\mathbb{E}\left[C(.)q_i^\theta\right]}{\mathbb{E}\left[s_i q_i^\theta\right]} \tag{A6}$$

$$\text{With PCP:} \quad p_i^{PCP}(\eta^j) = \frac{\theta}{\theta-1}\frac{\mathbb{E}\left[C(.)s_i^\theta q_i^\theta\right]}{\mathbb{E}\left[s_i^\theta q_i^\theta\right]} \tag{A7}$$

$$\text{With RCP:} \quad p_i^{RCP}(\eta^j) = \frac{\theta}{\theta-1}\frac{\mathbb{E}\left[C(.)\left(\frac{s_r}{q_i s_i}\right)^{-\theta}\right]}{\mathbb{E}\left[s_r^{1-\theta}s_i^\theta q_i^\theta\right]} \tag{A8}$$

$$\text{With DCP:} \quad p_i^{DCP}(\eta^j) = \frac{\theta}{\theta-1}\frac{\mathbb{E}\left[C(.)\left(\frac{s_d}{q_i s_i}\right)^{-\theta}\right]}{\mathbb{E}\left[s_d^{1-\theta}s_i^\theta q_i^\theta\right]} \tag{A9}$$

Hence, we obtain profits for firm $j$ in market $i$, given an optimal price choice, as a function of $\eta^j$ and the exogenous variables:

$$\pi_i^{LCP*}(\eta^j) = \mathbb{E}\left[s_i q_i^\theta\left(p_i^{LCP}(.)\right)^{1-\theta} - C(.)q_i^\theta(p_i^{LCP}(.))^{-\theta}\right] \tag{A10}$$

$$\pi_i^{PCP*}(\eta^j) = \mathbb{E}\left[\left(s_i^\theta q_i^\theta p_i^{PCP}(.)\right)^{1-\theta} - C(.)q_i^\theta\left(p_i^{PCP}(.)\right)^{-\theta}(s_i)^\theta\right] \tag{A11}$$

$$\pi_i^{RCP*}(\eta^j) = \mathbb{E}\left[s_i^\theta q_i^\theta(p_i^{RCP}(.))^{1-\theta}(s_r)^{1-\theta} - C(.)q_i^\theta\left(p_i^{RCP}(.)\right)^{-\theta}(s_i/s_r)^\theta\right] \tag{A12}$$

$$\pi_i^{DCP*}(\eta^j) = \mathbb{E}\left[s_i^\theta q_i^\theta(p_i^{DCP}(.))^{1-\theta}(s_d)^{1-\theta} - C(.)q_i^\theta\left(p_i^{DCP}(.)\right)^{-\theta}(s_i/s_d)^\theta\right] \tag{A13}$$

## E.2 Define profits across all markets for the firm

The profits of the firm come from aggregating across all of its markets. Completing the expression in equation (7), each firm $j$ chooses its currency of credit $\eta^j$ to maximize the profit function $\Pi^j(\eta^j)$ that is defined by:

$$\begin{aligned}\Pi^j(\eta^j) = &\int_{\Delta^{LCP}(\eta^j)}\pi_i^{LCP*}(\eta^j)di + \int_{\Delta^{PCP}(\eta^j)}\pi_i^{PCP*}(\eta^j)di + \int_{\Delta^{RCP}(\eta^j)}\pi_i^{RCP*}(\eta^j)di \\ &+ \int_{\Delta^{DCP}(\eta^j)}\pi_i^{DCP*}di + \delta_r\pi_r^{RCP*}(\eta^j) + \delta_d\pi_d^{DCP*}(\eta^j)\end{aligned} \tag{A14}$$

The four sets in the integrals correspond to the the partition of the continuum of markets the firm sells to according to the pricing technology the firm uses in them: $\Delta^{LCP} \cup \Delta^{PCP} \cup$

$\Delta^{RCP} \cup \Delta^{DCP} = [0,1]$. The mass in each of these sets depends on $\eta^j$.

The terms $\pi_r^{RCP*}$ and $\pi_d^{DCP*}$ correspond to profits in the $r$ and $d$ markets respectively. These markets have mass $\delta_r$ and $\delta_d$. The expression above assumes that sales to the $r$ and $d$ markets always employ LCP, which of course is the same as RCP and DCP, respectively.

## E.3 Extension: currency of credit versus currency of inputs

When the firm chooses $\eta^j$ in period 0, it is choosing the type of input it will use in period 1 and what currency that input's price will be denominated in. We assume the firm also matches the currency of its borrowing with the currency of the input. However, the firm could choose to borrow in another currency and use it to buy the currency of the input at the exchange rate in period 1. This firm would then have to pay back the loan in period 2, which would require exchanging the currency of its sales to the currency of the credit. Insofar as the exchange rates in period 1 and 2 are different, then this creates exchange-rate risk. We now ask the question of whether the firm will want to have the currencies of inputs and credit match to avoid this risk, or not.

To answer it, the first new assumption is that the exchange rates at date 1, call them $\tilde{S}$ are not longer the same as in period 2, denoted by $S$ as before. Input $l^j$ is now chosen in period 2, once all uncertainty is realized, and to meet demand at the sticky price. Input $x^j$ though is paid for and chosen in period 1, using credit in either the $r$ currency, if $\zeta^j = 1$, or the $d$ currency if $\zeta^j = 0$. The variable $\zeta^j$ is chosen optimally by the firm and we do not ex-ante restrict the firm from choosing an interior solution. The realised cost of $x^j$, as function of both $\zeta^j$ and $\eta^j$, is now given by:

$$\eta^j \tilde{s}_r \left( \rho_r \frac{\varepsilon^j}{b_r} \zeta^j \frac{s_r}{\tilde{s}_r} + \frac{1}{b_d}(1-\zeta^j)\frac{s_d}{\tilde{s}_d} \right) + (1-\eta^j)\tilde{s}_d \left( \rho_d \frac{\varepsilon^j}{b_r} \zeta^j \frac{s_r}{\tilde{s}_r} + \frac{1}{b_d}(1-\zeta^j)\frac{s_d}{\tilde{s}_d} \right). \tag{A15}$$

Note if $\eta^j = \zeta^j$, the risk from the intermediate exchange rates are perfectly hedged and we are back to the problem in the main text.

We make a few auxiliary assumptions to make the analysis simpler: (i) all markets $i$ are identical and the firm does not sell to the $d$ and $r$ markets, (ii) $w$ is known and $q_i = 1$ for all markets, (iii) the marginal distributions of $s_r$ and $s_d$ are identical, as are those of $\tilde{s}_r$ and $\tilde{s}_d$, and (iv) all exchange rates follow random walks. Using these, the following holds:

**Proposition A1.** *The choices of currency of credit and currency of inputs are both bang-bang:* $\eta \in \{0,1\}$ *and* $\zeta \in \{0,1\}$. *A firm* $j$ *only chooses* $(\eta^j, \zeta^j) = (0,0)$ *or* $(\eta^j, \zeta^j) = (1,1)$ *so the*

*currency of credit and the currency of the inputs coincide under LCP. The sufficient condition for the same to be true under PCP is* $\sigma_{i\tilde{r}} = \sigma_{i\tilde{d}}$. *The sufficient condition under RCP or DCP is* $\sigma_{i\tilde{r}} = \sigma_{i\tilde{d}}$ *and* $\sigma_{\tilde{r}\tilde{d}} \geq 0$.

The choices of currency of credit and currency of inputs are both bang-bang: $\eta^j \in \{0,1\}$ and $\zeta^j \in \{0,1\}$.

The convexity of the profit function extends to both currency choices. The relevant question then is whether the firm ever chooses $(\eta^j, \zeta^j) = (1,0)$ or $(\eta^j, \zeta^j) = (0,1)$, that is to have the currency of its inputs and credit mismatched. The answer is that this is never the case under LCP and under mild conditions under PCP, DCP or RCP. The firm typically does not want to introduce a mismatch between part of its inputs and the credit, since this introduces variability in its marginal costs, and thus the markup resulting from sticky prices deviates from its optimal level more often.

The sufficient conditions in the proposition simply imply that the covariances between the exchange rates are such that the firm cannot hedge exchange rate driven fluctuations in markups by having a mismatch between its trade credit and the currency of inputs. These are stringent sufficient conditions; the full (lengthy) conditions are provided in the following proof of the proposition.

## E.4 Extension: demand complementarities

This section studies three extensions to the main results. First, it allows the production function to be a generic homogeneous function of degree one, $F(x^j, l^j)$, as opposed to a Cobb-Douglas specification. Second, it allows for a generic demand function in market $i$ given by $Y(p_i^j/q_i)$ as opposed to a constant-elasticity of demand, where $p_i^j$ is the price in local currency units and $q_i$ is the local demand shifter. Following Arkolakis *et al.* (2018), this specification is quite general and accommodates demand complementarities: if other firms raise their price in a particular market, this can be captured by an increase in $q_i$. More relevant for the question in this paper, if more firms choose their prices in a particular currency, then the covariance of $q_i$ and that exchange rate will rise, and this provides an impetus for firm $j$ itself to also choose to invoice in this currency. The parameter $\lambda$ measures the elasticity of the firm's desired price to $q_i$ and so captures the strength of this strategic complementarity.

The third extension is that we now allow the vector of random variables $(S, w, Q)$ to follow any distribution. At the same time, all the results now follow from log-linear approximations around the non-stochastic price choice across markets. It is useful to define

$\mathcal{S} = (\varepsilon^j, S, w, q, C)$ as the vector of all the random variables, and redundantly including the marginal cost in it, as it is also a function of the state variable as well as the currency of credit choice variable.

**Proposition A2.** *In the case where the demand curve exhibits strategic complementarities and the firm's production function is homogeneous of degree 1, to the second order, the model exhibits the following properties:*

*(a) The currency choice of invoice is still determined by thresholds $\Phi$ and $\Omega$ as in propositions 1 and 3.*

*(b) If demand complementarities are sufficiently strong, $\lambda > 1/2$, an increase in $\sigma_{qr}$ makes it more likely that the firm will choose RCP over LCP.*

*(c) A shift in the distribution of credit costs to $\tilde{G}^j(\varepsilon^j)$ that is first-order stochastically dominated by the previous one still weakly leads to an increase in r-currency invoicing and r-currency credit as in proposition 3.*

The lessons in this paper are unchanged, especially as it concerns part (c), and the empirical predictions that followed from it.

At the same time, result (b) introduces a new mechanism. The presence of demand complementarities can introduce a new amplification force for the $r$ currency. If more firms start pricing in $r$ currency in market $i$ (raising $\sigma_{qr}$), the firm wants to follow them and price in $r$ currency as well. The larger is the demand complementarity, the stronger this force is.

## E.5 Extension: heterogeneous effects

To illustrate heterogeneous effects, appendix F.6 proves the following:

**Proposition A3.** *Consider a firm that initially uses d-credit, for whom the distribution of $\varepsilon^j$ shifts to $\tilde{G}^j(\varepsilon^j)$ from $G^j(\varepsilon^j)$, as defined in proposition 3(a), as a result of a new swap line. The swap line will have a greater impact on the firm's use of the r-currency, either in terms of picking r-credit or increasing the share of markets where the firm chooses RCP conditional on choosing r-credit, if:*

*(a) the size of the r market becomes larger, starting from the point where the d and r markets are approximately the same size;*

*(b) $\alpha$ is higher, so there are more imported inputs using credit.*

The first prediction follows directly from proposition 2(b). The firm prices in currency $r$ in the $r$ market and the complementarity between pricing currency and credit currency means that, abstracting from the relative cost of borrowing, profits are greater in the $r$ market when $r$-credit is used. Hence, a larger $r$-market raises $\Psi$. This means that it is easier for the introduction of a swap line to lead to a switch to $r$-credit.

The second result in the proposition pertains to a higher $\alpha$. In the model this corresponds to a greater share of the inputs requiring working capital. The change in $\alpha$ has an impact through the left hand side of the threshold in proposition 2a). In particular, the higher $\alpha$ the greater the change in the expected borrowing costs that arises through the introduction. To see this, start by considering what happens as $\alpha \to 0$. Then working capital plays a minimal role in the firm's cost of production and the reduction in the tail risk of borrowing costs brought about by the swap line has a negligible impact on the firm's choices. As $\alpha$ increases, the introduction of the swap line generates a greater change in the left-hand side of the threshold in proposition 2a) and, therefore, the firm becomes more likely to cross the threshold and switch to $r$-credit.

# F Proofs

## F.1 Proof of proposition 1

**Part a)** Let the part of marginal costs that depends on the $x^j$ input be denoted by:

$$c(\eta^j) = \eta^j s_r \rho_r(\varepsilon^j / b_r) + (1 - \eta^j) s_d(\rho_d / b_d). \tag{A16}$$

For the general choice of $\eta^j$, optimal profits with LCP in market $i$ can be written as:

$$\pi_i^{LCP*}(c(\eta^j)) = \frac{1}{\theta - 1}\left(\frac{\theta}{\theta - 1}\right)^{-\theta} \mathbb{E}\left[s_i\right]^{\theta} \mathbb{E}\left[\left(\frac{c(\eta^j)}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right]^{1-\theta}. \tag{A17}$$

These two functions are continuous and differentiable. Crucially, given our assumptions, the $\pi_i^{LCP*}(.)$ function only depends on $\eta^j$ via the $c(.)$ function. And since the $c(\eta^j)$

function is linear $\frac{\partial^2 c(\eta)}{\partial \eta^2} = 0$. The chain rule then implies that:

$$\frac{\partial^2 \pi_i^{LCP*}(c)}{\partial \eta^2} = \theta \left(\frac{\theta}{\theta-1}\right)^{-\theta} \mathbb{E}\left[s_i\right]^{\theta} \mathbb{E}\left[\left(\frac{c(\eta^j)}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right]^{-\theta-1} \mathbb{E}\left[\frac{\partial c(\eta^j)}{\partial \eta} c(\eta^j)^{\alpha-1}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right]^2$$
$$+(1-\alpha)\left(\frac{\theta}{\theta-1}\right)^{-\theta} \mathbb{E}\left[s_i\right]^{\theta} \mathbb{E}\left[\left(\frac{c(\eta^j)}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right]^{-\theta} \mathbb{E}\left[\left(\frac{\partial c(\eta^j)}{\partial \eta}\right)^2 c(\eta^j)^{\alpha-2}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right].$$

Both terms on the right-hand side are positive since $\alpha < 1$. Therefore: $\frac{\partial^2 \pi_i^{LCP*}(c)}{\partial \eta^2} \geq 0$. It is straightforward to verify the same is true under alternative pricing currencies.

Now consider the firm's total profit function across all markets laid out under equation (A14). Start by focussing on the first two terms of the expression for $\Pi(\eta)$:

$$\int_{\Delta^{LCP}(\eta)} \pi_i^{LCP*}(\eta) di + \int_{\Delta^{PCP}(\eta)} \pi_i^{PCP*}(\eta) di. \tag{A18}$$

Using Leibniz's rule, the first derivative of this expression is:

$$\int_{\Delta^{LCP}} \frac{\partial \pi_i^{LCP*}}{\partial \eta} di + \int_{\Delta^{PCP}} \frac{\partial \pi_i^{PCP*}}{\partial \eta} di + \underbrace{\pi_k^{LCP*} - \pi_k^{PCP*}}_{=0}, \tag{A19}$$

where $k$ is the marginal market at which the firm was just indifferent between these two pricing options before the change. Thus, the last term must be zero. Taking another round of derivatives:

$$\underbrace{\int_{\Delta^{LCP}} \frac{\partial^2 \pi_i^{LCP*}}{\partial \eta^2} di + \int_{\Delta^{PCP}} \frac{\partial^2 \pi_i^{PCP*}}{\partial \eta^2} di}_{>0} + \underbrace{\frac{\partial \pi_k^{LCP*}}{\partial \eta} - \frac{\partial \pi_k^{PCP*}}{\partial \eta}}_{>0} \tag{A20}$$

where we assumed that the the size of the set $\Delta^{LCP*}$ increased at the expense of the set $\Delta^{PCP*}$ following an increase in $\eta$. The first two terms are strictly positive since we already showed above that the profit functions in individual markets are convex. The following difference of two terms is also positive: since the marginal market switched to LCP, it must be that the difference in marginal profits is positive. If instead the change in $\eta$ decreased the size of $\Delta^{LCP*}$, then the difference of terms would reverse signs, which would then also be positive.

Considering the other two integrals, over the DCP and RCP markets, leads by the

same logic to the same conclusion. Each of the profit functions within non-marginal markets is convex, and each of the multiple combinations of positive marginal markets all must be positive because at the optimum, any switcher has the property that the first derivative of the profit function under the new pricing currency exceeds that of the first derivative under the old pricing currency. Finally, adding in markets $r$ and $d$ keeps the result, since profits in those markets are convex in $\eta^j$ and the firm always chooses the equivalent of LCP.

Altogether, we conclude that the overall profits of the firm across all the markets is a convex function of $\eta$. Since the firm is risk neutral it follows that the optimal choice is at one of the bounds, either $\eta^j = 0$ or $\eta^j = 1$.

**Part b)** If $\eta^j = 1$, marginal costs are equal to

$$C(1, \varepsilon^j, S, w) = \left(\frac{s_r \rho_r (\varepsilon^j / b_r)}{\alpha}\right)^{\alpha} \left(\frac{w}{1-\alpha}\right)^{1-\alpha}. \tag{A21}$$

Plugging optimal prices when $\eta^j = 1$ into the profit functions in equations (A10)-(A13) and simplifying gives the expressions for maximized profits under LCP, RCP, DCP and PCP:

$$\pi^{LCP*}(\eta^j = 1) = \Xi \, \mathbb{E}\left[s_i q_i^{\theta}\right]^{\theta} \mathbb{E}\left[(s_r)^{\alpha} (w)^{1-\alpha} (q_i)^{\theta}\right]^{(1-\theta)}, \tag{A22}$$

$$\pi^{PCP*}(\eta^j = 1) = \Xi \, \mathbb{E}\left[(s_i q_i)^{\theta}\right]^{\theta} \mathbb{E}\left[(s_r)^{\alpha} (w)^{1-\alpha} (s_i q_i)^{\theta}\right]^{1-\theta}, \tag{A23}$$

$$\pi^{RCP*}(\eta^j = 1) = \Xi \, \mathbb{E}\left[(s_r)^{1-\theta} (s_i q_i)^{\theta}\right]^{\theta} \mathbb{E}\left[(s_r)^{\alpha-\theta} (w)^{1-\alpha} (s_i q_i)^{\theta}\right]^{1-\theta}, \tag{A24}$$

$$\pi^{DCP*}(\eta^j = 1) = \Xi \, \mathbb{E}\left[(s_d)^{1-\theta} (s_i q_i)^{\theta}\right]^{\theta} \mathbb{E}\left[(s_r)^{\alpha} (w)^{1-\alpha} (s_i q_i / s_d)^{\theta}\right]^{1-\theta}, \tag{A25}$$

$$\text{where} \quad \Xi \equiv \frac{1}{\theta - 1} \left(\frac{\theta}{\theta - 1}\right)^{-\theta} \mathbb{E}\left[\left(\frac{\rho_r \varepsilon^j / b_r}{\alpha}\right)^{\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\right]^{1-\theta}. \tag{A26}$$

If $\eta^j = 0$, we would instead have $\Xi \equiv \frac{1}{\theta-1}\left(\frac{\theta}{\theta-1}\right)^{-\theta}\left[\left(\frac{\rho_d / b_d}{\alpha}\right)^{\alpha}\left(\frac{1}{1-\alpha}\right)^{1-\alpha}\right]^{1-\theta}$ and would swap $s_r$ for $s_d$ in the second expectation that appears in each of the four profit functions above.

Under the assumption that $\varepsilon^j = 1$ and that $d$ and $r$ are otherwise identical in terms of mean, variance and costs such that (i) $\rho_r = \rho_d$, (ii) $b_r = b_d$, (iii) $\mu_r = \mu_d$ and (iv) $\sigma_r = \sigma_d$, then the condition for a switch to $r$-credit from $d$ credit increasing profits in market $i$ under

RCP is:

$$\pi^{RCP*}(1) > \pi^{RCP*}(0) \Leftrightarrow \mathbb{E}\left[s_r^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]^{1-\theta} > \mathbb{E}\left[s_d^{\alpha} w^{1-\alpha} s_i^{\theta} s_r^{-\theta} q_i^{\theta}\right]^{1-\theta}. \tag{A27}$$

Using the properties of the log-normal distributions, and maintaining restrictions on the equality of parameters, this expression simplifies to:

$$\theta\left(\sigma_r^2 - \sigma_{rd}\right) > (1-\alpha)(\sigma_{rw} - \sigma_{dw}) + \theta\left(\sigma_{ri} - \sigma_{di}\right) + \theta\left(\sigma_{rq_i} - \sigma_{dq_i}\right) \tag{A28}$$

**Part c)** The firm prefers RCP over LCP in market $i$ if:

$$\pi_i^{RCP*}(1) \geq \pi_i^{LCP*}(1) \;\Leftrightarrow \tag{A29}$$

$$\mathbb{E}\left[s_r^{1-\theta} s_i^{\theta} q_i^{\theta}\right]^{\theta} \mathbb{E}\left[s_r^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]^{1-\theta} \geq \mathbb{E}\left[s_i q_i^{\theta}\right]^{\theta} \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} q_i^{\theta}\right]^{1-\theta} \tag{A30}$$

Assuming log-normal distributions and that $d$ and $r$ have the same mean and variance, this expression simplifies to:

$$\sigma_i^2 \geq \sigma_r^2 + 2\left[\alpha(\sigma_{ir} - \sigma_r^2) + (1-\alpha)(\sigma_{iw} - \sigma_{rw})\right]. \tag{A31}$$

## F.2 Proof of proposition 2

**Part a)** This proof for now assumes that PCP is not used, so $\Delta^{PCP}(\eta) = \emptyset$. This would be justified by the condition in proposition 3c) holding. Moreover, proposition 3c) will show that if $\eta^j = 1$, then $\Delta^{DCP}(1) = \emptyset$ and conversely that $\Delta^{RCP}(0) = \emptyset$.

The condition for $r$ credit to be chosen by firm $j$ is that $\Pi^j(1) \geq \Pi^j(0)$. This translates into:

$$\left[\left(\frac{\rho_r / b_r}{\alpha}\right)^{\alpha} \int \left(\varepsilon^j\right)^{\alpha} dG^j(\varepsilon^j)\right]^{1-\theta} A_r \geq \left[\left(\frac{\rho_d / b_d}{\alpha}\right)^{\alpha}\right]^{1-\theta} A_d \tag{A32}$$

where the two terms are defined as:

$$A_r = \int_{\Delta^{RCP}(1)} \mathbb{E}\left[s_r^{1-\theta} s_i^{\theta} q_i^{\theta}\right]^{\theta} \left(\mathbb{E}\left[s_r^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]\right)^{1-\theta} di + \int_{\Delta^{LCP}(1)} \mathbb{E}[s_i q_i^{\theta}]^{\theta}\, \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} q_i^{\theta}\right]^{1-\theta} di$$
$$+ \delta_r\, \mathbb{E}[s_r q_r^{\theta}]^{\theta}\, \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} q_r^{\theta}\right]^{1-\theta} + \delta_d\, \mathbb{E}[s_d q_d^{\theta}]^{\theta}\, \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} q_d^{\theta}\right]^{1-\theta}. \tag{A33}$$

$$A_d = \int_{\Delta^{DCP}(0)} \mathbb{E}\left[s_d^{1-\theta} s_i^{\theta} q_i^{\theta}\right]^{\theta} \left(\mathbb{E}\left[s_d^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]\right)^{1-\theta} di + \int_{\Delta^{LCP}(0)} \mathbb{E}\left[s_i q_i^{\theta}\right]^{\theta}\, \mathbb{E}\left[s_d^{\alpha} w^{1-\alpha} q_i^{\theta}\right]^{1-\theta} di$$
$$+ \delta_r\, \mathbb{E}\left[s_r q_r^{\theta}\right]^{\theta}\, \mathbb{E}\left[s_d^{\alpha} w^{1-\alpha} q_r^{\theta}\right]^{1-\theta} + \delta_d\, \mathbb{E}[s_d q_d^{\theta}]^{\theta}\, \mathbb{E}\left[s_d^{\alpha} w^{1-\alpha} q_d^{\theta}\right]^{1-\theta}. \tag{A34}$$

Rewriting this produces the result in the proposition where $\Psi = (A_r/A_d)^{\frac{1}{(\theta-1)\alpha}}$.

Relaxing the assumption that $\Delta^{PCP}(\eta) = \emptyset$ simply adds the expected revenues from the set of PCP markets to the two equations.

**Part b)** First note that under assumption 1, we have $\Delta^{DCP}(0) = \Delta^{RCP}(1)$ and $\Delta^{LCP}(0) = \Delta^{LCP}(1)$. Moreover, under the assumption, all the expectations mirror one another; that is: $\mathbb{E}\left[s_r^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right] = \mathbb{E}\left[s_d^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]$ etc. Hence, so long as $\delta_r = \delta_d$, $\Psi = 1$.

Starting from this point an increase in $\delta_r$ raises $A_r$ by:

$$\mathbb{E}[s_r q_r^{\theta}]^{\theta}\, \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} q_r^{\theta}\right]^{1-\theta},$$

and $A_d$ by

$$E\left[s_r q_r^{\theta}\right]^{\theta}\, \mathbb{E}\left[s_d^{\alpha} w^{1-\alpha} q_r^{\theta}\right]^{1-\theta}.$$

Assumption 1 ensures that $\mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} q_r^{\theta}\right]^{1-\theta} > \mathbb{E}\left[s_d^{\alpha} w^{1-\alpha} q_r^{\theta}\right]^{1-\theta}$. Hence, $A_r$ increases by more than $A_d$. So long as $A_r \geq A_d$ this amounts to an increase in $\Psi$.

## F.3 Proof of proposition 3

**Part a)** This follows immediately from the description of how the swap line works, and the definition of borrowing costs.

**Part b)** This follows directly from proposition 2.

**Part c)** Using the profits under the different pricing regimes stated in the proof of 2, the

firm prefers RCP over DCP in market $i$ if:

$$\pi_i^{RCP*}(1) \geq \pi_i^{DCP*}(1) \quad \Leftrightarrow \tag{A35}$$

$$\mathbb{E}\left[s_r^{1-\theta} s_i^{\theta} q_i^{\theta}\right]^{\theta} \mathbb{E}\left[s_r^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]^{1-\theta} \geq \mathbb{E}\left[s_d^{1-\theta} s_i^{\theta} q_i^{\theta}\right]^{\theta} \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} s_d^{-\theta} s_i^{\theta} q_i^{\theta}\right]^{1-\theta}. \tag{A36}$$

Under the assumption that all of these random variables follow log-normal distributions and that the $r$ and $d$ currencies have the same expected rate of depreciation, due to the assumed peg, this simplifies to:

$$\left[\alpha\left(\sigma_r^2 - \sigma_{rd}\right)\right] \geq (1-\alpha)\left(\sigma_{dw} - \sigma_{rw}\right) - \frac{\sigma_r^2 - \sigma_d^2}{2}. \tag{A37}$$

We further assumed that the $r$ and $d$ currencies were similar to each other in the sense that $\sigma_r^2 = \sigma_d^2$ and that $\sigma_{rw} - \sigma_{dw}$. Therefore the condition boils down to $\sigma_r^2 - \sigma_{rd} \geq 0$ which is always true unless the two currencies are perfectly correlated.

Next, the firm prefers RCP over PCP if:

$$\pi_i^{RCP*}(1) \geq \pi_i^{PCP*}(1) \;\Leftrightarrow \tag{A38}$$

$$\mathbb{E}\left[s_r^{1-\theta} s_i^{\theta} q_i^{\theta}\right]^{\theta} \mathbb{E}\left[s_r^{\alpha-\theta} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]^{1-\theta} \geq \mathbb{E}\left[s_i^{\theta} q_i^{\theta}\right]^{\theta} \mathbb{E}\left[s_r^{\alpha} w^{1-\alpha} s_i^{\theta} q_i^{\theta}\right]^{1-\theta} \tag{A39}$$

Under the log-normal distribution and the assumption of equal means, this can be simplified to

$$(2\alpha - 1)\sigma_r^2 + 2(1-\alpha)\sigma_{rw} \geq 0 \quad \Leftrightarrow \quad \sigma_{rw} \geq \sigma_r^2\left(\frac{0.5-\alpha}{1-\alpha}\right) \equiv \Omega. \tag{A40}$$

This proves the result.

## F.4 Proof of proposition A1

Define the firm's realized cost of buying one unit of input $x^j$ as:

$$c(\eta^j, \zeta^j) = \eta^j \tilde{s}_r \rho_r \left(\frac{\varepsilon^j}{b_r}\zeta^j \frac{s_r}{\tilde{s}_r} + \frac{1}{b_d}(1-\zeta^j)\frac{s_d}{\tilde{s}_d}\right) + (1-\eta^j)\tilde{s}_d \rho_d \left(\frac{\varepsilon^j}{b_r}\zeta^j \frac{s_r}{\tilde{s}_r} + \frac{1}{b_d}(1-\zeta^j)\frac{s_d}{\tilde{s}_d}\right). \tag{A41}$$

By substituting $c(\eta^j, \zeta^j)$ for $c(\eta^j)$ and repeating the steps in part a) of the proof of proposition 1 in Appendix F.1, it is straightforward to show that for any given choice of $\eta^j$ the problem is convex in $\zeta^j$ and vice versa under LCP. The same holds in other pricing

regimes. Hence the firm will make four potential choices: $(\eta^j, \zeta^j) \in \{(0,0),(0,1),(1,0),(1,1)\}$.

The proof of the proposition proceeds as follows. We always assume that the firm prefers $(\eta^j, \zeta^j) = (1,1)$ to $(\eta^j, \zeta^j) = (0,0)$, or $r$ as opposed to $d$ as its currencies of credit and capital. We ask whether it will choose $\zeta^j = 1$ if $\eta^j = 1$. That is, we derive the sufficient conditions for the firm to always choose $r$ credit, if it is buying $r$-denominated capital.

The proof is broken down by pricing regimes.

**The sufficient condition under LCP.** Since all markets are the same, under LCP the firm's profits are given by:

$$\pi^{LCP*}(\eta^j, \zeta^j) = \mathbb{E}\left[ s_i (p_i^{LCP})^{1-\theta} - \left(\frac{c(\eta^j, \zeta^j)}{\alpha}\right)^{\alpha} \left(\frac{w}{1-\alpha}\right)^{1-\alpha} (p_i^{LCP})^{-\theta} \right]. \tag{A42}$$

Using the definition of optimal prices from appendix E.1 we obtain:

$$p_i^{LCP} = \frac{\theta}{\theta - 1} \frac{\mathbb{E}\left[\left(\frac{c(\eta^j, \zeta^j)}{\alpha}\right)^{\alpha}\right]}{\mathbb{E}\left[s_i\right]} \left(\frac{w}{1-\alpha}\right)^{1-\alpha}. \tag{A43}$$

Dropping terms that do not depend on choices, the firm chooses $\eta^j, \zeta^j$ to solve:

$$\max_{\eta^j, \zeta^j} \left\{ \mathbb{E}\left[ \left( c(\eta^j, \zeta^j) \right)^{\alpha} \right]^{1-\theta} \right\}. \tag{A44}$$

Therefore, using the definition of $c(.)$ in equation (A41), the firm will choose $(\eta^j, \zeta^j) = (1,1)$ over $(\eta^j, \zeta^j) = (0,0)$ if:

$$\mathbb{E}\left[ \left( \rho_r (\varepsilon^j / b_r) s_r \right)^{\alpha} \right] \leq \mathbb{E}\left[ \left( (\rho_d / b_d) s_d \right)^{\alpha} \right]. \tag{A45}$$

Since $s_r$ and $s_d$ have the same marginal distributions, this amounts to $\mathbb{E}\left[\varepsilon_j^{\alpha}\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^{\alpha}$.

Now, imagine that $\eta^j = 1$, and determined the optimal choice of $\zeta^j$. Convexity means the firm will go for a bang-bang solution. In particular, it will choose $\zeta^j = 1$ if:

$$\mathbb{E}\left[ \left( \rho_r (\varepsilon^j / b_r) s_r \right)^{\alpha} \right] \leq \mathbb{E}\left[ \left( \tilde{s}_r (\rho_d / b_d) \frac{s_d}{\tilde{s}_d} \right)^{\alpha} \right]. \tag{A46}$$

Using the log-normal distribution assumption:

$$\mathbb{E}\left[\varepsilon_j^{\alpha}\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^{\alpha} \frac{\mathbb{E}\left[s_d^{\alpha}\tilde{s}_d^{-\alpha}\tilde{s}_r^{\alpha}\right]}{\mathbb{E}\left[s_r^{\alpha}\right]} \tag{A47}$$
$$= \exp\left\{\alpha(\mu_d - \mu_r) + \frac{\alpha^2}{2}(\sigma_d^2 - \sigma_r^2) + \alpha(\tilde{\mu}_r - \tilde{\mu}_d) + \frac{\alpha^2}{2}\sigma_{\tilde{r}}^2 + \frac{\alpha^2}{2}\sigma_{\tilde{d}}^2 - \alpha^2\sigma_{\tilde{r}\tilde{d}} - \alpha^2\sigma_{d\tilde{d}} + \alpha^2\sigma_{d\tilde{r}}\right\}.$$

With common marginals ($\sigma_d^2 - \sigma_r^2 = \mu_d - \mu_r = \tilde{\mu}_r - \tilde{\mu}_d = 0$), this simplifies to:

$$\mathbb{E}\left[\varepsilon_j^{\alpha}\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^{\alpha} \exp\left\{\frac{\alpha^2}{2}\sigma_{\tilde{r}}^2 + \frac{\alpha^2}{2}\sigma_{\tilde{d}}^2 - \alpha^2\sigma_{\tilde{r}\tilde{d}} + \alpha^2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}})\right\}. \tag{A48}$$

Recall that the condition under which the firm will choose $(\eta^j, \zeta^j) = (1,1)$ against $(\eta^j, \zeta^j) = (0,0)$ is $\mathbb{E}\left[\varepsilon_j^{\alpha}\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^{\alpha}$. The sufficient condition for the firm to prefer $(\eta^j, \zeta^j) = (1,1)$ to $(\eta^j, \zeta^j) = (1,0)$ is then:

$$\sigma_{\tilde{r}}^2 + \sigma_{\tilde{d}}^2 - 2\sigma_{\tilde{r}\tilde{d}} + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) \geq 0. \tag{A49}$$

Using the facts that $\text{Var}(\tilde{s}_r - \tilde{s}_d) = \sigma_{\tilde{d}}^2 + \sigma_{\tilde{r}}^2 - 2\sigma_{\tilde{d}\tilde{r}} \geq 0$ to replace the first three terms, we obtain:

$$\text{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) \geq 0. \tag{A50}$$

The steps can easily be repeated for the symmetric case where the firm chooses between $(\eta^j, \zeta^j) = (0,0)$ and $(\eta^j, \zeta^j) = (0,1)$. The condition is now:

$$\text{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{r\tilde{d}} - \sigma_{r\tilde{r}}) \geq 0. \tag{A51}$$

**The sufficient condition under PCP.** Analogous steps to those taken above under PCP, lead to the objective:

$$\max_{\eta^j, \zeta^j} \left\{\mathbb{E}\left[\left(c(\eta^j, \zeta^j)\right)^{\alpha} s_i^{\theta}\right]^{1-\theta}\right\}, \tag{A52}$$

and to the condition $\mathbb{E}\left[\varepsilon_j^{\alpha}\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^{\alpha} \exp\left\{\alpha\theta(\sigma_{id} - \sigma_{ir})\right\}$ for the firm to choose $(\eta^j, \zeta^j) = (1,1)$ over $(\eta^j, \zeta^j) = (0,0)$.

If $\eta^j = 1$, what is the optimal choice of $\zeta^j$? As before, the firm will go for a bang-bang

solution. It will choose $\zeta^j = 1$ if:

$$\mathbb{E}\left[\left(\rho_r(\varepsilon^j/b_r)s_r\right)^\alpha s_i^\theta\right] \leq \mathbb{E}\left[\left(\tilde{s}_r(\rho_d/b_d)\frac{s_d}{\tilde{s}_d}\right)^\alpha s_i^\theta\right] \quad \Leftrightarrow \tag{A53}$$

$$\mathbb{E}\left[\varepsilon_j^\alpha\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^\alpha \frac{\mathbb{E}_0\left[s_d^\alpha \tilde{s}_d^{-\alpha}\tilde{s}_r^\alpha s_i^\theta\right]}{\mathbb{E}_0\left[s_r^\alpha s_i^\theta\right]} \tag{A54}$$

With the assumption that $s_d$ and $s_r$ have the same marginals as do $\tilde{s}_d$ and $\tilde{s}_r$, this becomes:

$$\mathbb{E}\left[\varepsilon_j^\alpha\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^\alpha \exp\left\{\frac{\alpha^2}{2}\sigma_{\tilde{r}}^2 + \frac{\alpha^2}{2}\sigma_{\tilde{d}}^2 - \alpha^2\sigma_{\tilde{r}\tilde{d}} + \alpha^2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) + \alpha\theta(\sigma_{di} + \sigma_{i\tilde{r}} - \sigma_{ir} - \sigma_{i\tilde{d}})\right\}. \tag{A55}$$

Using the condition for $r$ currency to be used over $d$ currency in both choices, the sufficient condition for choosing $\zeta^j = 1$ is:

$$\mathrm{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) + \frac{2\theta}{\alpha}(\sigma_{i\tilde{r}} - \sigma_{i\tilde{d}}) \geq 0. \tag{A56}$$

**The sufficient condition under RCP.** Now consider a firm acting under RCP. Assume that the condition $\mathbb{E}_0\left[\varepsilon_j^\alpha\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^\alpha \exp\left\{\alpha\theta(\sigma_{id} - \sigma_{rd} - \sigma_{ir})\right\}$ is satisfied; this means that the firm will choose $(\eta^j, \zeta^j) = (1,1)$ over $(\eta^j, \zeta^j) = (0,0)$.

Again, imagine $\eta^j = 1$, and derive the optimal choice of $\zeta^j$. Following the analogous steps to the cases above, the firm will choose $\zeta^j = 1$ if:

$$\mathbb{E}\left[\left(\rho_r(\varepsilon^j/b_r)\right)^\alpha (s_r)^{\alpha-\theta}(s_i)^\theta\right] \leq \mathbb{E}\left[\left(\tilde{s}_r(\rho_d/b_d)\frac{s_d}{\tilde{s}_d}\right)^\alpha (s_r)^{-\theta}(s_i)^\theta\right] \quad \Leftrightarrow \tag{A57}$$

$$\mathbb{E}\left[\varepsilon_j^\alpha\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^\alpha \frac{\mathbb{E}\left[(s_d)^\alpha(\tilde{s}_d)^{-\alpha}(\tilde{s}_r)^\alpha(s_i)^\theta(s_r)^{-\theta}\right]}{\mathbb{E}\left[(s_r)^{\alpha-\theta}(s_i)^\theta\right]}. \tag{A58}$$

Since $s_d$ and $s_r$ have the same marginals as $\tilde{s}_d$ and $\tilde{s}_r$, the condition becomes:

$$\mathbb{E}\left[\varepsilon_j^\alpha\right] < \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^\alpha \times$$
$$\exp\left\{\frac{\alpha^2}{2}\sigma_{\tilde{r}}^2 + \frac{\alpha^2}{2}\sigma_{\tilde{d}}^2 - \alpha^2\sigma_{\tilde{r}\tilde{d}} + \alpha^2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) + \alpha\theta(\sigma_{id} + \sigma_{i\tilde{r}} - \sigma_{i\tilde{d}} - \sigma_{ir}) - \alpha\theta(\sigma_{dr} + \sigma_{r\tilde{r}} - \sigma_{r\tilde{d}})\right\}. \tag{A59}$$

Since $\mathbb{E}\left[\varepsilon_j^{\alpha}\right] \leq \left(\frac{\rho_d b_r}{\rho_r b_d}\right)^{\alpha} \exp\{\alpha\theta(\sigma_{id} - \sigma_{rd} - \sigma_{ir})\}$, this condition becomes:

$$\sigma_{\tilde{r}}^2 + \sigma_{\tilde{d}}^2 - 2\sigma_{\tilde{r}\tilde{d}} + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) + \frac{2\theta}{\alpha}(\sigma_{i\tilde{r}} - \sigma_{i\tilde{d}}) + \frac{2\theta}{\alpha}(\sigma_r^2 + \sigma_{r\tilde{d}} - \sigma_{r\tilde{r}}) \geq 0, \tag{A60}$$

with a symmetric condition for $\eta^j = 0$ under DCP.

**Completing the proof.** We have now derived three sufficient conditions, under the three different currency pricing regimes, for the firm to choose $\zeta^j = 1$ if $\eta^j = 1$, assuming the firm already prefers $(\eta^j, \zeta^j) = (1,1)$ to $(\eta^j, \zeta^j) = (0,0)$. To repeat, these are:

$$\text{With LCP:} \quad \text{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) \geq 0 \tag{A61}$$

$$\text{With PCP:} \quad \text{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) + \frac{2\theta}{\alpha}(\sigma_{i\tilde{r}} - \sigma_{i\tilde{d}}) \geq 0 \tag{A62}$$

$$\text{With RCP:} \quad \text{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) + \frac{2\theta}{\alpha}(\sigma_{i\tilde{r}} - \sigma_{i\tilde{d}}) + \frac{2\theta}{\alpha}(\sigma_r^2 + \sigma_{r\tilde{d}} - \sigma_{r\tilde{r}}) \geq 0 \tag{A63}$$

Symmetric conditions hold for the firm always choosing $\zeta^j = 0$ if $\eta^j = 0$.

Start with the LCP case. Recall the assumption that the exchange rates are random walks. It implies that:

$$\sigma_{d\tilde{d}} = \sigma_{\tilde{d}}^2, \quad \sigma_{r\tilde{r}} = \sigma_{\tilde{r}}^2, \quad \sigma_{r\tilde{d}} = \sigma_{\tilde{r}d} = \sigma_{\tilde{r}\tilde{d}}. \tag{A64}$$

Hence

$$\text{Var}(\tilde{s}_r - \tilde{s}_d) + 2(\sigma_{d\tilde{r}} - \sigma_{d\tilde{d}}) = \sigma_{\tilde{d}}^2 + \sigma_{\tilde{r}}^2 - 2\sigma_{\tilde{d}\tilde{r}} + 2(\sigma_{\tilde{d}\tilde{r}} - \sigma_{\tilde{d}}^2). \tag{A65}$$

Under the assumption that $\tilde{s}_d$ and $\tilde{s}_r$ share the same marginal distribution, we have $\sigma_{\tilde{d}}^2 + \sigma_{\tilde{r}}^2 - 2\sigma_{\tilde{d}}^2 = 0$. Hence a firm choosing LCP will never choose $(\eta, \zeta) = (1,0)$. Symmetrically, it will never choose $(\eta, \zeta) = (0,1)$.

Turning to the PCP case, if the firm chooses $(\eta^j, \zeta^j) = (1,1)$ over $(\eta^j, \zeta^j) = (1,0)$ under LCP, the sufficient condition for the firm to do so under PCP is $\sigma_{i\tilde{r}} \geq \sigma_{i\tilde{d}}$. Symmetrically, the sufficient condition for the firm not choosing $(\eta, \zeta) = (0,1)$ is $\sigma_{i\tilde{r}} - \sigma_{i\tilde{d}} \leq 0$. Hence, $\sigma_{i\tilde{r}} = \sigma_{i\tilde{d}}$ is the sufficient condition for the firm to always choose $(\eta^j, \zeta^j) = (0,0)$ or $(\eta^j, \zeta^j) = (1,1)$ under PCP.

Last, under RCP, and since we assumed that $\sigma_{i\tilde{r}} = \sigma_{i\tilde{d}}$, the sufficient condition is $\sigma_r^2 + \sigma_{r\tilde{d}} - \sigma_{r\tilde{r}} \geq 0$. But $\sigma_r^2 > \sigma_{r\tilde{r}}$, so $\sigma_{r\tilde{d}} \geq 0$ is sufficient. Under random walk exchange rates $\sigma_{r\tilde{d}} = \sigma_{\tilde{r}\tilde{d}}$. Hence, the sufficient condition becomes $\sigma_{\tilde{r}\tilde{d}} \geq 0$. This is the sufficient condition due to symmetry in the $\eta = 0$ DCP case also.

## F.5 Proof of proposition A2

**Proof Preliminary: The flexible price optimum.** The expression for profits when the price is set in local currency is now:

$$\pi_i^{LCP}(p_i^j, \mathcal{S}) = \left[s_i p_i^j - C\right] Y\left(\frac{p_i^j}{q_i}\right). \tag{A66}$$

Let $p_i^{F,j}(\mathcal{S})$ be the optimal price set by a firm that maximizes this expression. This is the optimal flexible price set by the firm that faces no nominal stickiness. The fact that we express this in local currency, as opposed to any of the alternatives, is irrelevant since the price flexibly adjusts to the exchange rates.

We approximate the model around the point where stochastic variables are at a fixed point equal to their means: $\mathcal{S} = (\bar{\varepsilon}^j, \bar{S}, \bar{w}, \bar{q}, \bar{C})$. We denote with a hat log-linear deviations from this point. It is straightforward to derive (e.g., Arkolakis *et al.*, 2018) that the optimal flexible price is, to the first order:

$$\hat{p}_i^{F,j} = (1-\lambda)\left(\hat{c}^j - \hat{s}_i\right) + \lambda \hat{q}_i \tag{A67}$$

where $\lambda$ depends on the shape of the demand function. For example, if the demand curve follows a Kimball Aggregator, $Y(p_i^j/q_i) = (1 - \vartheta(\ln(p_i^j) - \ln(q^i)))^{\theta/\vartheta}$, as for instance in Klenow & Willis (2016), then: $\lambda = 1 - (1 + \frac{\vartheta}{\theta - 1})^{-1}$.

Since $\hat{q}_i$ is common to all firms in that market, this introduces a complementarity in demand. The larger is $\lambda$, the stronger this is.

**Proof Preliminary: the marginal cost function.** The firm produces using a production function $F(x^j, l^j)$, which is homogeneous of degree one and has corresponding marginal cost function $C(\eta^j, \varepsilon^j, S, w, q)$. The approximation point that we used above is therefore defined by: $\bar{C}(\eta^j) = C^j(\eta^j, \bar{\varepsilon}^j, \bar{S}, \bar{w}, \bar{q})$.

To a first approximation around this point, we get:

$$\hat{c}^j(1, .) = \kappa_{1,w} w + \kappa_{1,r} s_r + \kappa_{1,\varepsilon^j} \varepsilon^j \tag{A68}$$

The new parameters are defined as:

$$\kappa_{1,w} = \frac{\partial C}{\bar{w}\partial w}(1, \bar{\varepsilon}^j, \bar{S}, \bar{w}, \bar{q}), \quad \kappa_{1,r} = \frac{\partial C}{\bar{S}_r \partial S_r}(1, \bar{\varepsilon}^j, \bar{S}, \bar{w}, \bar{q}), \quad \kappa_{1,\varepsilon^j} = \frac{\partial C}{\bar{\varepsilon}^j \partial \varepsilon^j}(1, \bar{\varepsilon}^j, \bar{S}, \bar{w}, \bar{q}). \tag{A69}$$

Finally, define $\sigma_c^2$ as the variance of $\hat{c}^j$ and $\sigma_{cx}$ as the relevant covariance with another log-linearized variable $x$.

**Proof Preliminary: LCP vs. PCP.** Recall the definition of the expressions for profits under LCP and PCP, re-written as a ratio of those at the steady state:

$$\pi_i^{LCP}(\hat{p}_i^j, \mathcal{S}) = \left[\exp\{\hat{s}_i + \hat{p}_i^j\} - C^j\right] Y \left(\exp\{\hat{p}_i^j - \hat{q}_i\}\right), \tag{A70}$$

$$\pi_i^{PCP}(\hat{p}_i^j, \mathcal{S}) = \left[\exp\{\hat{s}_i + \hat{p}_i^j\} - C^j\right] Y \left(\exp\{\hat{p}_i^j - \hat{s}_i - \hat{q}_i\}\right). \tag{A71}$$

We will approximate these about the flexible-price equilibrium, since when there is no uncertainty in the steady state, it is as if prices are flexible. Note however that since $\hat{p}_i^{F,j}$ was written in local-currency units, then it is the approximation point for LCP. For PCP, the point is: $\hat{p}_i^{F,j} - \hat{s}_i$.

From the definition of profit-maximizing prices:

$$\frac{\partial \pi^{PCP}(\hat{p}_i^{F,j} - \hat{s}_i, \mathcal{S})}{\partial \hat{p}_i^{F,j}} = \frac{\partial \pi^{LCP}(\hat{p}_i^{F,j}, \mathcal{S})}{\partial \hat{p}_i^{F,j}} = 0 \tag{A72}$$

Similarly, the second-derivatives will be the same and less than zero at this point. Therefore, to the second-order around the flexible price, we have that:

$$\pi^{PCP}(\hat{p}_i^j; \mathcal{S}) - \pi^{LCP}(\hat{p}_i^j; \mathcal{S}) = \frac{1}{2} \frac{\partial^2 \pi^{LCP}(\hat{p}_i^{F,j}; \mathcal{S})}{\partial \left(\hat{p}_i^{F,j}\right)^2} \left[\left(\hat{p}_i^j - \hat{s}_i - \hat{p}_i^{F,j}(\mathcal{S})\right)^2 - \left(\hat{p}_i^j - \hat{p}_i^{F,j}(\mathcal{S})\right)^2\right]. \tag{A73}$$

Next, we approximate around the non-stochastic point: $\bar{\mathcal{S}}$. Note that:

$$\frac{\partial^2 \pi^{LCP}(\hat{p}_i^{F,j}; \mathcal{S})}{\partial \left(\hat{p}_i^{F,j}\right)^2} = \frac{\partial^2 \pi^{LCP}(\hat{p}_i^{F,j}; \bar{\mathcal{S}})}{\partial \left(\hat{p}_i^{F,j}\right)^2} + \mathcal{O}(\|\mathcal{S} - \bar{\mathcal{S}}\|)) \tag{A74}$$

Therefore, taking expectations of the previous expression one gets:

$$\mathbb{E}\left[\pi^{PCP}(\hat{p}_i^j; \mathcal{S}) - \pi^{LCP}(\hat{p}_i^j; \mathcal{S})\right] \approx \frac{1}{2} \frac{\partial^2 \pi^{LCP}(\hat{p}_i^{F,j}; \bar{\mathcal{S}})}{\partial \left(\hat{p}_i^{F,j}\right)^2} \mathbb{E}\left[\left(\hat{p}_i^j - \hat{s}_i - \hat{p}_i^{F,j}(\mathcal{S})\right)^2 - \left(\hat{p}_i^j - \hat{p}_i^{F,j}(\mathcal{S})\right)^2\right]. \tag{A75}$$

It follows that the firm will choose PCP over LCP if this expression is negative, or:

$$\mathbb{E}\left(\hat{p}_i^j - \hat{s}_i - \hat{p}_i^{F,j}\right)^2 \leq \mathbb{E}\left(\hat{p}_i^j - \hat{p}_i^{F,j}\right)^2. \tag{A76}$$

Using equation (A67), this becomes:

$$\mathbb{E}\left((1-\lambda)\left(\hat{c}^j\right) + \lambda\hat{q}_i + \lambda\hat{s}_i\right)^2 \leq \mathbb{E}\left((1-\lambda)\left(\hat{c}^j - \hat{s}_i\right) + \lambda\hat{q}_i\right)^2. \tag{A77}$$

Expanding the expectations and rearranging gives

$$2\sigma_{ic}(1-\lambda) + 2\lambda\sigma_{iq} \leq (1-2\lambda)\sigma_i^2. \tag{A78}$$

We will make use of equation (A78) when comparing RCP to LCP below.

**Proof of proposition part (a): the $\Omega$ threshold.** The state-specific profits under RCP are:

$$\pi_i^{RCP}(\hat{p}_i^j, \mathcal{S}) = \left[\exp\{\hat{s}_r + \hat{p}_i^j\} - C^j\right] Y\left(\exp\{\hat{p}_i^j + \hat{s}_r - \hat{s}_i - \hat{q}_i\}\right). \tag{A79}$$

By similar steps the difference between this expression and the PCP expression is, to second-order:

$$\begin{aligned}&\mathbb{E}\left[\pi^{RCP}(\hat{p}_i^j; \mathcal{S}) - \pi^{PCP}(\hat{p}_i^j; \mathcal{S})\right] \approx \\ &\frac{1}{2}\frac{\partial^2 \pi^{PCP}(\hat{p}_i^{F,j}; \bar{\mathcal{S}})}{\partial\left(\hat{p}_i^{F,j}\right)^2}\mathbb{E}\left[\left(\hat{p}_i^{P,j} + \hat{s}_r - \hat{s}_i - \hat{p}_i^{F,j}(\mathcal{S})\right)^2 - \left(\hat{p}_i^j - \hat{p}_i^{F,j}(\mathcal{S})\right)^2\right].\end{aligned} \tag{A80}$$

Again combining with equation (A67), this becomes:

$$\mathbb{E}\left((1-\lambda)\hat{c}^j - \hat{s_r} + \lambda\hat{q}_i + \lambda\hat{s}_i\right)^2 \leq \mathbb{E}\left((1-\lambda)\hat{c}^j + \lambda\hat{q}_i + \lambda\hat{s}_i\right)^2. \tag{A81}$$

Evaluating the expectations gives:

$$\frac{1}{2}\sigma_r^2 \leq (1-\lambda)\sigma_{cr} + \lambda(\sigma_{qr} + \sigma_{ir}). \tag{A82}$$

Now, marginal costs are in equation (A68). Therefore: $\sigma_{cr} = \kappa_{1,r}\sigma_r^2 + \kappa_{1,w}\sigma_{rw}$. There-

fore, the expression above becomes:

$$\frac{1}{2}\sigma_r^2 \leq (1-\lambda)\left(\kappa_{1,r}\sigma_r^2 + \kappa_{1,w}\sigma_{rw}\right) + \lambda(\sigma_{qr} + \sigma_{ir}) \Leftrightarrow \tag{A83}$$

$$\sigma_{rw} \geq \frac{1}{2(1-\lambda)\kappa_{1,w}}\sigma_r^2 - \frac{\lambda}{(1-\lambda)\kappa_{1,w}}(\sigma_{qr} + \sigma_{ir}) - \frac{\kappa_{1,r}}{\kappa_{1,w}}\sigma_r^2. \tag{A84}$$

This threshold is just like the one in proposition 3(c). In fact, when $\lambda = 0$ and the production function is Cobb-Douglas so $\kappa_{1,r} = \alpha$ and $\kappa_{1,w} = 1 - \alpha$, then the right-hand side of the expression above simplifies to the $\Omega$ defined in the proposition.

**Proof of proposition part (a): the $\Phi$ threshold.** Inspecting equation (A79), it is apparent that to compare RCP and LCP it is sufficient to add $\sigma_r^2 - 2(1-\lambda)\sigma_{cr} - 2\lambda(1+\lambda)(\sigma_{qr} + \sigma_{ir})$ to equation (A78). So the condition for choosing RCP over LCP is:

$$\sigma_i^2 \geq \frac{1}{(1-2\lambda)}\left[\sigma_r^2 - 2(1-\lambda)\sigma_{cr} - 2\lambda(1-\lambda)(\sigma_{qr} + \sigma_{ir}) + 2\sigma_{ic}(1-\lambda) + 2\lambda\sigma_{iq})\right]. \tag{A85}$$

This threshold is just like the one in proposition 1(c). Again, when $\lambda = 0$ and the production function is Cobb-Douglas so $\kappa_{1,r} = \alpha$ and $\kappa_{1,w} = 1 - \alpha$, then the condition above simplifies to the one defined in the proposition.

**Proof of proposition part (b): demand complementarities.** In general, how the degree of demand complementarities affects the choice of RCP versus LCP is ambiguous. However, note that the derivative of the left-hand side of equation (A85) with respect to $\lambda$ is given by

$$\frac{2}{(1-2\lambda)^2}\left[2(\sigma_{cr} - \sigma_{ic}) - 2(1-2\lambda)(\sigma_{qr} + \sigma_{ir}) + 2\sigma_{iq})\right] \tag{A86}$$

This means that if $\lambda > 1/2$, an increase in $\sigma_{qr}$ makes it more likely the firm will choose RCP over LCP. This proves result (b).

**Proof of proposition part (c): effect of policy.** The same proof as in the baseline case can be used to show that the profit functions in each market are convex in $\eta^j$ independently of the pricing choice. In turn, recall from appendix E.2, that the profits of the firm are given

by equation (A14), repeated here for convenience:

$$\Pi^j(\eta^j) = \int_{\Delta^{LCP}(\eta^j)} \pi_i^{LCP*}(\eta^j)di + \int_{\Delta^{PCP}(\eta^j)} \pi_i^{PCP*}(\eta^j)di + \int_{\Delta^{RCP}(\eta^j)} \pi_i^{RCP*}(\eta^j)di + \int_{\Delta^{DCP}(\eta^j)} \pi_i^{DCP*}di + \delta_r \pi_0^{RCP*}(\eta^j) + \delta_d \pi_1^{DCP*}(\eta^j)$$

The same proof shows that this is convex in $\eta^j$, so again there will be a bang-bang solution.

Imagine a firm that is currently operating with d-currency credit $\eta^j = 0$, and is considering switching to r-currency credit $\eta^j = 1$. It is feasible for the firm to make that switch but leave the pricing currency decisions unchanged, so the sets $\{\Delta^{LCP}, \Delta^{PCP}, \Delta^{RCP}, \Delta^{DCP}\}$ stay the same. The firm could, of course, do better by re-optimizing pricing. But, it is sufficient, to prove result (c), that the difference

$$\pi_i^{\mathcal{P}*}(1, \varepsilon^j, S, w, q) - \pi_i^{\mathcal{P}*}(0, \varepsilon^j, S, w, q) \tag{A87}$$

increases following the policy change for all $i$ and all choices of $\mathcal{P} \in \{LCP, PCP, RCP, DCP\}$

Note that $\pi_i^{\mathcal{P}*}(0, \varepsilon^j, S, w, q)$ is independent of $\varepsilon^j$, since if d-currency credit is used, the cost of r-currency credit is irrelevant. Therefore, we only need to show that $\pi_i^{\mathcal{P}*}(1, \varepsilon^j, S, w, q)$ increases. But, since $\tilde{G}^j(\varepsilon^j)$ first order stochastically dominates $G^j(\varepsilon^j)$ and the draw of $\varepsilon^j$ of independent of the other variables, this is always the case.

## F.6 Proof of proposition A3

**Part a)** This follows immediately from proposition 2(b).

**Part b)** An increase in $\sigma_{rw}$ and $\sigma_{dw}$, alters the thresholds $\Phi_i$ per proposition 1(c) and $\Omega$ per proposition 3(c) such that RCP becomes attractive compared to LCP and DCP.

**Part c)** To establish this result, let us start with a simplified case where $\varepsilon$ is binary. Specifically, $\varepsilon \in \{A, B\}$ with $B > A$, and $Pr(\varepsilon = A) = \omega$. We will assume that $A < \varepsilon^{swap} < B$. In which case, the question becomes is the ratio $\left(\frac{\omega A^\alpha + (1-\omega)B^\alpha}{A^\alpha}\right)^{1/\alpha}$ increasing or decreasing in $\alpha$?

This is true if

$$\frac{d}{d\alpha}\left(\frac{1}{\alpha}\log(\omega A^\alpha + (1-\omega)B^\alpha)\right) > \frac{d}{d\alpha}\left(\frac{1}{\alpha}\log(A^\alpha)\right),$$

or

$$\frac{\omega \log(A) A^{\alpha} + (1-\omega)\log(B) B^{\alpha}}{\omega A^{\alpha} + (1-\omega) B^{\alpha}} - \frac{1}{\alpha}\log\left(\omega A^{\alpha} + (1-\omega) B^{\alpha}\right) > \frac{\log(A) A^{\alpha}}{A^{\alpha}} - \frac{1}{\alpha}\log\left(A\right).$$

This expression can be rearranged to yield

$$\frac{(1-\omega) B^{\alpha}}{\omega A^{\alpha} + (1-\omega) B^{\alpha}}\log(B^{\alpha}) + \frac{\omega A^{\alpha}}{\omega A^{\alpha} + (1-\omega) B^{\alpha}}\log(A^{\alpha}) > \log\left((1-\omega)\left(B^{\alpha}\right) + \omega\left(A^{\alpha}\right)\right). \tag{A88}$$

Note that while $\frac{(1-\omega)B^{\alpha}}{\omega A^{\alpha}+(1-\omega)B^{\alpha}} + \frac{\omega A^{\alpha}}{\omega A^{\alpha}+(1-\omega)B^{\alpha}} = 1$, standard Jensen's inequality result for a concave function does not apply in this context as left-hand side uses different weights compared to the right hand side. Now as $B \to A$ both sides of the expression tend to $\alpha log(A)$: when $B = A$, the ratio of interest is unity and hence the derivative with respect to $\alpha$ is nil. Starting from the point $B = A$, it is therefore sufficient to prove that the right hand side in equation (A88) is increasing in $B$ faster than the left hand side. This is true if

$$\begin{aligned}&\frac{\left(\omega A^{\alpha} + (1-\omega) B^{\alpha}\right)(1-\omega) B^{\alpha-1}\left(\alpha \log(B^{\alpha}) + \alpha\right)}{\left(\omega A^{\alpha} + (1-\omega) B^{\alpha}\right)^2} \\ &- \frac{\alpha(1-\omega) B^{\alpha-1}\left(\omega \log(A^{\alpha}) A^{\alpha} + (1-\omega) B^{\alpha}\log(B)\right)}{\left(\omega A^{\alpha} + (1-\omega) B^{\alpha}\right)^2} > \frac{\alpha(1-\omega) B^{\alpha-1}}{\left(\omega A^{\alpha} + (1-\omega) B^{\alpha}\right)^2},\end{aligned}$$

or

$$\log(B^{\alpha}) > \frac{\omega A^{\alpha}}{(\omega A^{\alpha} + (1-\omega) B^{\alpha})}\log(A^{\alpha}) + \frac{(1-\omega) B^{\alpha}}{(\omega A^{\alpha} + (1-\omega) B^{\alpha})} log(B^{\alpha}).$$

Which is always true for $B > A$. Hence, we have that inequality in equation (A88) is satisfied for any $B > A$.

It is straightforward to extend these steps to a general distribution so long the swap line has a $\varepsilon^s$ that truncates it.

Figure A1: Sketch of the flows associated with a swap line transaction

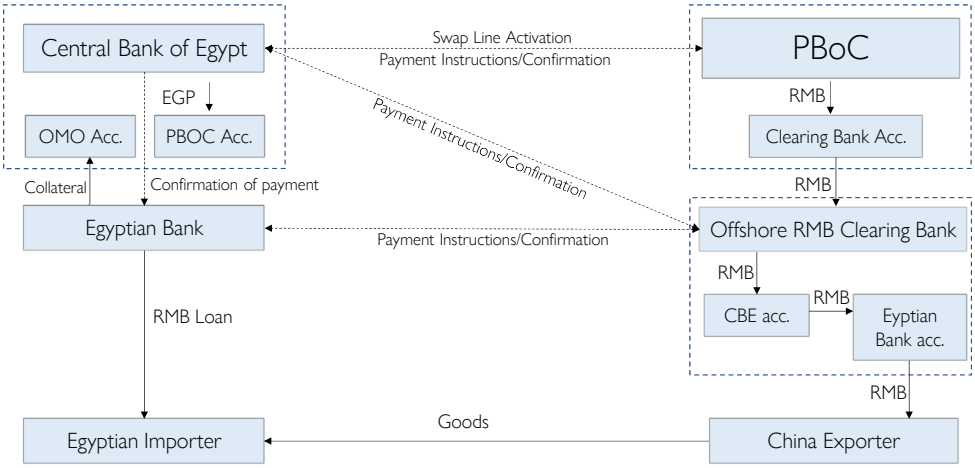
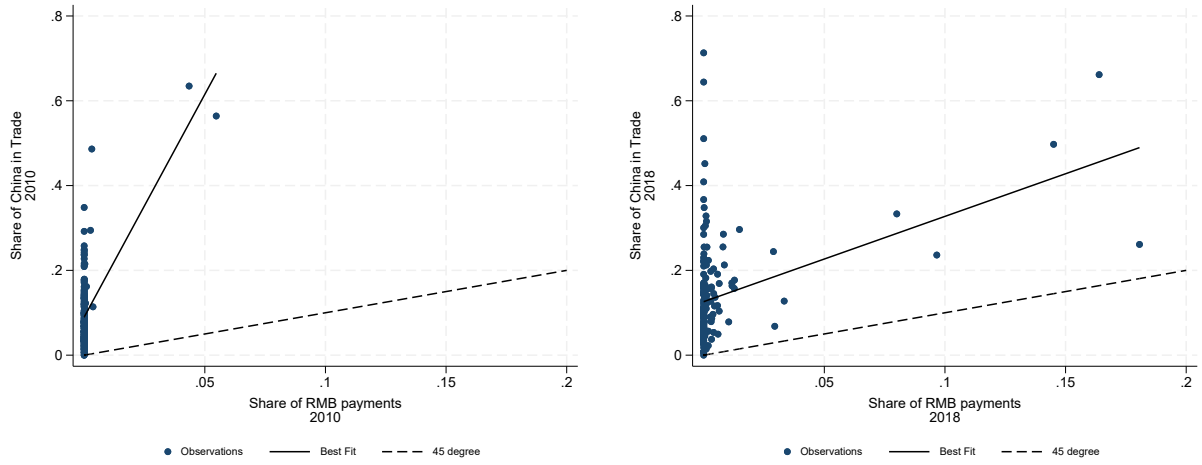



Figure A2: RMB payments per country vs. trade with China

(a) 2010 (b) 2018




Notes: As figure 3 data is presented for 2010 (panel (a)) and 2018 (panel (b)).

Table A1: Summary statistics: main regression sample

| | mean | p50 | min | max | sd |
|---|---|---|---|---|---|
| *RMB payments* | | | | | |
| RMB payment sent/received ($1(\text{Rpayment}_{i,t} > 0)$) | .258 | 0 | 0 | 1 | .438 |
| RMB payment sent/received excluding to/from China | .133 | 0 | 0 | 1 | .340 |
| RMB payment sent | .257 | 0 | 0 | 1 | .438 |
| RMB payment received | .258 | 0 | 0 | 1 | .438 |
| RMB trade credit sent/received (MT400 or MT700) | .050 | 0 | 0 | 1 | .217 |
| RMB share in all payments ($\text{Rshare}_{i,t}$, $\% \times 100$) | 4.0 | 0 | 0 | 92.5 | 3.3 |
| *Economic Linkages with China* | | | | | |
| Goods exports to China (% GDP) | .095 | .026 | 0 | .964 | .158 |
| Goods imports from China (% GDP) | .128 | .112 | 0 | .787 | .082 |
| Chinese direct investment (% GDP) | .017 | 0 | 0 | 24.64 | .262 |
| *Neighbor Variables* | | | | | |
| Share of neighbors using RMB ($\text{Neighbor Use}_{i,t}$) | .271 | .2 | 0 | 1 | .267 |
| Share of neighbors with swap line ($\text{Neighbor Swap}_{i,t}$) | .099 | 0 | 0 | .8 | .156 |
| *China policies* | | | | | |
| Has a PBoC Swap Line($\text{SwapLine}_{i,t}$) | .091 | 0 | 0 | 1 | .287 |
| Membership of AIIB | .067 | 0 | 0 | 1 | .251 |
| Has RMB Clearing Bank | .018 | 0 | 0 | 1 | .134 |
| Has Free Trade Agreement | .009 | 0 | 0 | 1 | .093 |
| *Country Characteristics* | | | | | |
| Intermediate input share | .466 | .473 | .076 | .802 | .112 |
| Export working capital needs | .150 | .151 | .080 | .206 | .021 |
| Observations | 12804 | | | | |

Notes: Summary statistics on baseline regression sample covering October 2010 to October 2018. Sample selection criteria described in Section 2. Total sample is 124 countries.

Table A2: Effect of swap lines on RMB payments ex China and on trade with China

| | Ex payments to China | | Ex payments to BRI | | Share of Trade w/ China | |
|---|---|---|---|---|---|---|
| | Time & Country f.e. | Incl. Controls | Time & Country f.e. | Incl. Controls | Time & Country f.e. | Incl. Controls |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\text{SwapLine}_{i,t}$ | 0.1608*** | 0.1657*** | 0.1611*** | 0.1264** | -0.0062 | -0.0057 |
| | (0.047) | (0.057) | (0.045) | (0.052) | (0.004) | (0.005) |
| $N$ treated | 21 | 21 | 21 | 21 | 21 | 21 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes |
| Trade Controls | No | Yes | No | Yes | No | No |
| Policy Controls | No | No | No | Yes | No | Yes |
| Neighbor Control | No | Yes | No | Yes | No | Yes |
| Neighbor Control | No | No | No | No | No | Yes |
| Belt and Road Control | No | No | No | Yes | No | Yes |
| Method | BJS(24) | BJS(24) | BJS(24) | BJS(24) | BJS(24) | BJS(24) |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Estimates of equation (1) with different outcome variables. The treatment variable is a dummy variable indicating whether the country's central bank, as of month $t$, has ever signed a swap line agreement with the PBoC ($\text{SwapLine}_{i,t}$). Sample period is October 2010 to October 2018. BJS(24) refers to the did imputation method from Borusyak *et al.* (2024). In columns (1)-(2) the outcome variable is an indicator variable for whether the country makes a payment denominated in RMB in a particular month where payment is defined by SWIFT message types MT 103 and MT 202 and excluding payments to China, Macau and Hong Kong. Column (1): includes only country and time fixed effects and no further controls. Column (2): as previous, but includes all controls. Column (3)-(4) as Columns (1)-(2), but additional excludes payments to countries that had ever signed up to China's Belt and Road initiative. Column (4) includes an extra control for whether the country in question is a member of the belt and road initiative. Column (5)-(6) as Columns (3)-(4), but changes the outcome variable to the share of the country's good trade with China. Trade Controls are a Chinese FTA dummy and goods imports and exports from/to China in log terms and as a share of country total. Policy Controls are dummies for membership of the AIIB and the presence of an RMB clearing bank and variables capturing Chinese investment flows into the country. Neighbor control captures the share of neighboring countries using the RMB. Belt and Road Control is a dummy that takes the value of one if the country is part of the belt and road initiative.

Table A3: Spillovers on neighbors RMB use in payments

| Outcome Variable: | Neighbor Use$_{i,t}$ | | | $1(\text{Rpayment}_{i,t} > 0)$ | | $ln(1+\text{Rpayment}_{i,t})$ | | $\text{Rpayment}_{i,t}$ | |
|---|---|---|---|---|---|---|---|---|---|
| | all countries | ex. swap line | all countries | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\text{SwapLine}_{i,t}$ | 0.1430*** | 0.1056*** | 0.1116*** | 0.0634 | 0.1089 | 1.5444 | 1.8993 | 1.3744*** | 0.9131*** |
| | (0.015) | (0.018) | (0.041) | (0.090) | (0.092) | (1.378) | (1.465) | (0.206) | (0.318) |
| $\text{SwapLine}_{i,t} \times$ | | | | 0.6000* | 0.6359* | 12.1459** | 12.1142** | 7.0075*** | 8.0183*** |
| Neighbor $\text{Swap}_{i,t}$ | | | | (0.333) | (0.335) | (4.830) | (5.206) | (2.505) | (2.670) |
| $(1 - \text{SwapLine}_{i,t}) \times$ | | | | 0.4381** | 0.4626** | 6.3681** | 6.7387** | 5.7555* | 6.4796** |
| Neighbor $\text{Swap}_{i,t}$ | | | | (0.198) | (0.193) | (2.706) | (2.654) | (2.941) | (2.849) |
| $N$ treated | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 58 | 58 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Trade Controls | No | No | No | No | Yes | No | Yes | No | Yes |
| Policy Controls | No | No | No | No | Yes | No | Yes | No | Yes |
| Log Controls | No | No | No | No | No | No | Yes | No | Yes |
| Method | BJS(24) | BJS(24) | OLS | OLS | OLS | OLS | OLS | PPML | PPML |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1)-(3) present estimates of equation (1) with the outcome variable changed to be neighboring countries' share of RMB use, where $NeighborUse_i, t$ os defined in Section 2. All threes specifications include only country and time fixed effects and no further controls. Column (1) uses the did imputation method from Borusyak *et al.* (2024) refered to as BJS(24). Column (2) is as column (1) but excludes neighboring countries that have ever signed a swap line with the PBoC. Column (3) as Column (1) but uses a least squares estimator. Columns (4)-(9) estimate spillover models where $NeighborSwap_{i,t}$ is the proportion of neighboring countries that have signed a swap agreement. The even columns include only time and country fixed effects, odd columns include all controls. Columns (4)-(5) use $1(\text{Rpayment}_{i,t} > 0)$ as the outcome variable and use a least squares estimator. Columns (6)-(7), $ln(1+\text{Rpayment}_{i,t})$ as the outcome variable and use a least squares estimator. Columns (8)-(9), $\text{Rpayment}_{i,t}$ as the outcome variable and use a psuedo Poisson maximum likelihood estimator. Sample period is October 2010 to October 2018. Trade Controls are a Chinese FTA dummy and goods imports and exports from/to China in log terms and as a share of country total. Policy Controls are dummies for membership of the AIIB and the presence of an RMB clearing bank and variables capturing Chinese investment flows into the country. Log Controls are the logarithm of the country's GDP and the logarithm of its total cross border payments, both in USD.

Table A4: Swap lines and the prob. the RMB is used for trade finance

| | Baseline Specification | | | | Robustness | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time & Country f.e. | Incl. China Trade | Incl. China Policy | Incl. Neigh Share | Least Squares | Payments Sent | Payments Rec'd | 6 Month Shift | Ex Mongolia | Incl. Developed |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $\text{SwapLine}_{i,t}$ | 0.1496*** | 0.1493*** | 0.1282*** | 0.1262*** | 0.1313** | 0.1262*** | 0.0698*** | 0.1604*** | 0.1371*** | 0.1610** |
| | (0.009) | (0.009) | (0.021) | (0.022) | (0.055) | (0.025) | (0.020) | (0.025) | (0.021) | (0.063) |
| $N$ treated | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 20 | 29 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 107 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Trade Controls | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Policy Controls | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Neighbor Control | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Method | BJS(24) | BJS(24) | BJS(24) | BJS(24) | OLS | BJS(24) | BJS(24) | BJS(24) | BJS(24) | BJS(24) |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: As table 2 except outcome variable is now defined as whether a country sends or receives a message MT400 or MT700 in RMB in a particular month.

Table A5: Swaplines and the intensive margin of RMB use: adding Mongolia to the sample

| Outcome Variable: | $\text{Rshare}_{i,t}$ | | | | | $ln(1+\text{Rpayment}_{i,t})$ | | | | $\text{Rpayment}_{i,t}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| $\text{SwapLine}_{i,t}$ | 0.9116*** | 0.8796*** | | 1.0663 | 0.9531 | 3.2812*** | 2.8894*** | 2.8581** | 1.9604 | 1.6425*** | 1.2256*** |
| | (0.018) | (0.010) | | (0.792) | (0.793) | (0.679) | (0.737) | (1.391) | (1.429) | (0.296) | (0.319) |
| 0-11 months | | | 0.1312*** | | | | | | | | |
| | | | (0.012) | | | | | | | | |
| 12-23 months | | | 0.2238*** | | | | | | | | |
| | | | (0.018) | | | | | | | | |
| 24-35 months | | | 0.5510*** | | | | | | | | |
| | | | (0.042) | | | | | | | | |
| 36-48 months | | | 0.8553*** | | | | | | | | |
| | | | (0.029) | | | | | | | | |
| $N$ treated | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| $N$ control | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 58 | 58 |
| $T$ | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 | 97 |
| Time f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Country f.e. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Trade Controls | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Policy Controls | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Neighbor Control | No | Yes | Yes | No | Yes | No | Yes | No | Yes | No | Yes |
| Log Controls | No | No | No | No | No | No | Yes | No | Yes | No | Yes |
| Method | BJS(24) | BJS(24) | BJS(24) | SDID | SDID | BJS(24) | BJS(24) | SDID | SDID | PPML | PPML |

Standard errors clustered by country in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: As table 3 except that Mongolia is now included in the sample.

Figure A3: Swap Lines and the Belt and Road Initiative (end 2018)

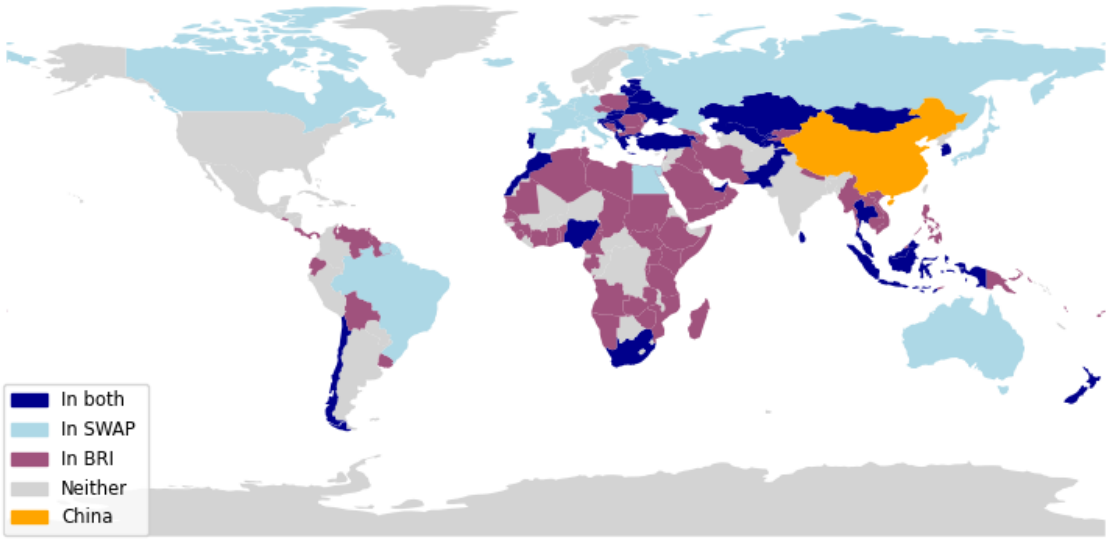
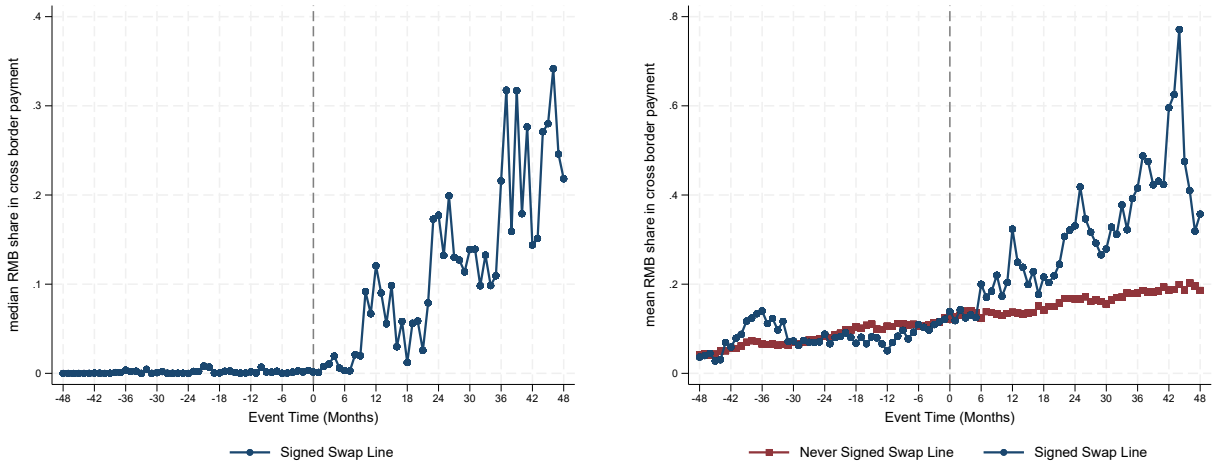



Figure A4: RMB payments share after a swap line is signed excluding Mongolia

(a) Median country

(b) Mean country




Notes: As Figure 4 except Mongolia is excluded from the sample.

Figure A5: The impact of the swap line