Does RMB Internationalization Promote Cross-Border Trade?

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Abstract

We investigate the internationalization of Renminbi (IoR) since 2006 by examining its increased utilization among Korean exporters to China. Employing proprietary data from Korean customs, which includes detailed invoicing information, our analysis reveals that products invoiced, either fully or partially, in RMB have experienced more rapid export growth. Furthermore, firms adopting RMB invoicing also exhibit faster export growth to China after controlling for relevant observables. Our findings remain robust when employing an instrumental variable approach to address potential endogeneity concerns. With the help of a currency invoicing model that demonstrates different impact channels, we show that the increased trade volume is due to Chinese importers facing lower currency costs when purchasing RMB-invoiced products compared to USD-invoiced products.

JEL classification: F14, F31, D22.

Keywords: RMB internalization, invoicing currency, international trade.

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1 Introduction

Since the fading away of the global financial crisis, the Chinese government has been advancing the internationalization of the Renminbi (IoR) (Lai, 2021). This strategic initiative reached a significant milestone in October 2022, when President Xi formally announced that the party would "promote the internationalization of the RMB (Renminbi) in an orderly way," as stated in the Report to the 20th National Congress of the Communist Party of China.[1] This study focuses on a specific aspect of IoR: whether RMB invoicing in trade promotes Korean exports to China.

As illustrated in Figure 1, despite the persistent dominance of the USD, there is a marked and sustained increase in the share of RMB from 2011 onwards, as depicted by the red dashed line, which almost displaces the USD share on a near one-to-one basis.[2] The rise of RMB can be attributed, to a large extent, to an array of government policies designed to promote the adoption of the RMB across both private and public sectors (Bahaj and Reis, 2020; Lai, 2021).[3] In light of these developments, it is imperative for economists to address the following questions: What are the implications of RMB invoicing in international trade? Does it promote trade flows? If so, what is the underlying mechanism?

The answers to these questions are not immediately apparent. Chinese officials assert that IoR would promote trade.[4] While RMB invoicing is more convenient for Chinese importers, it may present challenges for Korean exporters, as receiving RMB can be less convenient than receiving USD, which is more easily converted to KRW (Korean won).[5] Moreover, if the adoption of RMB was driven by interventionist measures from the Chi-

[1] https://www.gov.cn/xinwen/2022-10/25/content_5721685.htm

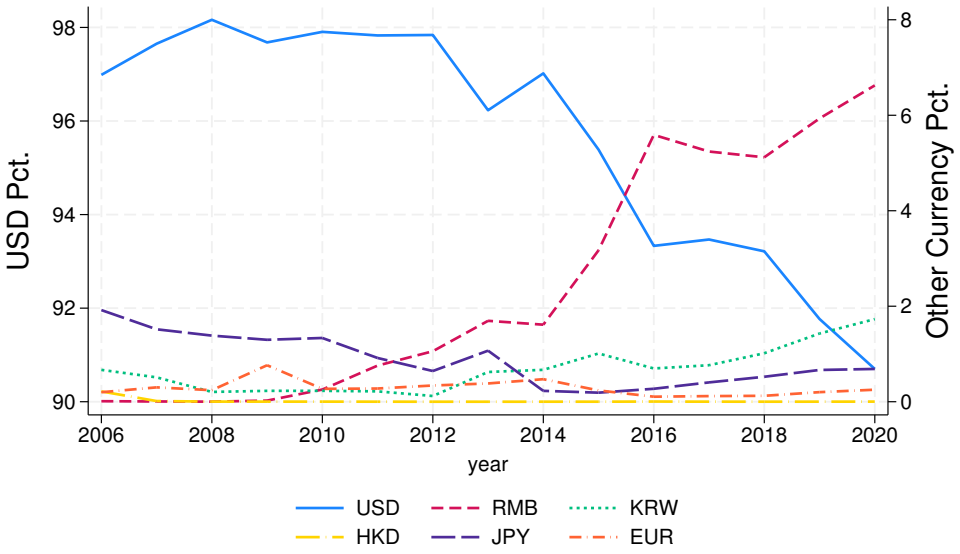
[2] The extant literature posits that the international usage of currencies exhibits a high degree of stability over time (Eichengreen, 2019; Boz et al., 2022). Consequently, the observed 6% increase in RMB share constitutes a substantial deviation from this norm.

[3] We elaborate on government policies in Section 3.1.

[4] A joint report from the Department of Commerce and the People's Bank of China highlights the "positive role of cross-border RMB business in serving the real economy and promoting trade and investment." http://www.pbc.gov.cn/huobizhengceersi/214481/214511/3406535/4763611/index.html

[5] Studies indicate that the currency cost borne by the exporter is a significant factor in currency invoicing (Berthou et al., 2022; Goldberg and Tille, 2008).

Figure 1: Evolution of Currency Invoicing Patterns in Korean Exports to China



Notes: These figures illustrate the percentage share of invoicing currencies in Korean exports to China. The data are sourced from Korean customs dataset.

nese government, it could significantly disrupt trade.

The key findings of the paper can be summarized as follows. First, at the product level, we find that products invoiced, either fully or partially, in RMB experienced faster export growth from South Korea to China. Second, at the firm (and firm-product) level, we observe that firms using RMB invoicing also experienced faster export growth. For both product and firm-level findings, we adopt an IV (instrumental variable) strategy to account for potential endogeneity and find that the results remain robust. Finally, we present a simple model of currency invoicing to decompose IoR's impact on exports into three channels: (1) reduced exchange rate risk, (2) lower goods price, and (3) lower marginal transaction costs incurred by importers.[6] After assessing the significance of each channel with data, we demonstrate that IoR primarily increases trade volume as Chinese importers face lower marginal currency transaction costs when purchasing RMB-invoiced

[6]In the theoretical model, we also account for Korean exporters' fixed and marginal currency transaction costs. Nevertheless, we establish that these costs do not affect trade volume *conditional on* the goods price, which already reflects such costs.

products relative to USD-invoiced products.

An examination of Korean exporting firms' invoicing patterns from 2006 to 2019 is crucial for several reasons. First, the rapid increase in RMB invoicing share represents an unusual event in the international monetary system. The extant literature indicates that currency invoicing patterns exhibit remarkable stability over time (Boz et al., 2022).[7] While our data indicate that the RMB has not yet posed a significant challenge to the USD as the dominant currency, we nonetheless document a relatively swift alteration in currency composition. Consequently, this study provides valuable insights into the ramifications of the IoR in international trade, by examining a special episode under the context of currency invoicing literature.

Second, despite South Korea's proximity to China, its invoicing patterns are less likely influenced by geopolitical considerations akin to those affecting Russia or Brazil. Consequently, we anticipate that RMB invoicing in cross-border trade will gain significant traction in other nations, particularly in countries neighboring China.[8] Therefore, our study illuminates the implications of RMB invoicing for other nations that are likely to adopt similar practices.

Literature Review

Our paper contributes to the expanding literature that investigates the determinants and consequences of currency invoicing in trade.[9] Theoretically, studies suggest that firms opt for an invoicing currency to minimize expected gap in output price from its optimal level (Engel, 2006; Gopinath et al., 2010). Furthermore, the literature identifies firms' strategic behaviors driven by variable markups (Amiti et al., 2022), import and export

[7] Gopinath and Itskhoki (2022) observes that "currency choice is remarkably stable in the time series with the status of dominant currencies remaining unchanged over decades." One might need to look back to the 1950s to witness a significant shift from the British Pound to the US Dollar (Eichengreen, 2019).

[8] A survey by Ito et al. (2021) indicates that Japanese overseas subsidiaries increasingly utilize RMB for export and import invoicing.

[9] Gopinath and Itskhoki (2022) provide a comprehensive review on the subject. An important strand of the literature on currency invoicing focuses on exchange rate pass-through (Gopinath et al., 2010; Corsetti et al., 2022; Chen et al., 2022; Chen and Yin, 2022). While exchange rate pass-through remains a central topic within currency invoicing research, it is not the primary focus of our paper.

linkages (Chung, 2016; Mukhin, 2022), and foreign financing costs (Bahaj and Reis, 2020) as crucial determinants of invoicing currency.[10] Our principal argument, however, hinges on the reduction of currency friction. Specifically, we posit that Korean firms' currency switching is primarily driven by a series of government policies that lowered the cost – whether fixed, marginal, or both – of RMB invoicing for Korean exporters.

In the empirical literature, numerous studies examine the currency frictions faced by firms. Notably, Goldberg and Tille (2008) demonstrates that currency cost, proxied by the bid-ask spread in the exchange market, is a significant factor in currency invoicing. Similarly, Crowley et al. (2020) identify currency management cost as a critical determinant in the dynamics of currency invoicing patterns. Berthou et al. (2022) show that heightened USD/EUR tensions in July 2011 increased hedging costs, leading French exporters reliant on hedging to reduce exports to "US dollar destinations." In our paper, we employ the term "currency cost" as a comprehensive concept that encompasses the full spectrum of additional expenses associated with the use of a foreign currency, as compared to the domestic currency.

The study most closely related to ours is Messer (2020), wherein the author finds that the "Local Currency Payments" system between Argentina and Brazil increased Brazilian exports by approximately 22 percent. Both Messer's study and our own highlight the crucial role of invoicing currency in international trade. A key distinction, however, lies in the mechanism: whereas the Argentina-Brazil system permits Argentine imports to be settled in Argentine Pesos and Brazilian exports to be received in Brazilian Reals, thereby obviating currency conversion for both sides, in our context, Korean firms receive RMB, which may be less convenient than USD, the prevailing alternative. Thus, it is unclear whether the findings from Messer (2020) can be directly applied to our context.[11]

[10] Ito and Chinn (2014) underscore the significance of financial development as a determinant in the currency denomination of trade invoicing. As detailed in Section 3.1, a series of capital liberalization policies by the Chinese government serves as a pivotal strategy in advancing the IoR.

[11] A substantial body of literature explores the impact of currency unions on trade (Rose, 2000; Rose and Stanley, 2005). The adoption of RMB invoicing by Korean firms is analogous to the formation of a currency union in that it eliminates the vehicle currency, yet it differs fundamentally from a currency union

Second, our paper contributes to the literature on the internationalization of the RMB, highlighting its increasing utilization in global finance and trade.[12] As early as Eichengreen (2011), scholars have anticipated the ascent of the RMB's international status. Recent studies corroborate this, documenting the growing share of the RMB in international payments (Bahaj and Reis, 2020). Our paper enhances this body of literature by presenting novel evidence derived from proprietary Korean customs data. Specifically, we observe that the RMB share in Korean exports surged from zero to over 6 percent between 2010 and 2020, with no indication of deceleration. Accordingly, this study provides valuable early insights into the implications of RMB internationalization.

The remainder of the paper is structured as follows. Section 2 provides a concise overview of the data sources utilized in our study. Section 3, the core of our analysis, discusses the history of IoR in Korea and presents evidence from both product-level and firm-level analyses that IoR can enhance trade volumes. Section 4 offers robustness checks of our findings. Finally, the concluding section summarizes our results and discusses their implications.

2 Data

The principal dataset employed in our study is the the Korean customs data, curated by the Korea Trade Statistics Promotion Institute (KTSPI).[13] Our sample comprises all exporting firms documented in the KISVALUE dataset spanning the years 2006 to 2019.[14]

for two reasons: first, RMB is still not a domestic currency for Korean firms; second, the formation of a currency union can be regarded as exogenous for each firm, whereas the decision on currency invoicing is endogenous.

[12] Lai (2021) provides an excellent review on the subject of RMB internationalization.

[13] We access the customs data from the KTSPI with an approval of the Korea Customs Service, subject to disclosure restrictions. We extracted balance sheet information for exporting firms from the KISVALUE dataset, covering the period from 2006 to 2019, and the KTSPI merged the KISVALUE dataset with its customs data within its facility. Although the merged dataset was not provided to us directly, the KTSPI conducted data analyses under our close supervision and guidance. We express our sincere appreciation to the staff at KTSPI and the Korea Customs Service for their valuable support.

[14] Given that our firm selection is based on the exporters identified in the KISVALUE dataset, we posit that our sample adequately represents the aggregate export trends. Although the Korean customs data

From the Korean customs dataset, we primarily extract data on each exporting firm's currency invoicing choices and the currency composition for each product. Given the proportional increase in data acquisition costs with the number of observations, we aggregate the raw data to the HS 4-digit product level while preserving the currency invoicing details. This granularity allows us to discern whether a firm exports the same 4-digit product to China using multiple currencies within a given year.

Firm-level data are sourced from the KISVALUE database, which encompasses comprehensive financial information for all listed and voluntarily audited firms in Korea. KISVALUE is extensively utilized in scholarly research on Korean firms and has been referenced in influential studies, such as Kim et al. (2015). From this dataset, we extract firms' business registration number and various firm characteristics, including gross assets, annual sales, tangible assets, number of employees, industry classification, headquarters location, group affiliation (chaebol), and listing status. Additionally, in one of our analyses exploring the mechanism of IoR, we employ KISVALUE data to compute the median export turnover at the industry level, defined as the ratio of a firm's export revenue to foreign currency accounts receivable.

Trade flow data at the HS 4-digit level between South Korea and its trading partners are obtained from the BACI dataset (Gaulier and Zignago, 2010).[15] Furthermore, to validate the representativeness of our sample, we utilize currency invoicing patterns reported by the Bank of Korea and demonstrate that the longitudinal patterns of currency invoicing align closely with our sample.

also contain the import activities of these firms, firms that solely import without exporting are absent from our sample due to our firm selection criteria. Consequently, while we utilize import data to examine the influence of imports on firms' invoicing behaviors, import activity is not employed as a dependent variable in our analysis.

[15] While our Korean customs data also allow us to calculate product-level trade flows, they are inherently limited to exporters identified by the KISVALUE data. Therefore, we prefer using the BACI trade data due to its comprehensive depiction of South Korea's trade patterns. Robustness checks, as detailed in Section 4, indicate that our primary findings are not sensitive to this choice.

3 Does IoR Increase Trade?

This section encompasses a concise background on IoR (Section 3.1), a detailed analysis of product-level findings (Section 3.2), of firm- and firm-product-level findings (Section 3.3), and an exploration of the mechanisms through which IoR facilitates international trade (Section 3.4). Summary statistics for the key regression variables are provided in Appendix Table C.1.

3.1 Internationalization of RMB

There are three primary roles of money: a medium of exchange, a unit of account, and a store of value. RMB internationalization can be understood as expanded global use or RMB in these three aspects. For instance, as an increasing number of Korean firms invoice their exports in RMB, the RMB is progressively replacing the US dollar as a unit of account. Similarly, when foreign investors purchase RMB-denominated bonds, the RMB is functioning as a store of value.

As noted by Lai (2021), the Chinese government has implemented a multitude of policies to promote IoR. These initiatives include the establishment of offshore RMB markets, the signing of currency swap agreements, and the liberalization of capital flows. This section provides a brief review of the key milestone events in the economic relationship between Korea and China and refers readers to Appendix A for a more detailed background on IoR.

Table 1 provides a summary of key milestone events in the IoR between China and South Korea. These events encompass the initial bilateral currency swap agreement in 2008, the establishment of the first RMB clearing bank in Korea in 2014, and the subsequent establishment of direct interbank exchange markets in both Korea and China by the end of 2016. As evidenced by the table, pinpointing a precise inception date for IoR is challenging. Instead, it should be interpreted as a series of incremental government

Table 1: Key Events in RMB Internationalization between China and South Korea

Time	Key Events
Dec. 2008	China and South Korea sign the first bilateral currency swap agreement (180 billion yuan)
Jul. 2009	People's Bank of China initiates clearing services for trade settlement for corporations located in Hong Kong, Macau, and ASEAN
Aug. 2011	Korea Eximbank issues the first Dim Sum Bond from a South Korean institution
Oct. 2011	China and South Korea expand the bilateral currency swap agreement (360 billion yuan, later renewed in 2014 and 2017)
July 2014	Bank of Communications, Seoul Branch, becomes the first RMB clearing bank in South Korea
Oct. 2014	Shinhan BNP Paribas becomes the first South Korean company to obtain an R-QFII license
Dec. 2014	KRW-RMB interbank direct exchange is launched in Korea (12 market maker banks)
Oct. 2015	Phase I of the CIPS is launched
Jun. 2016	KRW-RMB interbank direct exchange is launched in China (14 market maker banks)
May 2018	Phase II of CIPS is launched

Notes: The table provides a summary of key events pertinent to the internationalization of the RMB between China and South Korea. R-QFII stands for Renminbi Qualified Foreign Institutional Investor, and CIPS stands for Cross-Border Interbank Payment System.

policies that progressively reduced the cost of using RMB for Korean exporting firms.

3.2 Product-Level Investigation

The increase in RMB invoicing in trade was substantial. At the HS4 (Harmonized System 4-digit) product level, the percentage of products with any RMB invoicing surged from 1.35% (11 out of 812) in 2007 to 63.89% (559 out of 875) in 2019.[16]

The adoption of RMB invoicing exhibited significant heterogeneity across products. In Figure 2, we present a histogram of RMB invoicing patterns in 2019, conditional on the product having positive RMB invoicing. The figure reveals a non-linear distribution in the use of RMB invoicing. Specifically, while 41.7% of products (77.8% when including those with zero RMB invoicing) utilized RMB for less than 20% of their trade volume, there is a noticeable increase toward the higher end, with some products approaching 100% RMB invoicing.

In Figure 3, we categorize HS4 products based on their RMB invoicing share and plot the change in the logarithm of trade volume between 2009 and 2019.[17] The figure illustrates a clear pattern: products that did not use any RMB invoicing in 2019 exhibited the least growth, while the growth in trade volume over the decade increases with the RMB invoicing share in 2019.

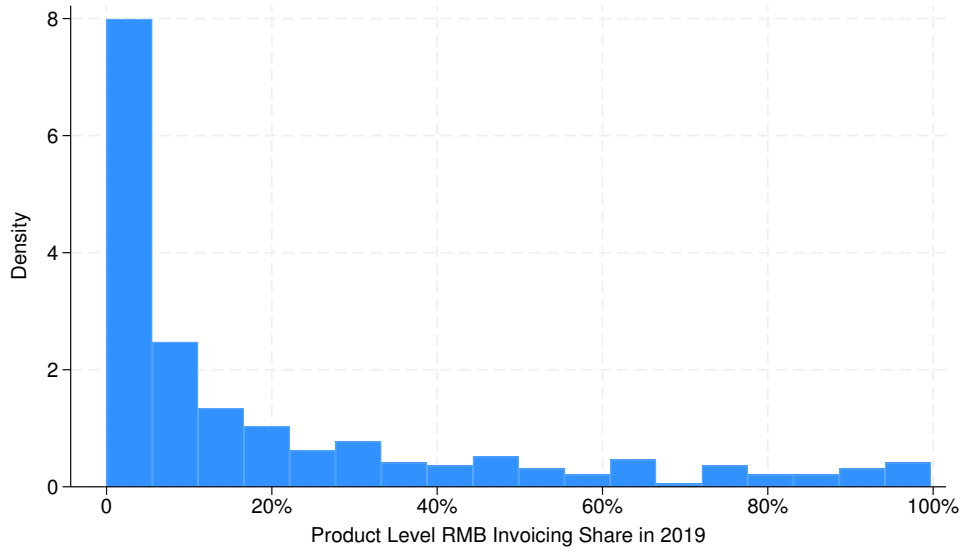
We hypothesize that the international use of RMB could benefit Korean exports to China by reducing currency costs.[18] Furthermore, we hypothesize that certain products, such as gold and cotton, which are predominantly invoiced in USD, are minimally affected by IoR, thereby serving as a "control" group. In contrast, given the absence of RMB invoicing in 2007, products with a positive RMB invoicing share in 2019 are likely

[16]While it is not the primary focus of our paper, it is equally intriguing to explore why RMB is more prevalent for certain subsets of products. For instance, Appendix Table C.2 indicates that RMB invoicing is more common in "differentiated goods" categories, as defined by Rauch (1999). A rigorous examination of the RMB invoicing patterns across different products is beyond the scope of this paper.

[17]We compare the log change from 2009 to mitigate the effects of the global financial crisis.

[18]Specifically, a series of government policies reduced the cost of RMB usage for Korean firms, resulting in an increase in RMB-invoiced export products. These products are particularly appealing to Chinese

Figure 2: Percentage Distribution of RMB Invoicing across HS 4-digit Products in 2019



Notes: This figure presents a histogram of RMB invoicing percentages across HS 4-digit products exported by South Korea to China in 2019.

to have benefited from reduced currency costs, thus constituting a "treatment" group for IoR.[19]

Accordingly, we employ a simple difference-in-difference (DID) regression model with the following specification

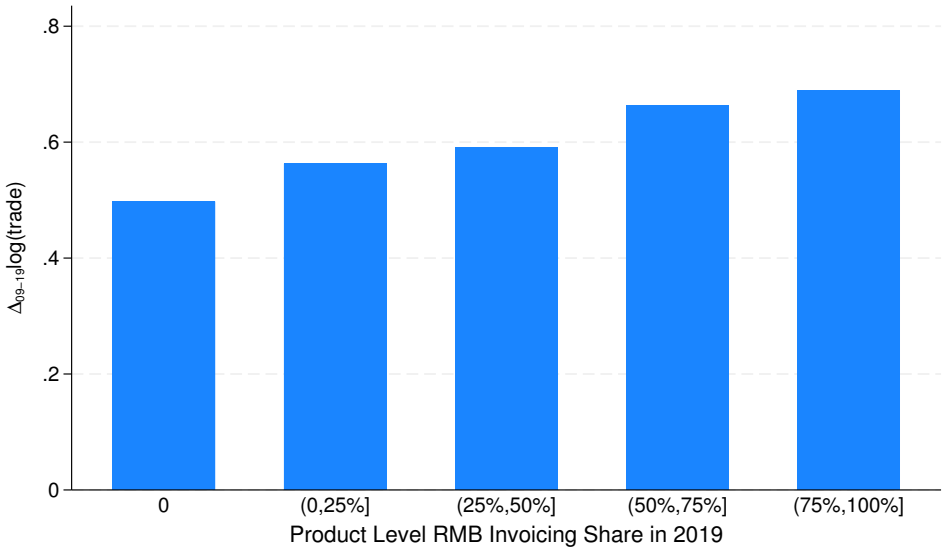
$$\log(\text{Export}_{ht}) = \beta_0 + \beta_1 \mathbb{1}_h(\text{RMB Pos in 2019}) \times \mathbb{1}_t(\text{Year} \geq 2011) + \mathbf{D}_h + \mathbf{D}_t + \epsilon_{ht}. \quad (1)$$

For our main analysis, we use the natural logarithm of product-level Korean exports to China as the dependent variable. The variable $\mathbb{1}_h(\text{RMB Pos in 2019})$ takes the value of one if the product h had any positive RMB invoicing in 2019, and zero otherwise. The variable $\mathbb{1}_t(\text{Year} \geq 2011)$ takes a value of one if the observation is from 2011 or later years, and zero otherwise. We include a full set of HS4 and year fixed effects ($\mathbf{D}_h$ and $\mathbf{D}_t$, respectively) to control for product-level average export volumes and temporal trade shocks. Standard

importers, as they eliminate the need for USD in the import process.

[19] We employ quotation marks for the terms "treatment" and "control" group, as the government policies in question were not explicitly targeted at specific products. While IoR-relevant policies are expected to reduce currency costs across the board, the response to such cost reductions may vary by product type. We use the term "treatment" group in the sense that the effects of IoR can only be observed in sectors where RMB is actually utilized.

Figure 3: RMB Invoicing Percentage and Growth of Trade 2009-2019



Notes: This figure displays the average change in the logarithm of trade volume between 2009 and 2019 for different HS 4-digit products exported by South Korea to China, categorized by their RMB invoicing share.

errors are estimated to account for heteroskedasticity and potential serial correlation of ϵ_{ht} at the HS4 product level.[20]

Table 2 presents the main estimation results at the HS4 product level. Column (1) indicates that products with a positive RMB invoicing share in 2019 experienced 42.9 percent faster export growth (relative to products without any) after 2011. Column (2) reports the results of a weighted regression where the product-level export volume in 2007 is used as the weight. The result remains highly robust, suggesting that our main findings are not driven by potentially more volatile growth in smaller product categories. In column (3), we estimate equation (1) using PPML (Poisson Pseudo Maximum Likelihood) to address potential heteroskedasticity issues when the dependent variable is log-transformed (Silva and Tenreyro, 2006; Kwon et al., 2022).[21] The PPML estimation result suggests that trade

[20] A more conservative approach is to define each cluster at HS2 product level to account for potential correlation of ϵ_{ht} across HS4 products within each HS2 category. Our main remain results are not sensitive to this choice and we present the robustness check in Section 4.

[21] Specifically, when the true model implies $\mathbb{E}[Y] = \exp(\beta X)\epsilon$ where $\mathbb{E}[\epsilon] = 1$, the log transformation $\log(Y) = \beta X + \log(\epsilon)$ introduces a problem because $\mathbb{E}[\log(\epsilon)] \neq 0$ due to Jensen's inequality.

volume increases by 28.5 percent.[22]

Next, it is conceivable that Chinese imports of the same products from other countries, irrespective of the invoicing currency, expanded at a comparable rate. Similarly, Korean exports denominated in RMB might have grown uniformly across all destination markets. Should this be the case, the results presented in columns (1) through (3) may not exclusively capture the growth attributable to RMB invoicing. In column (4), we control for China's product-level imports from countries other than Korea (log(Non-KR Import)) and Korean product-level exports to all countries other than China (log(Non-CN Export)). As expected, both variables are highly positive and significant, yet our main coefficient of interest remains highly significant, with its magnitude only marginally reduced.

We then examine the intensive margin effect of RMB invoicing on trade. In column (5), we confirm that HS4 products with a higher RMB share exhibited faster growth in trade volume. However, this impact appears to be primarily at the extensive margin, as the coefficient in column (6), where we only include samples with a positive RMB share, is not significant. While our hypothesis posits that products with higher RMB invoicing shares would benefit more from lower transaction costs, it is possible that the elasticity of trade with respect to transaction costs varies significantly across HS4 products. Consequently, the effect of RMB invoicing may be predominantly observed at the extensive margin and less visible at the intensive margin.

Finally, we perform a placebo test in column (7). Specifically, we regress Korea's product-level exports to the rest of the world, excluding China. The estimated coefficient suggests that products using RMB invoicing in 2019 did not experience faster export growth compared to other products since 2011.[23] Overall, the evidence presented in Table 2 compellingly suggests that HS4 products adopting RMB invoicing in 2019 — likely

[22] This is calculated as $0.285 = \exp(0.289) - 1$.

[23] It is noteworthy that using China's imports from the rest of the world, excluding Korea, as a dependent variable for a placebo test would be inappropriate. This is because other countries might also increase their use of RMB invoicing for the same products as Korean exporters, leading to a potential correlation between Korean exporters' RMB invoicing patterns and other countries' exports to China.

those most impacted by the deepening of IoR — exhibited accelerated export growth to China.

A critical identification assumption in the DID specification in equation (1) is the absence of pre-trends. In Figure 4, we conduct an event-study analysis for the regression in column (1) of Table 2 to demonstrate that the DID regression results are not driven by pre-existing trends or anomalies in specific years. All point estimates in Figure 4 are presented relative to the level in 2011, the year when RMB invoicing began to gain momentum according to Figure 1. We observe that HS4 products with positive RMB invoicing in 2019 do not exhibit any particular pre-trend leading up to 2011. The positive coefficient, while not statistically significant at the 10% level in 2012 (p-value = 0.72), attains consistent significance at the 5% level from 2013 onwards and exhibits a gradual increase in magnitude. This pattern suggests that the DID estimation presented in column (1) of Table 2 is not influenced by anomalies in specific years.

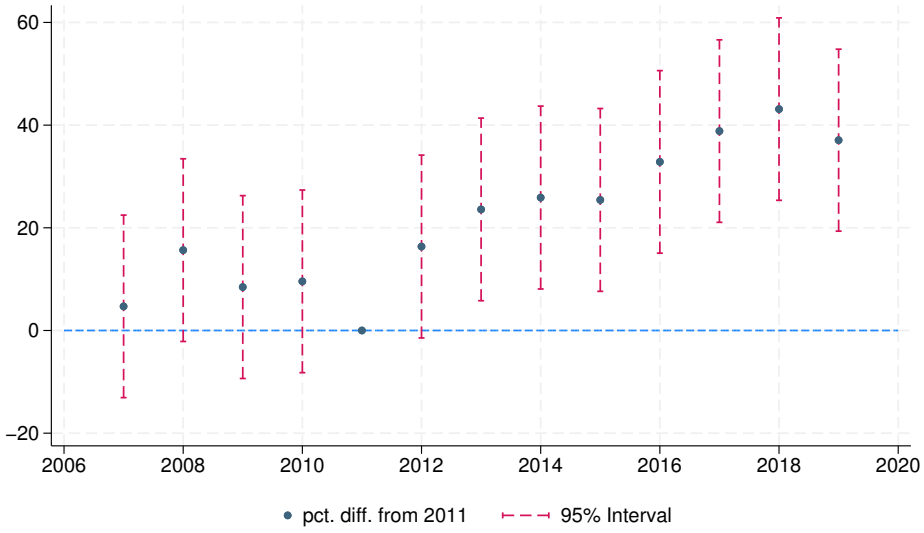
Finally, we assess the impact of RMB invoicing on Korean exports to China compared to other destination countries. Specifically, we estimate column (4) of Table 2 using exports to other countries as the dependent variable, one country at a time. We then obtain 185 coefficients for destinations other than China and plot them against the point estimate for China in Figure 5. The point estimate for China stands out prominently from the rest. In fact, our estimates rank China 4$^{\text{th}}$ among 186 countries, only behind Kiribati (0.453), Saint Lucia (0.433), and Eswatini (0.414). This figure suggests that the positive effects of RMB invoicing on Korean exports to China are highly unlikely to be driven by coincidence or data noise.

Table 2: Export Growth of RMB-invoiced Products (DID)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	baseline	weighted	PPML	add. cov.	RMB share	inten. marg.	placebo
Dependent Variable	log(HS4 Export to China)						
$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$	0.429***	0.528***	0.289**	0.386***			0.003
	(0.071)	(0.068)	(0.135)	(0.066)			(0.045)
$s_{RMB,2019} \times 2011+$					0.537***	0.165	
					(0.141)	(0.148)	
log(Non-KR Import)				0.414***			
				(0.038)			
log(Non-CN Export)				0.185***			
				(0.034)			
Observations	14,230	13,746	14,230	14,196	14,230	7,221	14,196
R^2	0.891	0.908		0.896	0.890	0.938	0.945
HS4 FE	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓

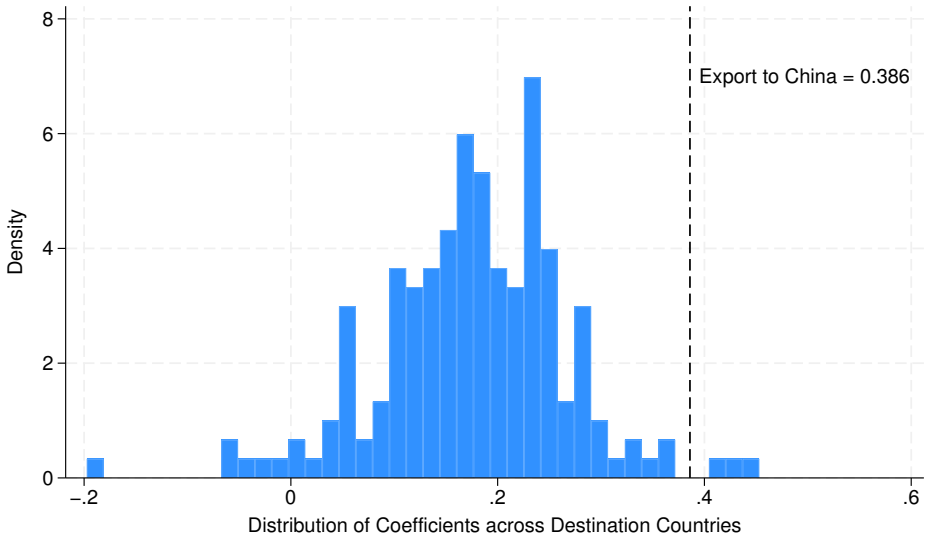
Notes: This table presents the results of a difference-in-difference regression analysis based on equation (1). The dependent variable is the log of product-level exports to China in columns (1) through (6), while column (7) uses the log of Korea's product-level exports to regions other than China. The primary independent variable, '$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$,' is the interaction between a dummy variable indicating positive RMB invoicing in 2019 and a dummy variable representing year 2011 and beyond. All regression models include a full set of product and year fixed effects. Clustered standard errors, robust to heteroskedasticity and serial correlation at the HS 4-digit level, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 4: Export Growth of RMB-invoiced Products (Event-type)



Notes: This figure presents an event-type analysis of export growth to China for HS 4-digit products invoiced in RMB in 2019.

Figure 5: Distribution of Regression Coefficients by Destination Countries



Notes: This figure presents the distribution of regression coefficients (equivalent to column (4) of Table 2) for each destination country other than China. The coefficient for Korean exports to China ranks 4th among 186 destination countries.

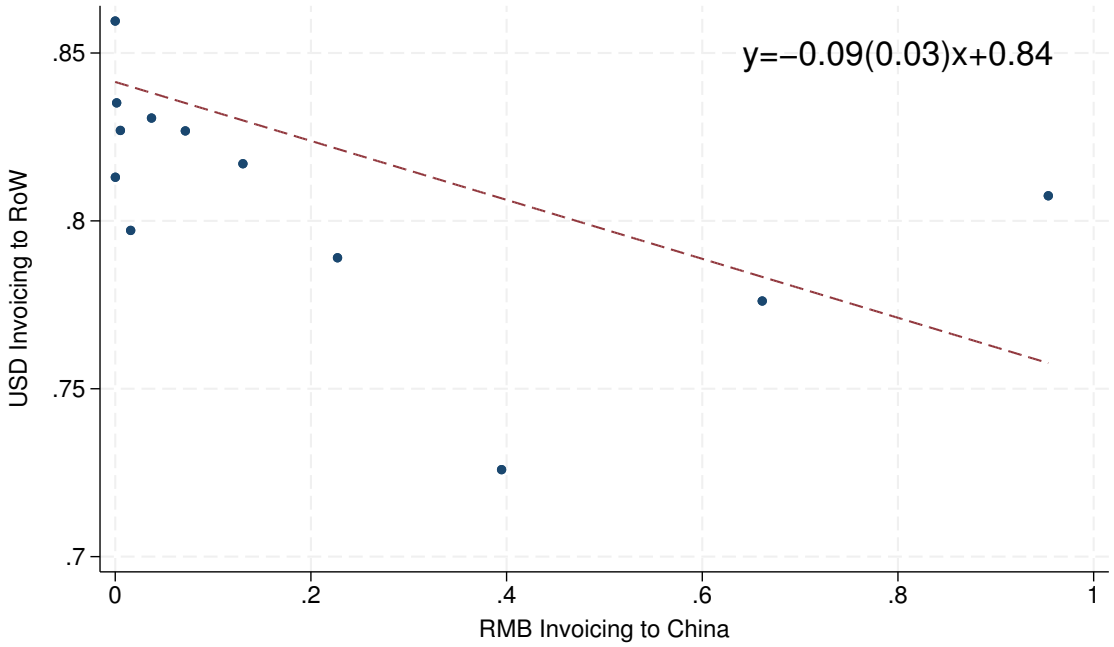
3.2.1 Endogeneity Concerns and IV Strategy

Another identification threat to our main DID specification in equation (1) is the potential endogeneity problem through reverse causality. Specifically, Amiti et al. (2022) show that firms exporting more to a destination country tend to align with the local invoicing pattern due to strategic complementarity. Moreover, it is plausible that adopting RMB invoicing involves some fixed cost that potentially lowers the marginal transaction cost. In this case, a positive selection mechanism may be at work where only firms expecting to grow in the Chinese market select positively into RMB invoicing. A second source of endogeneity may be that firms' RMB invoicing is correlated with other unobservables, such as close business connections with China.

Our IV strategy is motivated by the observation that some products are more likely to be invoiced in USD across all destinations. For instance, products that are exchange-traded or reference priced according to Rauch (1999) are more likely to be invoiced in USD. For instance, commodities such as gold or cotton are predominantly invoiced in USD in all bilateral trade. This naturally leads to our IV strategy: at the HS4 product level, we posit that whether Korean exporters use USD for invoicing when exporting to countries other than China should be negatively correlated with whether the same product uses RMB for invoicing when exporting to China (IV relevance). Additionally, it seems plausible to assume that whether the product is invoiced in USD when exported to other countries is conditionally exogenous to Korean export growth to China (IV exogeneity). Therefore, we use a dummy variable indicating whether the USD invoicing share is greater than 90% at the product level in 2019, $\mathbb{1}(s_{USD,2019} > 90\%)$, multiplied by the post-2011 dummy, to instrument our main DID regression equation (1).

The binned scatter plot in Figure 6 clearly depicts the negative correlation between the RMB invoicing share for exports to China and the USD invoicing share for exports to the rest of the world. The regression line, based on HS4 product-level observations, has a slope coefficient of -0.09, which is statistically significant. This negative correlation

Figure 6: Negative Product-Level Correlation between RMB Invoicing in China and USD Invoicing in the Rest of the World



Notes: This figure presents the binned scatter plot of Korean exporting firms.

supports our proposition that USD invoicing tends to dominate in some products for both exports to China and the rest of the world, implying that a high USD invoicing share elsewhere corresponds to lower RMB invoicing for exports to China.

Our first stage and 2SLS (two-stage least squares) regression results are presented in Tables 3 and 4, respectively. In Table 3, our first-stage results indicate that products with a high USD share in exports to other countries exhibit a correspondingly low RMB share in exports to China. The coefficient on the instrumental variable is negative and statistically significant, as anticipated, and the F-statistics indicate that the instrument is strongly correlated with the endogenous variable, though with slightly diminished strength in column (3), where the endogenous variable is the RMB share.

Column (1) of Table 4 presents our main IV regression result, showing that RMB invoicing has a strong positive and significant impact on export volume. In column (2), we extend the analysis by controlling for trade volumes with the rest of the world, finding

that the IV regression estimates remain highly consistent with those in column (1). Lastly, in column (3), we examine the IV regression results using the interaction between RMB invoicing share and the post-2011 indicator variable as the regressor. While the point estimates in column (3) are larger and accompanied by higher standard errors, the coefficient persists as positive and statistically significant.

Overall, the evidence presented in this section suggests that HS4 products benefiting from IoR (proxied by whether the products feature positive RMB invoicing share in 2019) experienced faster export growth from South Korea to China. These findings are intuitive and suggest that RMB internationalization contributes positively to trade. In the next section, we examine the impact of RMB internationalization at the firm and firm-product level to provide further evidence at a more granular level.

Table 3: Export Growth of RMB-invoiced Products (First Stage)

	(1)	(2)	(3)
	baseline	add. cov.	RMB share
Dependent Variable	$\mathbb{1}(s_{RMB,2019} > 90\%) \times 2011+$		$s_{RMB,2019} \times 2011+$
$\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+$	-0.180***	-0.183***	-0.048***
	(0.029)	(0.029)	(0.015)
log(Non-KR Import)		0.016*	
		(0.008)	
log(Non-CN Export)		-0.003	
		(0.006)	
Observations	14,230	14,196	14,230
Adjusted R^2	0.756	0.757	0.692
HS4 FE	✓	✓	✓
Year FE	✓	✓	✓
KP F-Stat	37.74	38.90	9.97

Notes: This table presents the first stage results of the 2SLS procedure to estimate equation (1). The dependent variable, '$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$,' is the interaction between a dummy variable indicating positive RMB invoicing in 2019 and a dummy variable representing year 2011 and beyond. '$s_{RMB,2019} \times 2011+$' is similarly defined using the share of RMB invoicing in 2019. We instrument RMB invoicing in 2019 with whether the product uses more than 90% USD invoicing when exported to other countries. All regression models include comprehensive product and year fixed effects. Clustered standard errors, robust to heteroskedasticity and serial correlation at the HS 4-digit level, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Kleibergen-Paap F statistics are reported in the last row of the first-stage regressions.

Table 4: Export Growth of RMB-invoiced Products (2SLS)

	(1)	(2)	(3)
	baseline	add. cov.	RMB share
Dependent Variable	log(HS4 Export to China)		
$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$	1.136***	1.088***	
	(0.409)	(0.374)	
$s_{RMB,2019} \times 2011+$			4.312**
			(1.924)
log(Non-KR Import)		0.403***	
		(0.038)	
log(Non-CN Export)		0.185***	
		(0.034)	
Observations	14,230	14,196	14,230
HS4 FE	✓	✓	✓
Year FE	✓	✓	✓

Notes: This table presents the 2SLS regression results of estimating equation (1). The dependent variable is the natural logarithm of product-level exports to China. The primary independent variable, '$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$,' is the interaction between a dummy variable indicating positive RMB invoicing in 2019 and a dummy variable representing year 2011 and beyond. '$s_{RMB,2019} \times 2011+$' is similarly defined using the share of RMB invoicing in 2019. All regression models include comprehensive product and year fixed effects. Clustered standard errors, robust to heteroskedasticity and serial correlation at the HS 4-digit level, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.3 Firm and Firm-Product Level Investigation

Thus far, we have examined the effect of RMB invoicing at the HS4 product level. A significant advantage of utilizing customs data is the ability to assess whether this effect is observable at the firm level.

A nuanced aspect of firm-level observation is the potential for firms to use multiple currencies when exporting to China within a given year. Therefore, we first explore the extent to which a typical Korean exporting firm employs multiple currencies for export invoicing. Table 5 presents the number of HS4 products a firm exports to China in a given year, alongside the number of currencies used within the same period. The table indicates that multi-product firms are prevalent in our sample. Indeed, multi-product firms constitute 59% of the sample in a given year, compared to 41% for single-product firms. In contrast, we find that the vast majority of firms (84.34%) invoice their Chinese exports using only one currency in a given year.[24]

Table 5 provides empirical support for the "currency management cost" concept articulated by Crowley et al. (2020). According to Crowley et al., the cost associated with currency management, which escalates with a more diverse currency mix, incentivizes firms to utilize a single currency across multiple markets. In our context, we extend this notion to the product space. Specifically, we propose that currency management costs exhibit increasing returns to scale with respect to the number of products, thereby encouraging firms to use a single currency to invoice various products.[25] It follows intuitively that firms would opt for a single currency for all products exported to China to avoid the additional costs associated with a diversified currency mix.[26]

[24] At the firm-product level, approximately 95% of observations use only one currency for exporting. This indicates that very few firms employ multiple currencies when exporting the same product to China within a given year. It is noteworthy that our dataset permits the observation of multi-currency invoicing patterns even for firms exporting a single product to China in a given year.

[25] For instance, consider a fixed cost c for managing a single currency. If a firm employs two different currencies for two distinct products, the total cost becomes $2c$. Conversely, if the firm uses a single currency for both products, the invoicing cost is reduced to much lower than $2c$ (in the extreme case, reduces to c) due to the singular currency management.

[26] Although there may be benefits to using different currencies for different products, as long as the cur-

Table 5: Firm-level Distribution of HS 4-digit Products and Currency Invoicing

	Firm Level Distribution of the # of			
	Products	Percentage	Currencies	Percentage
1	13926	41.00%	28642	84.34%
2	7501	22.09%	4793	14.11%
3	4182	12.31%	506	1.49%
4	2537	7.47%	21	0.06%
5+	5816	17.13%		

Notes: This table presents the distribution of the number of HS 4-digit products exported by Korean firms to China and the number of currencies employed for invoicing by Korean firms within a given year.

Next, we examine the currency invoicing patterns of Korean exporting firms that employ more than one currency for exporting within a given year. Figure 7 illustrates the distribution of each firm's *largest* currency share. The distribution exhibits a pronounced left skew, indicating that even when firms employ multiple currencies for their exports to China, a single *main* invoicing currency predominates. On average, this main invoicing currency constitutes approximately 93% of the firm's total exports to China. This significant concentration towards a single invoicing currency aligns with the concept of currency management cost as discussed by Crowley et al. (2020).[27] The preceding discussions are summarized as follows:

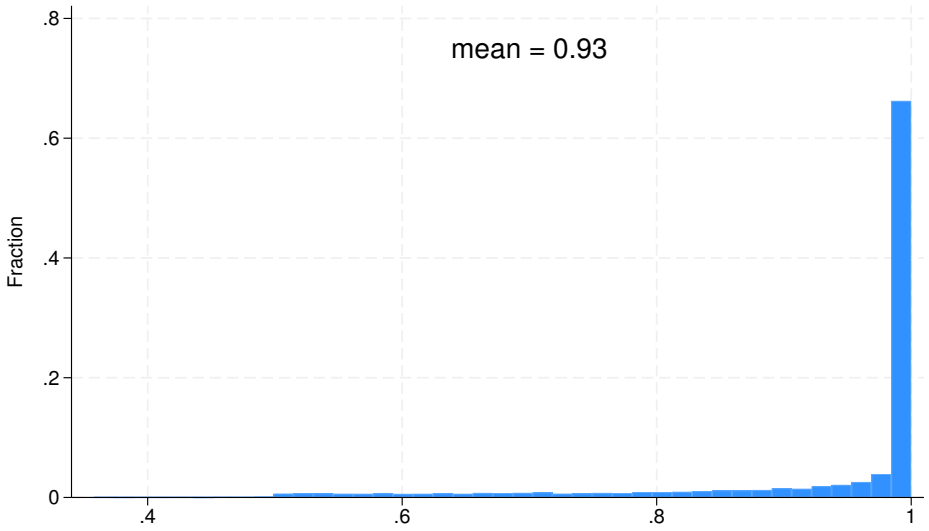
Stylized Fact *Korean firms predominantly use a single currency in a given year when exporting to China. Even if firms utilize more than one currency, a single main invoicing currency typically dominates. At the firm-product level, the concentration towards a single currency is even more pronounced.*

Accordingly, we assign a *main* invoicing currency each year for Korean firms exporting to China. Specifically, if a firm only uses a single currency for its exports to China,

rency management cost channel remains sufficiently strong, the arguments presented by Crowley et al. (2020) remain valid.

[27] We interpret the minor invoicing share of currencies other than the primary one as either a sluggish adjustment of the invoicing currency observed at the annual level or as highly idiosyncratic shocks to the invoicing cost.

Figure 7: Distribution of the Largest Currency Share Conditional on the Firm Using Multiple Currencies for Invoicing



Notes: This figure presents the distribution of the largest currency share among Korean exporting firms to China within a given year, conditional on these firms employing multiple currencies for invoicing during that period.

that currency is deemed to be the firm's main invoicing currency; if a firm uses multiple currencies, we identify the currency that accounts for the largest share of the firm's exports as its main invoicing currency.

Our baseline specification for the firm-level regression is defined as follows:

$$\log(\text{Export}_{it}) = \beta_0 + \sum_{l \in \{\text{KRW,RMB}\}} \beta_l \mathbb{1}\left(\text{Main Inv}_{it} = l\right) + \boldsymbol{X}_{it} + \mathbf{D}_i + \mathbf{D}_t + \epsilon_{it} \tag{2}$$

where the dependent variable is the natural logarithm of firm i's exports to China in year t. The key variables of interest, $\mathbb{1}\left(\text{Main Inv}_{it} = l\right)$, include two dummy variables indicating whether the main invoicing currency is currency $l \in \{\text{KRW}, \text{RMB}\}$. The reference group comprises firms that use USD as their main invoicing currency. $\boldsymbol{X}_{it}$ represents firm-level characteristics, including gross assets, annual sales, tangible assets, number of employees, industry classification, headquarters location, group affiliation (chaebol), and listing status. $\mathbf{D}_i$ and $\mathbf{D}_t$ denote firm and year fixed effects, respectively.

Another method to examine the effect of RMB invoicing is to analyze the change in export value in the year when the firm begins to use RMB. This approach mitigates concerns that the positive coefficient of RMB invoicing may be due to a spurious correlation between RMB invoicing and increased trade volume in far subsequent years. Consequently, we define an alternative regressor, "Change to RMB," which equals 1 when the firm uses RMB as the main invoicing currency in that year but not in the preceding year. To avoid grouping years before and after the firm switches to RMB in the same control group, we further introduce "After Change#Firm FE" to apply distinct firm fixed effects for the periods up until and after the RMB change.[28]

Given that firm-level regression may be criticized for aggregation bias — overweighting large products and underweighting small ones, when all products should be weighted equally — we extend the specification in equation (2) to perform a firm-product level regression:

$$\log(\text{Export}_{iht}) = \beta_0 + \sum_{l \in \{\text{KRW,RMB}\}} \beta_l \mathbb{1}\left(\text{Main Inv}_{it} = l\right) + \boldsymbol{X}_{it} + \mathbf{D}_{ih} + \mathbf{D}_t + \epsilon_{it} \qquad (3)$$

where the dependent variable is the natural logarithm of firm i's exports of product h to China in year t, and $\mathbf{D}_{ih}$ represents firm-product level fixed effects. The advantage of this firm-product level analysis is that it is not susceptible to potential aggregation bias at the firm level due to the firm's product mix. Intuitively, if products invoiced in RMB are more appealing to Chinese importers, we should observe the positive effect of RMB invoicing at both firm and firm-product levels.[29] We also estimate slight variants of equation (3) by defining the main invoicing currency at the firm-product level.

Our main firm-level and firm-product-level regression results are presented in Table

[28] In specific, "After Change#Firm FE" is coded as 1 for all years after the firm adopts RMB. Thus, a conventional firm fixed effect would absorb any firm-characteristics throughout the years, whereas "After Change#Firm FE" absorbs any structural change to the firm after adopting RMB. In this case, "Change to RMB", which is coded as 1 only at the transition year of RMB invoicing, should be interpreted as the firm's instantaneous increase in trade volume upon RMB invoicng.

[29] Instead, if the positive effects of RMB invoicing were observed at the firm level, but not at the firm-

6. In column (1), we control for industry and year fixed effects to observe how RMB and KRW coefficients are identified primarily across firms. The results indicate that, relative to USD-invoicing firms, those using RMB (KRW) generally export more (less) to China. This hierarchy of currency invoicing patterns is highly consistent with Amiti et al. (2022).

In column (2), we include firm fixed effects to evaluate how the RMB coefficient is identified based on within-firm variation. The coefficient estimate for RMB demonstrates that firms increase their exports to China by 46.8% when they begin using RMB for invoicing. Interestingly, the sign of KRW is reversed, becoming positive and marginally significant.[30] The results for RMB remain consistent in column (3), where we include firm characteristics variables, and in column (4), where we restrict the sample to firms that have used RMB at least once.

In column (5), we still restrict the sample to firms that have utilized RMB invoicing at least once, thereby estimating the impact of "Change to RMB" on firm-level export volumes. Importantly, our specification incorporates two distinct firm fixed effects: the first accounts for firm-specific factors up to and including the initial year of RMB usage, while the second captures firm-specific factors in all subsequent years. This approach allows the latter fixed effect to isolate the long-term influence of RMB invoicing on export performance, with the coefficient on "Change to RMB" representing the deviation observed in the first year of RMB adoption relative to the prior year. As presented in column (5) of Table 6, the coefficient on "Change to RMB" is both positive and statistically significant, with magnitudes comparable to columns (3) and (4). This result suggests that the adoption of RMB invoicing exerts an immediate effect on export volumes from the first year of implementation.

Columns (6) through (9) present our firm-product level regression results. In columns

product level, it suggests that the firm-level results may have been driven by aggregation bias.

[30] It is possible that some Korean firms encountered Chinese firms willing to pay in KRW. If Korean firms can lower prices by eliminating the need to incur USD exchange costs, the total export volume could increase as a result. Conversely, if firms begin to employ KRW as the invoicing currency, it may suggest the firm's export volume has become smaller (Amiti et al., 2022). Thus, the correlation between KRW invoicing and export volume is not straightforward.

(6) and (7), we show that RMB invoicing, whether defined at the firm or firm-product level, positively affects most products exported by the firm. Column (8) reveals that the positive effect is observable from the first year the firm adopts RMB. Finally, in column (9), we limit the sample to firms that use RMB as the main invoicing currency in a given year. The results in column (9) suggest that even for firms whose overall main invoicing currency is RMB, the positive effect on trade is only observed for the subset of products that are invoiced in RMB. This provides strong evidence that the positive impact of RMB invoicing at the product level is specific to those products and not driven by spurious correlations between RMB invoicing and omitted variables, such as unobserved firm characteristics, that may affect all products equally.

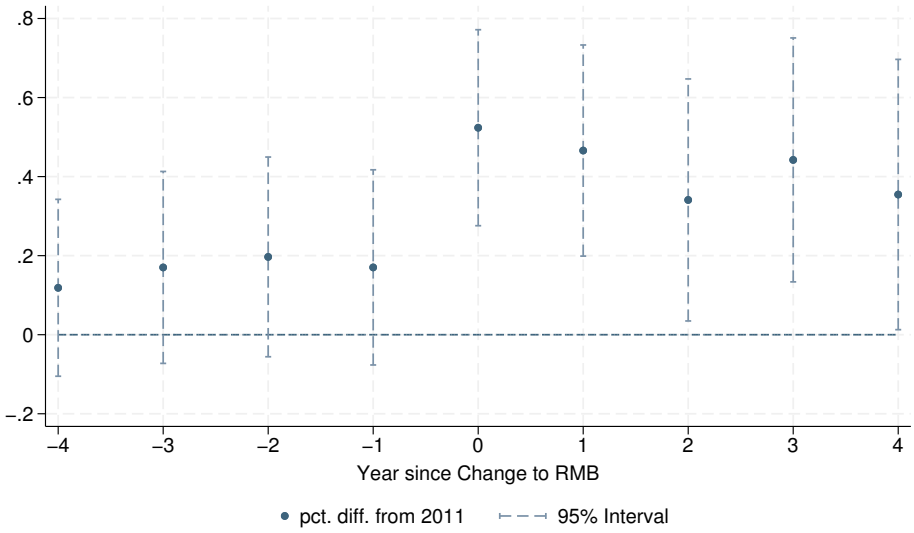
Table 6: RMB Invoicing Increases Export Volume at Firm and Firm-Product Levels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	firm level					firm-product level			
Dependent Variable	log(Firm Export to China)					log(Firm-Product Export to China)			
RMB Inv.	0.686***	0.468***	0.444***	0.518***		0.206***			
	(0.131)	(0.098)	(0.095)	(0.104)		(0.044)			
KRW Inv.	-0.547***	0.226*	0.236*	0.255		0.268***			
	(0.185)	(0.132)	(0.129)	(0.405)		(0.055)			
Change to RMB					0.434***			0.183***	
					(0.115)			(0.056)	
RMB Inv. (Prod.)							0.240***		0.548***
							(0.044)		(0.132)
KRW Inv. (Prod.)							0.388***		0.157
							(0.057)		(0.479)
Observations	32 984	32 700	32 700	4 131	4 065	182 834	182 834	25 087	8 814
Industry FE	✓								
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Firm FE		✓	✓	✓	✓				
Firm Char.			✓	✓	✓	✓	✓	✓	✓
Firm-Prod FE						✓	✓	✓	✓
After Change#Firm FE					✓				
After Change#Firm-Prod FE								✓	

Notes: This table presents the estimation results for the firm and firm-product level regressions specified in equations (2) and (3), respectively. The dependent variable in the analysis is the natural logarithm of export volume to China. The primary independent variable is 'RMB Inv.,' which indicates if the firm uses RMB as the main invoicing currency in that year. 'KRW Inv.' is defined similarly and is included as another control group. The reference group consists of firms that adopt USD as the main invoicing currency. 'Change to RMB' is a dummy variable equal to 1 only in the year when the firm switches from either KRW or USD to RMB. 'RMB Inv. (Prod.)' and 'KRW Inv. (Prod.)' are dummy variables indicating the main currency defined at the firm-product level. In columns (4), (5), and (8), the sample is restricted to firms that have ever changed the currency to RMB. In column (9), only firms whose main currency at the firm level is RMB are included. Clustered standard errors, robust to heteroskedasticity and serial correlation at the firm and firm-product levels, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Finally, there might be concerns regarding the pretrend. Specifically, if there is a pretrend in export growth that correlates with firms' invoicing decisions, the positive correlation between RMB invoicing and trade volume should be interpreted as a spurious correlation driven by the continuation of the pretrend. To address this concern, we perform an event-type analysis and present the results in Figure 8.[31] The figure demonstrates that there is no apparent increasing trend in trade volume for firms that adopt RMB for exporting.

Figure 8: Export Growth of RMB-invoiced Firms (Event-type)



Notes: This figure shows the event-type analysis of export growth to China for firms that switch to RMB invoicing.

3.3.1 Endogeneity Concerns and IV Strategy

The endogeneity concerns in the firm-level regressions are similar to the product-level cases discussed in Section 3.2.1. To address these concerns, we use whether the products in question use USD for invoicing for more than 90% of the trade volume in other markets as a negative predictor of whether the same products will be invoiced in RMB when

[31] Specifically, we include distinct fixed effects for the period spanning four years before and four years after the firm's initial use of RMB, in addition to firm fixed effects.

exported to China. However, the IV designed in Section 3.2.1 is tailored for product-level regressions. Therefore, we take the following steps to construct firm-level IVs.

First, we transform our product-level IV as follows:

$$\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+^{*}_{it} = \sum_{h} s^{CN}_{iht} \times [\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+]\,. \tag{4}$$

In equation (4), the left-hand side variable represents the firm-level IV, with an $*$ indicating that the corresponding variable has been transformed at the firm level. Here, s^{CN}_{iht} denotes firm i's export share to China of product h in year t, and $[\mathbb{1}(s_{USD2019} > 90\%) \times 2011+]$ is defined in the product-level IV regression in Section 3.2.1. Intuitively, equation (4) implies that if a firm exports to China a greater proportion of goods that are predominantly invoiced in USD when exported to other markets, it is reasonable to infer that RMB is less likely to serve as the firm's main invoicing currency for exports to China.

Additionally, we construct another firm-level IV as follows:[32]

$$\text{RMB Share}^{*}_{it} = \sum_{h} s^{CN}_{iht} \times \text{RMB Share}_{(-i)ht}, \tag{5}$$

where $\text{RMB Share}_{(-i)ht}$ denotes the product-level share of RMB invoicing for product h for all Korean firms except for firm i. Intuitively, equation (5) uses the RMB invoicing patterns of other Korean exporting firms that export the same products to instrument the firm's RMB invoicing patterns, ensuring it is not correlated with other unobservables potentially correlated with the firm's export volume in year t.

The rationale for using other Korean firms' invoicing patterns to instrument firm-level invoicing patterns can be justified in two ways. First, both Mukhin (2022) and Amiti et al. (2022) suggest that invoicing patterns exhibit strategic complementarity. Second, the invoicing patterns of other firms for each product reveal product-level information, such as whether Chinese importers of these products prefer RMB invoicing. In either case, it is straightforward to establish a positive link between other Korean firms' invoicing

[32]The primary reason for introducing a second IV for the firm-level regression is that a single IV does not sufficiently correlate with our endogenous variable.

patterns and that of the firm in question.

One potential concern with this strategy is that firms producing product h might have faced sectoral shocks, leading to an overall increase in their exports during period t. Consequently, s_{iht}^{CN} might introduce endogeneity.

To address this concern, we include a control variable defined as

$$\text{Export to China } (-\text{i})_{it}^{*} \equiv \log\left(\sum_{h} s_{iht}^{CN} \text{Export to China}_{(-i)ht}\right), \tag{6}$$

where $\text{Export to China}_{(-i)ht}$ represents the total amount of Korean exports to China of product h in year t, excluding firm i. This control variable effectively accounts for aggregate supply or demand shocks related to product h that impact all firms similarly.

In the firm-product level regression, we do not need to perform the firm-level transformation. Therefore, we use the variables defined in equations (4) through (6) at the product level without an asterisk.[33]

In summary, we use two IVs, $\mathbb{1}(s_{USD2019} > 90\%) \times 2011+_{it}^{*}$ and $\text{RMB Share}_{it}^{*}$, to instrument whether a Korean firm uses RMB as the main invoicing currency, while controlling for product-level trade shocks $\text{Export to China } (-\text{i})_{it}^{*}$ that may be correlated with firms' export shares.

The firm and firm-product level first stage and 2SLS regression results are presented in Tables 7 and 8. Throughout the columns in Table 7, our IVs exhibit the expected signs in the first-stage regressions: $\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+$ is negative, while RMB Share is positive. This aligns with our hypothesis that products invoiced in USD in other markets tend not to be invoiced in RMB when exported to China and that Korean firms tend to use RMB invoicing for products for which other Korean firms also use RMB invoicing. As shown at the bottom of the table, all first-stage F-statistics are sufficiently large.

In column (1) of Table 8, we include only industry and year fixed effects and find that the coefficients of RMB and KRW are positive and negative, respectively, consistent with

[33]Specifically, $\mathbb{1}(s_{USD2019} > 90\%) \times 2011+_{iht}$ is defined the same way as in Section 3.2.1, RMB Share_{iht} is equal to $\text{RMB Share}_{(-i)ht}$, the RMB share of all firms exporting product h except for firm i, and

our previous results in Table 6. In column (2), we include firm fixed effects as control variables, and in column (3), we include both firm fixed effects and firm characteristics. We find that the IV coefficients for RMB are consistently positive, although not significant (p-value = 0.148) in column (3).

We further examine the effect of RMB invoicing at the firm-product level. Regardless of whether RMB invoicing is defined at the firm level (column 4) or at the firm-product level (column 5), the coefficients are both positive and significant. The impact of KRW at the firm-product level is also positive and significant, comparable to the effect of RMB. In all IV regressions, the sign of the export volume of all firms other than firm i is positive and significant, suggesting that there might be demand or supply shocks correlated across firms that export the same products. In summary, with the exception of column (3), the sign of RMB Inv. is positive and significant, indicating that an exogenous change to RMB invoicing would increase Korean firms' trade volume to China.

3.4 Mechanism

This section comprises of two subsections. In Section 3.4.1, we present the key aspects of a currency invoicing model that elucidates three channels through which IoR may potentially contribute to increased export to China: exchange rate risk, output price and currency cost on the importer side. Next in Section 3.4.2, we present empirical evidence to suggest that the reduced currency cost appears to be the main reason why firms export more when they adopt RMB invoicing. The full model is detailed in Appendix B.

3.4.1 Overview of the Currency Invoicing Model and Its Implications for the Mechanisms of IoR

To guide our empirical investigation, we present a two-period model of currency invoicing and trade in Appendix B. The model's key elements are as follows. In period 1,

Table 7: Firm and Firm-Product Level IV Regressions (First Stage)

	(1)	(2)	(3)	(4)	(5)
	firm level			firm-product level	
Dependent Variable	RMB Inv.			RMB Inv.	RMB Inv. (Prod.)
$\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+^*$	-0.010*	-0.011*	-0.011*		
	(0.005)	(0.006)	(0.006)		
RMB Share*	0.719***	0.575***	0.575***		
	(0.024)	(0.027)	(0.027)		
KRW Inv.	-0.055***	-0.071***	-0.072***	-0.113***	
	(0.007)	(0.011)	(0.011)	(0.006)	
Export to China $(-i)^*$	-0.001	-0.000	-0.000		
	(0.001)	(0.001)	(0.001)		
$\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+$				-0.007**	-0.014***
				(0.003)	(0.003)
RMB Share				0.465***	0.389***
				(0.011)	(0.011)
Export to China $(-i)$				0.001	-0.000
				(0.001)	(0.001)
KRW Inv. (Prod.)					-0.091***
					(0.005)
Observations	32,464	32,174	32,174	181,229	181,229
Industry FE	✓				
Year FE	✓	✓	✓	✓	✓
Firm FE		✓	✓	✓	✓
Firm Char.			✓	✓	✓
Firm-Prod FE					
KP F-Stat	448.27	233.03	232.38	918.57	665.31

Notes: This table presents the first stage results of the 2SLS procedure to estimate equations (2) and (3), respectively. The dependent variable is 'RMB Inv.,' which indicates if the firm uses RMB as the main invoicing currency in that year. 'RMB Inv. (Prod.)' is defined as the main invoicing currency at the firm-product level. For the definition of independent variables, please refer to the discussions in Section 3.3.1. Clustered standard errors, robust against heteroskedasticity and serial correlation at the firm and firm-product levels, respectively, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Kleibergen-Paap F statistics are reported in the last row of the first-stage regressions.

Table 8: Firm and Firm-Product Level IV Regressions (2SLS)

	(1)	(2)	(3)	(4)	(5)
	firm level			firm-product level	
Dependent Variable	log(Firm Export to China)			log(Firm-Product Export to China)	
RMB Inv.	0.597**	0.412*	0.350	0.262**	
	(0.249)	(0.243)	(0.242)	(0.124)	
KRW Inv.	-0.460***	0.211	0.221*	0.263***	
	(0.177)	(0.130)	(0.128)	(0.057)	
RMB Inv. (Prod.)					0.345**
					(0.148)
KRW Inv. (Prod.)					0.391***
					(0.059)
Export to China $(-i)^*$	0.356***	0.207***	0.201***		
	(0.017)	(0.014)	(0.014)		
Export to China $(-i)$				0.141***	0.141***
				(0.009)	(0.009)
Observations	32,464	32,174	32,174	181,229	181,229
Industry FE	✓				
Year FE	✓	✓	✓	✓	✓
Firm FE		✓	✓		
Firm Char.			✓	✓	✓
Firm-Prod FE				✓	✓

Notes: This table presents the IV estimation results for firm and firm-product level regressions specified in equations (2) and (3), respectively. The dependent variable is the natural logarithm of export volume to China. The primary independent variable is 'RMB Inv.,' which indicates if the firm uses RMB as the main invoicing currency in that year. 'KRW Inv.' is defined similarly and is included as another control group. The reference group comprises firms that adopt USD as the main invoicing currency. 'RMB Inv. (Prod.)' and 'KRW Inv. (Prod.)' are dummy variables indicating the main currency defined at the firm-product level. For the definition of other variables, please refer to the discussions in Section 3.3.1. Clustered standard errors, robust against heteroskedasticity and serial correlation at the firm and firm-product levels, respectively, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

exporting firms from country i select an invoicing currency l and set a price $p_l(\omega)$, where ω denotes the firm's productivity level. The choice of currency l is among (i, j, d), representing the currencies of countries i and j, and the dollar, respectively. Goods are differentiated by their invoicing currency, price, and household-specific preference shocks. The equilibrium prices exhibit variable markups, with larger firms able to charge higher markups due to facing less elastic demand.

Also in period 1, households in country j decide to purchase from a single firm, either foreign or domestic, to spend their exogenous income y, which is assumed to be identical for all households in country j. The measure of households in country j is denoted by n. Crucially for our analysis, we introduce marginal currency transaction costs τ_l^i and τ_l^j to represent the costs incurred by firms and households, respectively, when conducting transactions in currency l.

To simplify the model, we assume that all domestic firms in country j invoice in currency j, and we abstract from household demand in country i as it does not yield additional insights. In period 2, exchange rates are realized. Consumers derive utilities, and firms earn profits based on their respective choices made in the preceding period.

Let $\mathcal{M}(\omega, l)$ denote the market share of an exporting firm from country i in country j, with productivity level ω and currency invoicing in l. The total export volume of the firm is given by $ny\mathcal{M}(\omega, l)$. Appendix B demonstrates that the change in the firm's market share, and consequently its export volume, can be decomposed into three channels:

$$\mathrm{d}\mathcal{M}(\omega, l) = \mathcal{M}(1-\mathcal{M}) \left[\underbrace{\left(-\frac{1}{2}\frac{\lambda}{1+\lambda} \right) \mathrm{d}\sigma^2_{jl(\omega)}}_{\text{foreign exchange risk}} - \underbrace{\lambda \mathrm{d}p_l(\omega)}_{\text{price}} - \underbrace{\lambda \mathrm{d}\tau^j_{l(\omega)}}_{\substack{\text{household} \\ \text{currency cost}}} \right], \tag{7}$$

where λ is a parameter related to demand elasticity, and $\sigma^2_{l(\omega)i}$ represents the exchange rate volatility of currency l relative to the household's currency.

The first term captures the direct effect of changes in volatility. Given that households

$\text{Export to China } (-\text{i})_{iht}$ is equal to $\log\left(\text{Export to China}_{(-i)ht}\right)$, the natural logarithm of total Korean export

are risk-averse, they prefer to purchase from firms that invoice products in currency j to ensure stable consumption levels despite exchange rate shocks. If products are not invoiced in currency j, households still favor those invoiced in currencies with lower volatility.

The second and third terms indicate that export volume decreases with higher prices and increased household-side costs of using currency l. It is important to note that the household's currency cost may be non-pecuniary, making it challenging to quantify from the data. We later demonstrate that the USD/RMB exchange rate volatility do not appear to be a major factor from 2006 to 2019, and that Korean firms adopting RMB invoicing do not reduce their prices accordingly. Consequently, we conclude that the primary factor affecting trade volume is the household-side currency cost.

We note that although exporting firms' profits are subject to exchange rate shocks, these shocks do not influence equilibrium outcomes since firms are assumed to be risk-neutral. However, the exchange rate risk faced by households plays a significant role, as demonstrated in equation (7).

We summarize the preceding results in the following proposition.

Proposition 1. *RMB invoicing may increase firms' export volume by reducing the exchange rate risk faced by households, lowering the output price, and decreasing the household's currency cost.*

To illustrate the impact of currency costs faced by firms, we show that the change in output prices can be expressed as

$$\mathrm{d}p_l(\omega) = \underbrace{\frac{\lambda\left(1-\mathcal{M}(\omega,l)\right)}{\lambda\left(1-\mathcal{M}(\omega,l)\right)-1}\frac{1}{\omega}\mathrm{d}\tau^i_{l(\omega)}}_{\text{firm currency cost}} + \underbrace{\frac{\lambda}{\lambda\left(1-\mathcal{M}(\omega,l)\right)-1}\mathrm{d}\mathcal{M}(\omega,l)}_{\text{market power}}, \tag{8}$$

where the first term indicates that a lower marginal cost of using currency l reduces the output price, and the second term suggests that a firm with a larger market share can increase the price by charging a higher markup.

A few additional remarks are in order. First, the producer's marginal currency cost does *not* affect the trade volume conditional on the output price, which already incorporates such costs. While we expect that the cost of invoicing in RMB for Korean firms decreased during the period of analysis, our empirical analysis shows that Korean firms do not lower their prices when adopting RMB invoicing, indicating that lower producer-side currency costs cannot explain the increase in trade volume.[34]

Second, our model includes the fixed cost of currency invoicing. However, we demonstrate that the fixed cost of currency invoicing only influences firms' discrete invoicing decisions and does not impact their export volume *conditional on* their use of RMB. We summarize the preceding discussion as follows.

Proposition 2. *The change in firms' output prices can be attributed to changes in the marginal currency costs faced by firms and changes in their market shares. The firm's marginal currency cost impacts trade volume solely through its effect on output prices. The firm's fixed cost of currency invoicing influences the firm's decision on which currency to invoice in, but does not affect the trade volume once the invoicing decision is made.*

3.4.2 Investigating Possible Mechanisms

The main regression results exploring potential mechanisms are presented in Table 9. First, we investigate the role of exchange rate volatility. To do this, we calculate the median export turnover (Exp. TO) for each 4-digit KSIC (Korean Standard Industrial Classification), defined as the ratio of a firm's export revenue to foreign currency receivables.[35] If an industry's median export turnover is high, it suggests that foreign counterparts take longer to pay for the goods, thereby facing greater exchange rate risk if the invoicing cur-

volume to China of product h excluding firm i.

[34]The empirical findings that the output price is insensitive to RMB invoicing suggest that the markup may have been higher as a result. This is an interesting result, but we leave further investigation into this for future research.

[35]There are 495 different industry classifications in the 4-digit KSIC, which are comparable to the 4-digit International Standard Industrial Classification.

rency is *not* RMB. This leads to a plausible testable hypothesis: if the key benefit of RMB invoicing is hedging importers against exchange rate risk for future payments, we would expect RMB invoicing to have a greater positive effect in industries with higher export turnover.

We test this hypothesis by interacting our key variable of interest, RMB Inv., with industry-level median export turnover and present the results of firm-level and firm-product-level regressions in columns (1) and (2) of Table 9, respectively. In both regressions, the interaction term is slightly negative and insignificant, suggesting that RMB invoicing does not significantly increase trade in industries where the benefit of foreign exchange risk hedging is greater.[36] Thus, reducing exchange rate risk for importers does not appear to be a primary reason for favoring RMB-invoiced products.

To further substantiate the claim that the increase in trade is not attributable to heightened exchange rate volatility, we present the historical RMB/USD exchange rate volatility in Appendix Figure C.3. Except for the year 2018, which stands as an outlier, our analysis reveals no discernible upward trend in RMB/USD volatility that would incentivize Chinese importers to increasingly favor RMB-invoiced products for the purpose of stabilizing payment costs.

Continuing with Table 9, in columns (3) and (4), we examine the change in output price when a firm adopts RMB.[37] We observe that the drop in prices for firms using RMB invoicing is not significant at both firm and firm-product level regressions.[38]

As neither foreign exchange risk nor the price channels provide a compelling explanation for the increase in trade volume, we contend, based on equation (7), that the primary channel through which RMB invoicing augments Korean exporting firms' trade volume is

[36] One possible explanation for this is that Chinese firms may have financial instruments to hedge against foreign exchange risk.

[37] Price is defined as the value of shipment divided by weight. Price is unique for a firm-product observation. For firm-level regressions, we use the median of the firm's output prices. The results remain robust even if we use the mean of the firm's output prices.

[38] Moreover, the scale of the coefficient is not economically significant. For instance, a 2.2% decline at the product level does not justify a 26.2% increase in trade volume (cf. Table 8 column 4).

by mitigating Chinese importers' marginal currency cost. Intuitively, at a given price and level of foreign exchange risk, Chinese importers exhibit a preference for goods invoiced in RMB over those invoiced in USD, due to the latter's inherent currency cost (pecuniary or non-pecuniary). Our analysis posits that this is the mechanism through which RMB invoicing bolstered Korean exports to China during the period from 2006 to 2019.[39]

Finally, in column (5), we examine the potential linkage stemming from Chinese imports. Both Mukhin (2022) and Amiti et al. (2022) posit that firms utilizing foreign inputs intensively are more likely to invoice their outputs in the foreign currency.[40] To test this hypothesis, we regress a dummy variable indicating whether the firm uses RMB on its log import volume from China, while controlling for the firm's KRW invoicing status, firm characteristics, as well as firm and year fixed effects. Surprisingly, the coefficient for imports from China is *not* significant. One plausible reconciliation of this finding with the theory is that the majority of Korean imports from China are invoiced in USD, as illustrated in Appendix Figure C.2. On one hand, USD-invoiced Chinese imports might induce Korean firms to invoice their exports in USD; on the other hand, Chinese imports could signify a firm's strong connection with China. Thus, the overall impact of Chinese imports on Korean firms' RMB invoicing decisions is potentially ambiguous.

4 Further Discussion and Robustness Checks

This section offers an overview of the additional investigations and robustness checks conducted to mitigate potential concerns related to our primary analysis. All associated figures and tables pertaining to this section are presented in Appendix C.

We investigate the impact of RMB invoicing on other dimensions of firm performance.

[39] It is noteworthy that, irrespective of the temporal variations in the relative cost of using USD in China, a switch to RMB would always generate higher demand as long as RMB remains more convenient for Chinese importers. Therefore, our import-side currency cost channel is robust and does not depend on the decreasing relative cost of USD over time.

[40] It is also plausible that imports from China, potentially indicating a firm's strong connection with China, may influence the firm's decision to invoice in RMB.

Table 9: Potential Mechanism for RMB Invoicing

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	log(Export to China)		log(Export Price)		RMB Inv.
RMB Inv.	0.473***	0.097*	-0.056	-0.022	
	(0.106)	(0.051)	(0.041)	(0.018)	
RMB Inv. × Exp. TO	-0.012	-0.001			
	(0.009)	(0.006)			
KRW Inv.	0.244*	0.271***	0.087	0.044*	-0.087***
	(0.131)	(0.059)	(0.058)	(0.024)	(0.016)
Import from China					0.001
					(0.001)
Observations	27 653	150 985	29 352	162 150	21 071
Firm FE	✓		✓		✓
Firm Char.	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Firm-Prod FE		✓		✓	

Notes: This table investigates the potential mechanisms through which RMB invoicing promotes Korean exports to China. Columns (1), (3), and (5) are based on firm-level observations, while columns (2) and (4) on firm-product-level observations. In columns (1) and (2), the primary coefficient of interest is that of 'RMB Inv. × Exp. TO,' where 'Exp. TO' denotes the sectoral median level of export turnover as defined in Section 3.4.2. In columns (3) and (4), the dependent variable is the natural logarithm of export price (converted to dollars). In column (5), the dependent variable is a binary indicator of whether a Korean firm uses RMB as the main invoicing currency. 'Import from China' is measured as the logarithm of total imports from China. All regressions include year and firm (or firm-product) fixed effects. Standard errors clustered at the firm (or firm-product) level are robust to heteroskedasticity and serial correlation, and are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

These dimensions include firms' total exports to the rest of the world, total imports from China and other countries, total annual sales, employment, and tangible assets. A plausible concern is that RMB invoicing might be correlated with certain firm-specific factors that enhance overall firm performance (e.g., productivity improvements). If such correlations exist, our firm-level regression results on firms' exports to China should be interpreted with caution. However, as demonstrated in Appendix Table C.3, RMB invoicing does not appear to affect any of the key firm characteristics. This finding further bolsters the robustness of our conclusion that RMB invoicing has a causal effect on exports to China.

The benefits of RMB invoicing on exports may vary across different Korean firms. To explore this heterogeneity, we partition Korean firms into two equally sized groups based on three distinct criteria: total export volume to China, capital-to-labor ratio, and annual total sales. We also consider another group based on affiliation with the top 10 conglomerates (Chaebol). The corresponding results are detailed in Table C.4. Overall, our findings indicate that the positive effect of RMB invoicing is robust across these various subgroups of firms.

Our product-level analysis utilizes BACI trade data, which provides a comprehensive overview of global trade. In Appendix Table C.5, we employ product-level trade data constructed from our Korean customs dataset to re-estimate our product-level regression model. We observe that the magnitude of the RMB invoicing effect is even more pronounced, and our key results remain consistent.

It is instructive to examine the heterogeneous effects of RMB invoicing across different HS Sections.[41] By observing consistently positive and significant effects across HS sections, we can assert with greater confidence that our product-level results are not unduly influenced by outliers from a few anomalous sectors. To this end, we interact the

[41] HS codes are categorized into 21 sections. We have no observations in Section 19 "Arms and Ammunition" and do not report estimates for Section 1 "Live Animals" and Section 21 "Works of Art" due to the limited sample sizes in these sections — 36 and 9 observations, respectively.

primary regressor from equation (1), $\mathbb{1}_h(\text{RMB Pos in 2019}) \times \mathbb{1}_t(\text{Year} \geq 2011)$, with HS section dummies and present the point estimates along with their confidence intervals in Appendix Figure C.4. As depicted, nearly all point estimates exceed zero, with 11 out of 18 HS sections showing positive and statistically significant effects. Consequently, we conclude that the positive impact of RMB invoicing is observed across most HS sections, although the magnitude of these effects varies considerably across different sections.

A potential concern regarding the rapid pace of IoR is the possibility of manipulation by the Chinese government. Specifically, there is a concern that the Chinese government might mandate state-owned enterprises (SOEs) to import using RMB.[42] Although we are not aware of any evidence supporting this hypothesis, we can empirically test it by examining whether products predominantly imported by Chinese SOEs are more likely to be invoiced in RMB. To do so, we regress the product-year-level RMB invoicing share on the share of Chinese SOEs importing each HS 4-digit product in a given year. The results, presented in Appendix Table C.6, do not indicate any significant correlation between the RMB invoicing share and the share of Chinese state importers.

As an additional robustness check, we estimate a long-difference regression model to examine the long-term differential growth of Korean exports invoiced in RMB over the period from 2007 to 2019. The results, presented in Appendix Tables C.7, C.8 and C.9, indicate that both OLS and IV regression models consistently show a significant positive effect of RMB invoicing on trade. Notably, the magnitude of the coefficient is comparable to those reported in Tables 2 and 4.

Finally, in our product-level analysis reported in Table 2, we employ standard errors clustered at the HS 4-digit level, thereby assuming the absence of correlation among error terms across different HS 4-digit categories. To assess the robustness of our results, Table C.10 presents alternative estimates where standard errors are clustered at the HS 2-digit

[42]While it is plausible that the Chinese government could exert influence over both state-owned and private enterprises, we hypothesize that its influence would be more pronounced on SOEs, particularly during the early stages of IoR.

level. This alternative specification allows for potential correlation of error terms across HS 4-digit categories that fall within the same HS 2-digit classification. Our core findings demonstrate consistent robustness across these clustering approaches.

5 Conclusion

Our study utilizes granular currency invoicing data obtained from Korean customs to investigate the impact of RMB internationalization on international trade. Both our product-level and firm-level analyses collectively suggest that RMB internationalization promotes trade. After constructing a theoretical framework to analyze currency invoicing and trade, we further demonstrate that the primary driver behind the substantial increase in RMB-invoiced trade is the elimination of the necessity for Chinese importers to hold USD or other vehicle currencies, thereby reducing the currency costs incurred by the importers.

This paper constitutes one of the pioneering empirical investigations into the effects of RMB internationalization, a phenomenon that is still in rapid evolution and whose full implications are yet to be thoroughly understood. Accordingly, we propose two critical avenues for future research. First, to what extent will RMB invoicing displace USD invoicing at a steady-state equilibrium? Second, under what conditions will Korean firms adopt RMB invoicing for exports to countries other than China? Addressing these questions is essential for a deeper understanding of the long-term consequences of RMB internationalization.

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Online Appendix:
Does RMB Internationalization Promote Cross-Border Trade?

by

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A An Overview of RMB Internationalization

This section provides an overview of RMB internationalization's objectives, the benefits it brings to China, and the Chinese government's efforts to achieve this goal.

A.1 Objectives and Advantages

RMB internationalization can be broadly divided into three aspects, which correspond to three conventional functions of money: unit of account, medium of exchange, and store of value. The Chinese government seeks to promote the RMB as an invoicing currency for trade and financial transactions (unit of account), a settlement currency for these transactions (medium of exchange), and a reserve currency for corporations and other governments (store of value). Our paper concentrates on the role of the RMB as a trade invoicing currency.[43]

RMB internationalization offers multiple advantages to China. First, the widespread use of RMB in cross-border trade and financial transactions reduces exchange rate risk for Chinese citizens and businesses. Second, increased international demand for Chinese assets can decrease financing costs for Chinese firms and governments. Thirdly, as our

[43] Li (2013) observes that a mere 56% of merchandise settled in RMB was invoiced in RMB – a proportion significantly lower than that of the USD or Euro (Friberg and Wilander, 2008). Our paper's focus is on the RMB as an invoicing currency, and we defer the exploration of the discrepancy between invoicing and settlement currencies to future research.

paper investigates, RMB internationalization may benefit China's bilateral trade.[44]

A.2 Policies and Institutions for RMB Internationalization

Eichengreen (2011) suggests that there is a logical sequence of steps to internationalize a currency: first, promoting its use in invoicing and settling trade; second, encouraging its use in private financial transactions; and third, fostering its use by central banks and governments as a form in which to hold foreign reserves. In China's experience, the first and second steps have been pursued concurrently through the establishment of offshore RMB markets, the signing of currency swap agreements with other central banks, and the liberalization of international capital flows. The progress of RMB as a reserve currency has been much slower.[45]

A.2.1 Offshore RMB Markets

A path-breaking step towards RMB internationalization is the introduction of CNH, the offshore version of the RMB currency, whereas CNY is utilized for onshore transactions. Unlike RMB, CNH is fully convertible to other currencies in the offshore market. Various policies have been implemented to foster the growth of offshore RMB markets, which are closely related to, but not entirely integrated with, the onshore RMB market. Offshore RMB centers have been established in cities such as Hong Kong, Singapore, Taipei, and London, where CNH can be used for cross-border payments, issuing bonds, making loans, and bank deposits.

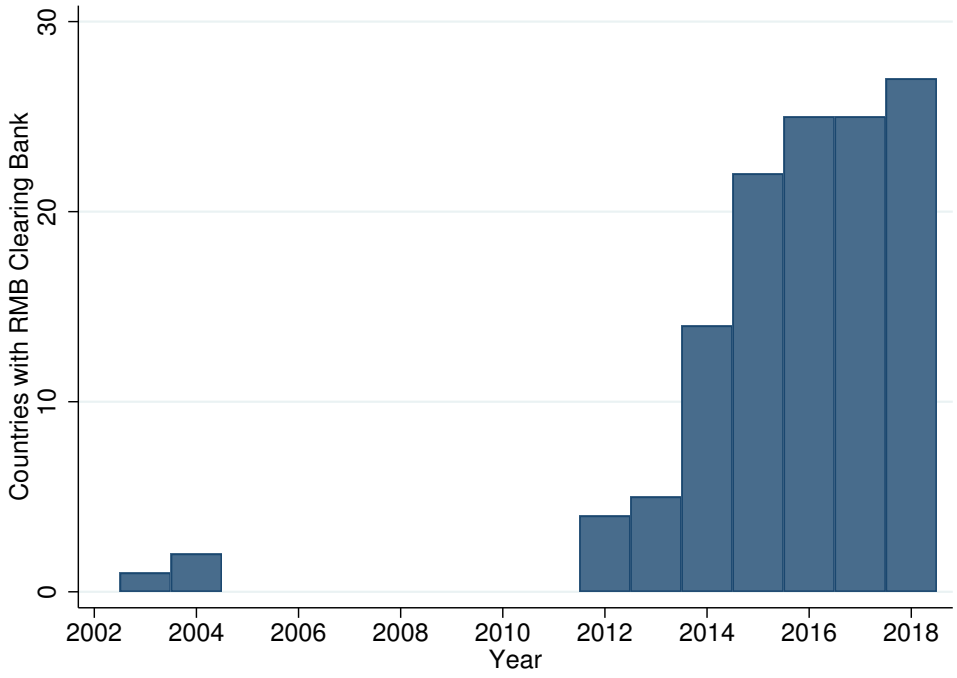
In offshore RMB markets, official clearing banks have played a pivotal role by monitoring and securing RMB payments between parties. The first two official clearing banks were established in Hong Kong and Macau in 2003 and 2004, respectively. However, it

[44] For a more comprehensive analysis of RMB internationalization's benefits to China, we direct readers to Lai (2021).

[45] According to the Currency Composition of Official Foreign Exchange Reserves, RMB accounts for less than 3% of the world's official reserve currency as of 2023.

was not until 2012 when the third official clearing bank was established in Laos. Subsequently, official RMB clearing banks rapidly expanded worldwide, reaching 25 countries by September 2020.[46] In addition to enhancing the overall liquidity of offshore RMB, these clearing banks encouraged commercial banks to accept RMB deposits and enabled People's Banks of China to provide RMB settlement services.

Figure A.1: Countries with Official RMB Clearing Banks



Source: People's Bank of China

A.2.2 Currency Swap Agreements

As noted in Bahaj and Reis (2020), the PBC signed multiple bilateral currency swaps with foreign counterparts to promote the internationalization of the RMB.[47] People's Bank of China claim that: "The renewal of the bilateral local currency swap agreement by the

[46] More details can be found at the 2021 RMB Internationalization Report published by the PBC. (http://www.pbc.gov.cn/en/3688110/3688172/4157443/4433239/2021122809344466286.pdf) See Figure A.1 for PBC's rapid expansion of offshore RMB clearing banks since 2012.

[47] While currency swaps can be signed in terms of USD instead of mutual currencies (e.g., Chiang-Mai Initiative), such swap agreements generally serve as a source of USD liquidity during crises and do not

central banks of China and South Korea will play a positive role in maintaining financial market stability, expanding the use of local currencies between China and South Korea, and at the same time help promote the facilitation of trade and investment."[48]

China's aggressive pursuit of bilateral currency swap agreements began in 2009, with South Korea becoming the first country to sign a reciprocal currency swap agreement with China. The official document claimed that the swap agreement aimed to (1) promote trade invoicing in mutual currency by providing trade credit and (2) provide security to the offshore KRW/RMB financial market via a central bank line of credit. Since then, as shown in Appendix Figure A.2, China has signed an average of approximately 5 bilateral currency swap agreements per year, with a total of 41 countries having signed such agreements with China by the end of 2020, amounting to more than 3.5 trillion RMB.[49]

A.2.3 Liberalization of Capital Flows

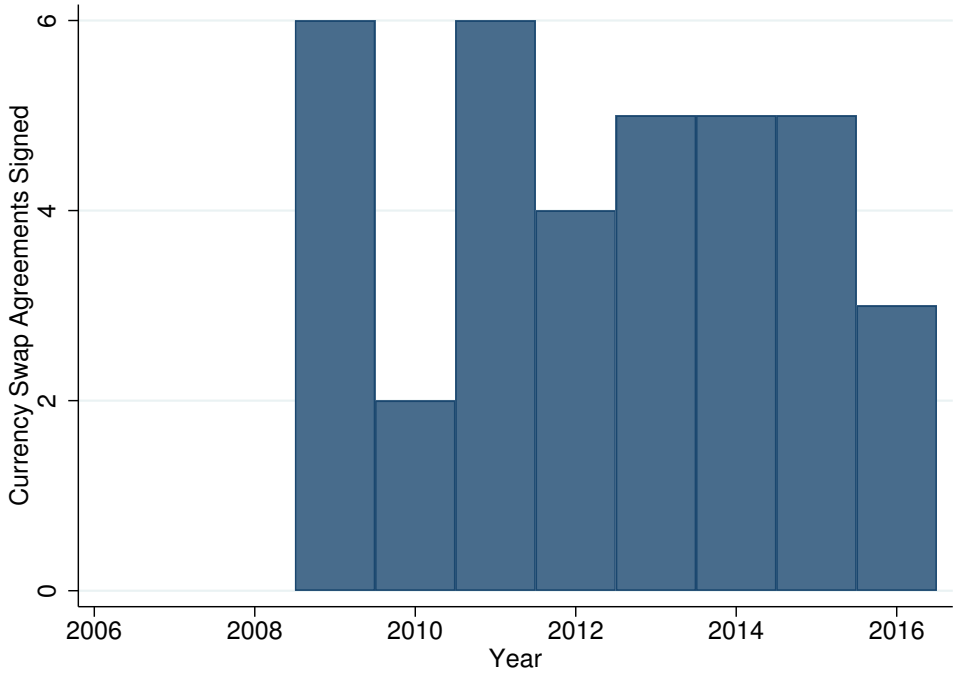
Another important aspect of RMB internationalization is to make it a viable currency for store of value, which requires the availability of more financial tools denominated in RMB both within and outside mainland China. Key policy and institutional changes to support this goal include the RMB Qualified Foreign Institutional Investor program (2011), the Shanghai–Hong Kong Stock Connect program (2014), the Chinese Interbank Bond Market Direct scheme (2016), and the Northbound Trading bond market (2017). Perhaps the most significant recent innovation is Cross-Border Interbank Payment System (CIPS), which began its phase I and II in 2015 and 2018, respectively. Essentially, CIPS is a modern large-value payment system backed by the PBC that aims to "provide fund clearing and settlement services to domestic and foreign participants in cross-border RMB

necessarily promote the use of either currency in trade invoicing.

[48] https://www.gov.cn/xinwen/2020-10/22/content_5553410.htm

[49] It is worth noting that reverse causality might be associated with bilateral currency swaps and currency invoicing in trade. In particular, Gopinath and Stein (2021) suggest that as a greater share of international trade is invoiced in a foreign currency, the central bank may have a greater incentive to accumulate foreign reserves in that currency. Central bank swap lines are a liquid buffer similar to foreign reserves, so it is plausible that the same motive would lead to more currency swap lines.

Figure A.2: Bilateral Currency Swaps in Reciprocal Currencies Signed by PBC



Source: People's Bank of China

businesses, serving as a 'highway' for RMB internationalization."[50]

B A Model of Currency Invoicing and Trade

We extend the model in Messer (2020) to incorporate the variable cost of currency invoicing. The objective is to elucidate the different mechanisms through which IoR may help to increase trade volume.

We consider two countries, i and j. Country i serves as the exporting country with a unit measure of exporting firms, while country j is the importing country with households, measured by n. The model spans two periods, $t \in \{1, 2\}$. In period 1, exporters decide on the invoicing currency $l \in \{i, j, d\}$, as well as the corresponding price $p_l(\omega)$.[51]

[50] The official statement announcing the phase 2 of CIPS can be found at http://www.pbc.gov.cn/english/130721/3533376/index.html.

[51] Here, ω represents a firm, its product, and its productivity level.

The subscripts i, j, and d denote the currencies of country i, country j, and the USD, respectively. This price remains fixed into period 2. Additionally, in period 1, households (or importing firms) select from which exporters and domestic firms to purchase. Households exhibit risk aversion and possess idiosyncratic preferences for producers, denoted $\epsilon_{h\omega}$, where h refers to a household and ω to an exporter. These preferences are known in period 1. We do not detail the households in country i since we are primarily concerned with the partial equilibrium between exporting firms from country i and households in country j.

In period 2, households allocate their (exogenously given) income to purchases from their selected exporter, paying the prevailing exchange-rate-adjusted price in currency j, $p_l(\omega)/\mathcal{E}_{jl(\omega)}$. Here, the exchange rate $\mathcal{E}_{jl(\omega)}$ represents the currency l price of a unit of currency j, where an increase in $\mathcal{E}_{jl(\omega)}$ indicates an appreciation of currency j relative to currency l.

We assume that household h incurs a currency conversion cost denoted by $\tau^j_{l(\omega)}$, such that the effective price becomes $p_l(\omega)\tau^j_{l(\omega)}/\mathcal{E}_{jl(\omega)}$. The cost of using the household's own currency is normalized to 1 (i.e., $\tau^j_j = 1$).[52] Household h chooses an exporting firm ω from which to purchase good x to maximize the utility given by:

$$\max_{\omega} \mathbb{E}\, U_h(x(\omega)) \tag{B.1}$$

$$\text{s.t.} \frac{p_l(\omega)\tau^j_{l(\omega)} x(\omega)}{\mathcal{E}_{jl(\omega)}} = y, \tag{B.2}$$

where $\mathbb{E}\, U_h(x(\omega))$ represents the expected utility from consuming good x provided by exporter ω. Household income y is exogenously determined and uniform across all households. The price $p_l(\omega)$ is the amount firm ω charges for its product when invoiced in currency l, thus the effective price in terms of currency j is $p_l(\omega)/\mathcal{E}_{jl(\omega)}$. The utility for

[52]The superscripts i and j in τ indicate who bears the currency invoicing cost. Specifically, j in τ^j_l indicates the cost is borne by the household in country j, while i in τ^i_l indicates the cost is borne by exporters in country i.

each household-exporter pair is described by

$$U_h(x(\omega)) = -e^{-\epsilon_{h\omega}} x(\omega)^{-\lambda},$$

where $\epsilon_{h\omega}$ signifies the idiosyncratic preference of household h for exporter ω, following a Type 1 Extreme Value distribution across different exporters. An increase in $\epsilon_{h\omega}$ indicates a stronger preference, thereby boosting household h's demand for product $x(\omega)$. Households are aware of their specific $\epsilon_{h\omega}$ realization in period 1.

As demonstrated in Appendix B.4, the expected utility in period 1 can be expressed as

$$\mathbb{E}U_h(x(\omega)) = \underbrace{\lambda(\ln y - \ln p_l(\omega) - \ln \tau^j_{l(\omega)}) - \frac{1}{2}\frac{\lambda}{1+\lambda}\sigma^2_{jl}}_{V_h(\omega)} + \epsilon_{h\omega},$$

where $V_h(\omega)$ is linearly independent of $\epsilon_{h\omega}$. Households in country j also have the option to purchase domestically. In this scenario, we assume a constant price $\bar{p}$, always offered in the local currency.

$$V_h(\omega^0) = \lambda(\ln y - \ln \bar{p}),$$

where we implicitly assume that $\ln \tau^j_j = 0$. Utilizing the properties of the $\epsilon_{h\omega}$ distribution, the probability that a representative household selects exporting firm ω over all other alternatives is given by

$$Pr(\omega = \arg\max_x \mathbb{E}U_h(x(\omega))) = \frac{\exp\left\{-\lambda\left(\ln p_l(\omega) + \ln \tau^j_{l(\omega)}\right) - \frac{1}{2}\frac{\lambda}{1+\lambda}\sigma^2_{jl}\right\}}{\exp\left\{-\lambda\left(\ln \bar{p}\right)\right\} + \sum_\omega \exp\left\{-\lambda\left(\ln p_l(\omega) + \ln \tau^j_{l(\omega)}\right) - \frac{1}{2}\frac{\lambda}{1+\lambda}\sigma^2_{jl}\right\}}. \quad \text{(B.3)}$$

Given that households in country j are assumed to be identical, the probability that a particular product ω maximizes the expected utility is the same across all households.

Consequently, this probability also represents the market share of exporting firm ω that invoices in currency l, denoted by $\mathcal{M}(\omega, l)$. The total income in country j is ny, thus the demand for firm ω's output can be expressed as $\mathcal{D}(\omega, l) = \frac{ny\mathcal{M}(\omega,l)}{p_l(\omega)}$. The elasticity of demand is given by

$$\begin{aligned} \eta_D(\omega, l) &\equiv -\frac{\partial \mathcal{D}(\omega, l)}{\partial p_l(\omega)} \frac{p_l(\omega)}{\mathcal{D}(\omega, l)} \\ &= \lambda(1 - \mathcal{M}(\omega, l)) - 1. \end{aligned} \tag{B.4}$$

For demand to be elastic, i.e., $\eta_D(\omega, l) > 1$, the parameter λ must be sufficiently large. For simplicity, we assume $\lambda > (1 - \bar{\mathcal{M}})^{-1}$, where $\bar{\mathcal{M}}$ represents the market share of the largest firm. An implication of equation (B.4) is that the demand faced by a firm becomes less elastic as its market share increases.

We now establish three comparative statics: the market share of a firm decreases with respect to price, household-side currency cost, and exchange rate risk.

The derivative of the market share with respect to the price of firm ω is given by

$$\frac{\partial \mathcal{M}(\omega, l)}{\partial p_l(\omega)} = \mathcal{M}(\omega, l)(1 - \mathcal{M}(\omega, l))(-\lambda / p_l(\omega)) < 0. \tag{B.5}$$

Given that market shares are constrained between 0 and 1, prices are positive, and $\lambda > 0$, the sign of the derivative is always negative. This indicates that the market share decreases as the price increases. Similarly, we can derive the partial derivative of market share with respect to the household cost of using currency l:

$$\frac{\partial \mathcal{M}(\omega, l)}{\partial \tau^j_{l(\omega)}} = \mathcal{M}(\omega, l)(1 - \mathcal{M}(\omega, l))(-\lambda / p_l(\omega)) < 0. \tag{B.6}$$

As the exchange rate is realized in period 2, two products with the same realized price may not have the same market share. This is because risk-averse households prefer to buy from importers that adopt a currency with lower exchange rate volatility, all else being equal. To illustrate this, we differentiate the market share with respect to the exchange rate volatility of currency l relative to currency j:

$$\frac{\partial \mathcal{M}(\omega, l)}{\partial \sigma_{jl}^2} = \mathcal{M}(\omega, l)(1 - \mathcal{M}(\omega, l)) \left(-\frac{1}{2} \frac{\lambda}{1+\lambda} \right) < 0. \tag{B.7}$$

It is straightforward to determine that the sign is negative.

B.1 Exporter's Pricing Decision

The firm's pricing decision can be viewed as a two-stage process. In the first stage, the firm chooses the optimal currency. In the second stage, the firm selects the optimal price given the invoicing currency. This section addresses the second-stage problem of pricing, while Section B.2 discusses the first-stage problem of currency selection. The profits for exporting firm ω, conditional on invoicing in currency l, are given by

$$\pi_l(\omega) = \left(\mathcal{E}_{l(\omega)i} p_l(\omega) - C(\omega) \right) \mathcal{D}(\omega, l) - \phi_l,$$

where $C(\omega)$ represents the marginal cost for firm ω. These costs are constant and equal to τ_l^i / ω, where τ_l^i denotes the cost of using currency l for exporters, and ϕ_l denotes the fixed cost of invoicing in a specific currency l.

Under Bertrand competition, firms set prices to maximize expected profits, taking the prices and invoicing decisions of other firms as given.

The first order condition with respect to price is given by

$$0 = \mathcal{D}(\omega, l) + (p_l(\omega) - C(\omega)) \frac{\partial \mathcal{D}(\omega, l)}{\partial p_l(\omega)}$$

The optimal price that maximizes the expected profit $\mathbb{E}[\pi(\omega, l)]$ can be expressed as

$$\hat{p}_l(\omega) = \frac{\tau_l^i}{\omega} \frac{\eta_D(\omega, l)}{\eta_D(\omega, l) - 1}$$

This implies that the markup $\frac{\eta_D(\omega,l)}{\eta_D(\omega,l)-1}$ is variable, decreasing (hence, increasing) with respect to demand elasticity (market share). Note that the choice of currency in period

1 affects the level of foreign exchange risk, which affects the firm's optimal price via its market share, even though the risk itself does not explicitly enter the expression of pricing.

Given the assumed process on the exchange rate and the expression for the optimal price, the maximized expected profits can be written as

$$\mathbb{E}\left[\pi(\omega, l)\right] = \frac{nyM(\omega, l)}{\eta_D(\omega, l)} - \phi_l \tag{B.8}$$

B.2 Exporter's Invoicing Decision

Exporters select the invoicing currency to maximize expected profit, given by

$$l(\omega) = \arg \max_{l \in \{i,j,d\}} \mathbb{E}[\pi(\omega, l)].$$

To characterize the optimal currency choice for firms with different levels of ω, it would be ideal to determine the signs of the cross partial derivatives $\frac{\partial \mathcal{M}^2}{\partial \tau^j_{l(\omega)} \partial \omega}$ and $\frac{\partial \mathcal{M}^2}{\partial \sigma^2_{jl} \partial \omega}$. However, since the partial derivatives $\frac{\partial \mathcal{M}}{\partial \tau^j_{l(\omega)}}$ and $\frac{\partial \mathcal{M}}{\partial \sigma^2_{jl}}$ are quadratic functions of $\mathcal{M}$, determining the signs of the cross partials is challenging.

Since the primary focus of this paper is the change in export volume when firms adopt RMB invoicing, rather than the reasons behind firms' choice to adopt RMB invoicing, we offer a brief discussion to rationalize some stylized facts from our data through the lens of our model. Assuming that the term $\mathcal{M}(\omega, l)(1 - \mathcal{M}(\omega, l))$ remains relatively stable in (B.6), it can be shown that $\partial \mathcal{M}(\omega, l)/\partial \tau^j_{l(\omega)}$ decreases (in absolute terms) with respect to $p_l(\omega)$. This implies that more productive firms have greater incentives to reduce the currency cost for households. Thus, if we follow the assumptions in Messer (2020) and Amiti et al. (2022) that $\phi_i < \phi_d < \phi_j$, we can replicate the empirical observation that Korean firms adopt KRW, USD, and RMB invoicing in increasing order of productivity. For our analysis, the crucial aspect of the model is to elucidate the channels through which the IoR affects export volume. We proceed to this analysis next.

B.3 Impact of Currency Choice on Export Volume

An exporting firm's total export revenue is given by $ny\mathcal{M}(\omega, l)$. Therefore, it is essential to examine how parameters associated with the IoR influence changes in market share. By totally differentiating the expression for market share, we obtain:

$$\begin{aligned} \mathrm{d}\mathcal{M}(\omega,l) &= \frac{\partial \mathcal{M}(\omega,l)}{\partial \sigma^2_{jl(\omega)}}\mathrm{d}\sigma^2_{jl(\omega)} + \frac{\partial \mathcal{M}(\omega,l)}{\partial p_l(\omega)}\mathrm{d}p_l(\omega) + \frac{\partial \mathcal{M}(\omega,l)}{\partial \tau^j_{l(\omega)}}\mathrm{d}\tau^j_{l(\omega)} \\ &= \mathcal{M}(1-\mathcal{M})\left[\underbrace{\left(-\frac{1}{2}\frac{\lambda}{1+\lambda}\right)\mathrm{d}\sigma^2_{jl(\omega)}}_{\text{foreign exchange risk}} - \underbrace{\lambda \mathrm{d}p_l(\omega)}_{\text{price}} - \underbrace{\lambda \mathrm{d}\tau^j_{l(\omega)}}_{\substack{\text{household's} \\ \text{currency cost}}}\right]. \end{aligned} \tag{B.9}$$

The first term captures the direct effect of changes in volatility, the second term arises from adjustments in the posted price, and the last term is due to changes in the household-side currency cost.

Additionally, note that totally differentiating the output price yields:

$$\begin{aligned} \mathrm{d}p_l(\omega) &= \frac{\partial p_l(\omega)}{\partial \tau^i_{l(\omega)}}\mathrm{d}\tau^i_{l(\omega)} + \frac{\partial p_l(\omega)}{\partial \mathcal{M}(\omega,l)}\mathrm{d}\mathcal{M}(\omega,l) \\ &= \underbrace{\frac{\lambda\left(1-\mathcal{M}(\omega,l)\right)}{\lambda\left(1-\mathcal{M}(\omega,l)\right)-1}\frac{1}{\omega}\mathrm{d}\tau^i_{l(\omega)}}_{\text{firm's currency cost}} + \underbrace{\frac{\lambda}{\lambda\left(1-\mathcal{M}(\omega,l)\right)-1}\mathrm{d}\mathcal{M}(\omega,l)}_{\text{market power}} \end{aligned} \tag{B.10}$$

Combining equations (B.9) and (B.10), we obtain:

$$\mathrm{d}\mathcal{M}(\omega,l) = \mu\left(\frac{\partial \mathcal{M}(\omega,l)}{\partial \sigma^2_{l(\omega)i}}\mathrm{d}\sigma^2_{l(\omega)i} + \frac{\partial \mathcal{M}(\omega,l)}{\partial \tau^i_{l(\omega)}}\mathrm{d}\tau^i_{l(\omega)} + \frac{\partial \mathcal{M}(\omega,l)}{\partial \tau^j_{l(\omega)}}\mathrm{d}\tau^j_{l(\omega)}\right), \tag{B.11}$$

where $\mu = \left(1 + \frac{\partial \mathcal{M}(\omega,l)}{\partial p_l(\omega)}\frac{\partial p_l(\omega)}{\partial \mathcal{M}(\omega,l)}\right)^{-1}$. We assume that the value of μ is positive, such that greater exchange rate risk, firm-side currency cost, and household-side currency cost all

reduce export volume.[53]

Equations (B.9) and (B.10) provide a clear framework to analyze how IoR impacts firms' trade volume. Our empirical analysis shows that neither KRW/RMB nor USD/RMB exchange rate volatility changed significantly during the period of our analysis. Additionally, firms adopting RMB invoicing do not significantly reduce their output prices. According to equation (B.9), this suggests that the primary channel through which IoR increases trade is by reducing the currency cost faced by households in the importing country. Intuitively, Chinese households prefer products invoiced in RMB because of convenience, not because of price stability or lower prices.

Equation (B.9) also indicates that the currency cost faced by the firm does not affect trade volume *conditional on* the output price. Given that a series of government policies aimed at IoR should lower the cost of using RMB for Korean firms, it is puzzling that prices have not decreased. One possible explanation is that Korean firms may charge a higher markup when switching to RMB. Regardless of the reason for the lack of price decline, our empirical findings suggest that the reduction in currency costs faced by exporting firms does not contribute to increased trade volume, as it does not translate into a corresponding decline in output prices.

[53]This assumption is also adopted in Messer (2020). Essentially, it requires that the firm's market share is not overly sensitive to its own price, and the price is not too sensitive to changes in market share due to variable markups.

B.4 Expected Utility Derivation

Under the assumptions of the model, the expected utility function can be rewritten as follows:

$$\begin{aligned}
\mathbb{E}U_h(x(\omega)) &= -\mathbb{E}\left[e^{-\epsilon_{h\omega}}\left(\frac{\mathcal{E}_{i(h)l(\omega)}y}{p^l(\omega)}\right)^{-\lambda}\right] \\
&= -e^{-\epsilon_{h\omega}}\left(\frac{y}{p^l(\omega)}\right)^{-\lambda}\mathbb{E}\left[\mathcal{E}_{i(h)l(\omega)}^{-\lambda}\right] \\
&= -e^{-\epsilon_{hw}}\frac{y}{p^l(\omega)}\mathbb{E}\left[e^{-\lambda\ln\mathcal{E}_{i(h)l(\omega)}}\right] \\
&= -e^{-\epsilon_{h\omega}}\left(\frac{y}{p^l(\omega)}\right)^{-\lambda}e^{-\lambda\mu_i(h)l(\omega)+\frac{1}{2}\lambda^2\sigma^2_{i(h)l(\omega)}}
\end{aligned} \tag{B.12}$$

where the last line follows from applying the normal moment generating function. Given the assumption that $\mu_{i(h)l(\omega)} = -\sigma^2_{i(h)l(\omega)}/2$, we have

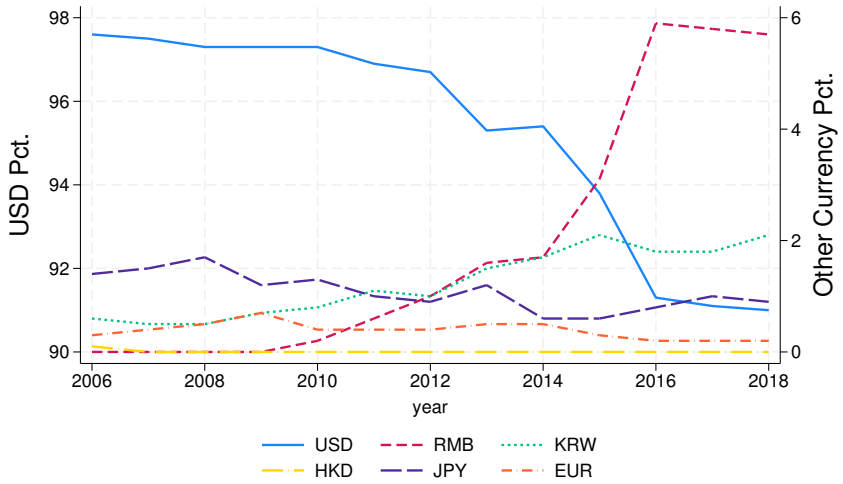
$$\mathbb{E}U_h(x(\omega)) = -e^{-\epsilon_{h\omega}}\left(\frac{y}{p^l(\omega)}\right)^{-\lambda}e^{\frac{1}{2}\frac{\lambda}{1+\lambda}\sigma^2_{i(h)l(\omega)}}$$

The agent wishes to maximize $\mathbb{E}U_h(x(\omega))$. This is equivalent to maximizing $-\ln(-\mathbb{E}U_h(x(\omega)))$ to arrive at the following objective function:

$$\underbrace{\lambda(\ln y - \ln p^l(\omega)) - \frac{1}{2}\frac{\lambda}{1+\lambda}\sigma^2_{i(h)l(\omega)}}_{V_h(\omega)} + \epsilon_{h\omega}$$

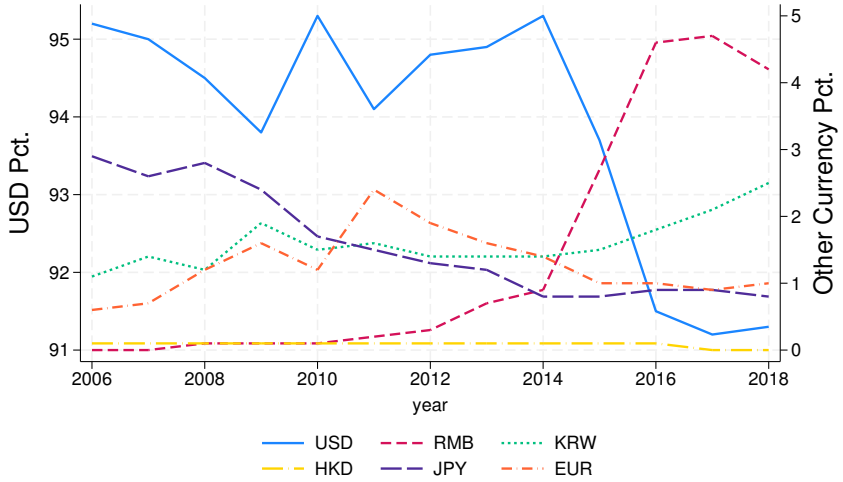
C Additional Figures and Tables

Figure C.1: Korean Exports to China



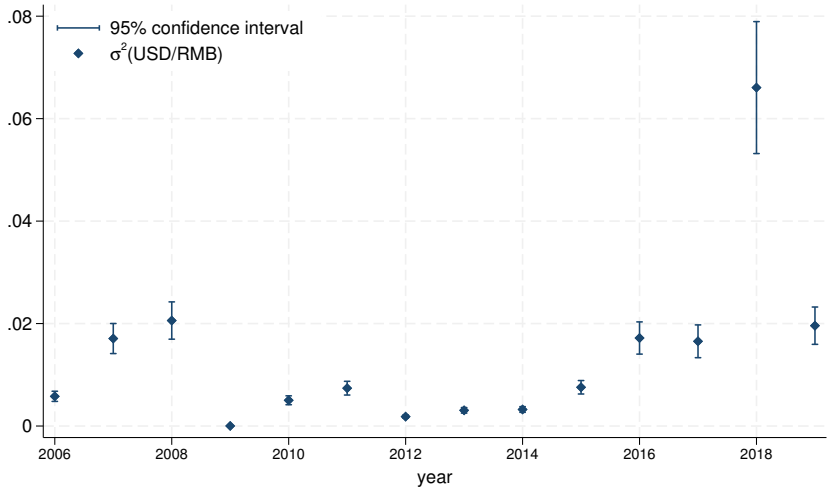
Notes: This figure illustrates the percentage share of invoicing currencies in Korean exports to China. The data are sourced from Bank of Korea.

Figure C.2: Korean Imports from China



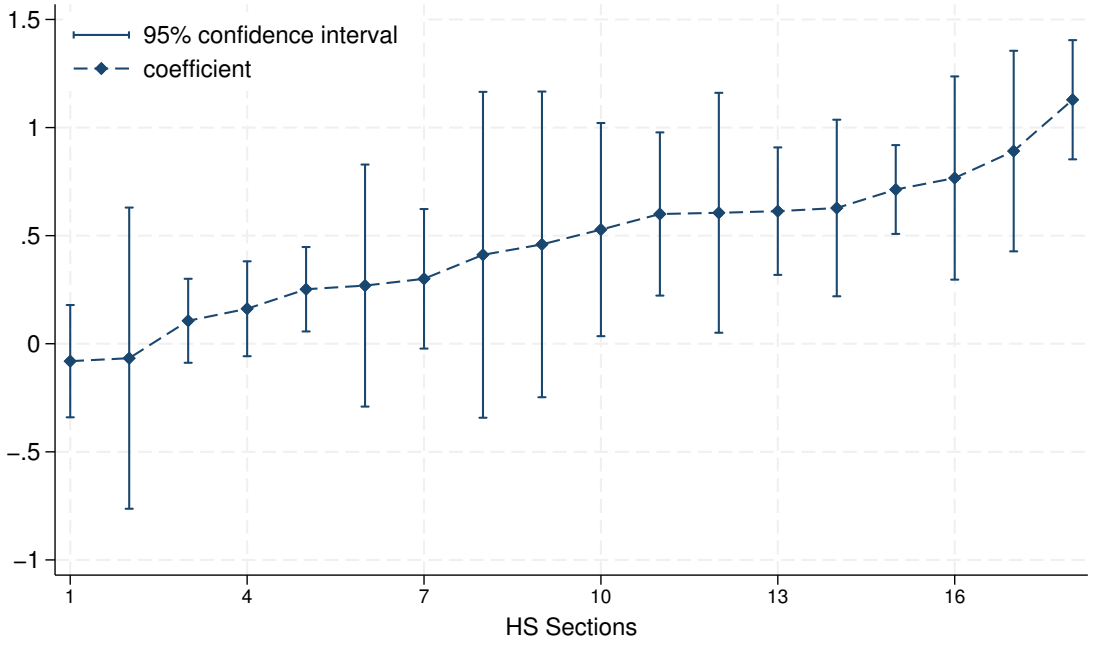
Notes: This figure illustrates the percentage share of invoicing currencies in Korean imports from China. The data are sourced from Bank of Korea.

Figure C.3: Renminbi Exchange Rate Volatility against the US Dollar



Notes: This figure illustrates the variance of the 30-day average RMB/USD exchange rate annually from 2006 to 2019.

Figure C.4: HS Section-specific Effects of RMB Invoicing



Notes: This table shows the point estimate and the 95% confidence intervals of β_1 estimates in equation (1) for each of 18 HS Sections.

Table C.1: Summary Statistics Table

	mean	median	min	max
Panel A: Product Level Summary Statistics				
	log(CN Export)			
Not RMB Inv.	5.86	6.07	-6.91	14.66
RMB Inv.	9.28	9.41	-3.47	17.91
	$\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+$			
Not RMB Inv.	0.42	0.00	0.00	1.00
RMB Inv.	0.30	0.00	0.00	1.00
Panel B: Firm Level Summary Statistics				
	log(CN Export)			
Not RMB Inv.	13.28	13.51	0.00	24.35
RMB Inv.	14.06	14.38	2.71	20.99
	$\mathbb{1}(s_{USD,2019} > 90\%) \times 2011+^*$			
Not RMB Inv.	0.18	0.00	0.00	1.00
RMB Inv.	0.17	0.00	0.00	1.00
	RMB Share*			
Not RMB Inv.	0.02	0.00	0.00	1.00
RMB Inv.	0.51	0.55	0.00	1.00
	log(Total Asset)			
Not RMB Inv.	24.54	24.62	0.00	33.07
RMB Inv.	25.18	25.08	0.00	31.67
	log(Total Sales)			
Not RMB Inv.	24.47	24.51	0.00	32.77
RMB Inv.	24.99	24.84	0.00	31.12
	log(Employment)			
Not RMB Inv.	4.68	4.77	0.00	11.60
RMB Inv.	5.09	5.04	0.00	10.43
Panel C: Firm-Product Level Summary Statistics				
	log(CN Export)			
Not RMB Inv.	10.59	10.61	0.00	24.26
RMB Inv.	10.23	10.22	0.00	20.33

Notes: This table provides the summary statistics for the principal regressors and covariates in the regression results presented in Tables 2, 3, 4, 6, 7 and 8.

Table C.2: Percentage of HS 4-digit Products with RMB Invoicing in 2019

	RMB	
Rauch Class.	Positive	$> 1\%$
exchange/ref. priced	59.77%	30.83%
differentiated	65.48%	39.42%

Notes: This table shows the percentage of HS 4-digit products that employ RMB invoicing with a positive and over 1 percent volume share, respectively. Products are divided into exchange-traded or reference priced and differentiated following Rauch (1999) classification.

Table C.3: Other Dimensions of RMB-Invoicing Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Export (RW)		Import (CN)		Import (RW)		Sales	Emp.	Asset
RMB Inv.	-0.029		0.058		0.050		0.004	0.060	0.004
	(0.054)		(0.116)		(0.106)		(0.043)	(0.046)	(0.026)
KRW Inv.	-0.144**		-0.150		-0.065		0.077	0.008	-0.029
	(0.060)		(0.154)		(0.136)		(0.097)	(0.067)	(0.063)
Change to RMB		-0.027		0.104		-0.053			
		(0.076)		(0.173)		(0.150)			
Observations	28 307	3 580	21 071	2 675	24 448	3 084	21 071	21 071	21 071
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Firm Char.	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
After Change#Firm FE		✓		✓		✓			

Notes: This table presents the estimation results for the firm-level regressions specified in equations (2). The dependent variables include exports to and imports from the rest of the world, imports from China, annual sales, number of employees, and total assets, all of which are log-transformed. The primary independent variable is 'RMB Inv.,' which indicates whether the firm uses RMB as the main invoicing currency in a given year. 'KRW Inv.' is similarly defined and included as an additional control. The reference group consists of firms that primarily use USD as their invoicing currency. The variable 'Change to RMB' is a binary indicator that equals 1 in the year when the firm transitions from either KRW or USD to RMB. Clustered standard errors, robust to heteroskedasticity and serial correlation at the firm level, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.4: Heterogeneous Effects of RMB Invoicing on Firms

	(1)	(2)	(3)	(4)
	log(Firm Export to China)			
RMB Inv. × Large CN Export	-0.541**			
	(0.247)			
RMB Inv. × High K/L Ratio		0.017		
		(0.190)		
RMB Inv. × ChaeBol			0.328	
			(0.443)	
RMB Inv. × Large Ann. Sales				0.296*
				(0.164)
RMB Inv.	0.866***	0.437***	0.436***	0.274**
	(0.225)	(0.125)	(0.096)	(0.128)
KRW Inv.	0.239*	0.236*	0.237*	0.235*
	(0.129)	(0.129)	(0.129)	(0.129)
Observations	32,700	32,700	32,700	32,700
Firm FE	✓	✓	✓	✓
Firm Char.	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: This table presents the estimation results from the firm-level regressions specified in equations (2). The dependent variable is the natural logarithm of export volume to China. The primary independent variable is 'RMB Inv.,' which indicates whether the firm uses RMB as the main invoicing currency in a given year. We interact 'RMB Inv.' with 4 dummy variables – 'Large CN Export' (above median or not), 'High K/L Ratio' (above median or not), 'ChaeBol' (top 10 conglomerate or not), and 'Large Ann. Sales' (above median or not). 'KRW Inv.' is similarly defined and included as an additional control. The reference group consists of firms that primarily use USD as their invoicing currency. Standard errors are Clustered standard errors, robust to heteroskedasticity and serial correlation at the firm level, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.5: Export Growth of RMB-invoiced Products (Korean customs dataset)

	(1)	(2)	(3)	(4)
	baseline	weighted	PPML	add. cov.
Dependent Variable	log(HS4 Export to China)			
$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$	0.621***	0.624***	0.335**	0.476***
	(0.127)	(0.132)	(0.133)	(0.106)
log(Non-KR Import)				0.365***
				(0.055)
logTradeToNonChina				0.284***
				(0.018)
Observations	10,299	10,253	10,299	8,718
HS4 FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓

Notes: This table presents the results of a difference-in-difference regression analysis based on equation (1). The dependent variable is the log of product-level exports to China. The primary independent variable, '$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$,' is the interaction between a dummy variable indicating positive RMB invoicing in 2019 and a dummy variable representing year 2011 and beyond. All regression models include a full set of product and year fixed effects. Clustered standard errors, robust to heteroskedasticity and serial correlation at the HS 4-digit level, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.6: RMB Invoicing and Chinese Import Products' State Share

	(1)	(2)	(3)	(4)
	RMB Share $\times 1000$			
CN State Share	-0.000	-0.003*	-0.000	-0.000
	(0.001)	(0.002)	(0.000)	(0.000)
Observations	10,909	10,797	8,313	7,604
Adjusted R^2	0.307	0.210		
HS4 FE	✓		✓	
Year FE	✓		✓	
HS2#Year FE		✓		✓

Notes: This table presents the results of a panel regression analysis using HS 4-digit product-level data from 2007 to 2019. The dependent variable is the RMB share (multiplied by 1000) of Korean firms' exports in these products, and the primary regressor is the share of Chinese importers that are state-owned enterprises. It is important to note that we only have data on China's state-firm share for each product from 2007 to 2013. For the period from 2014 onwards, the state-firm share is imputed using the corresponding 2013 values. Columns (1) and (2) are estimated using OLS, while columns (3) and (4) are estimated using PPML. Columns (1) and (3) include HS 4-digit product and year fixed effects, whereas columns (2) and (4) include HS 2-digit product-by-year fixed effects. Clustered standard errors, robust to heteroskedasticity and serial correlation at the HS 4-digit levels, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.7: Export Growth of RMB-invoiced Products (Long Difference)

	(1)	(2)	(3)	(4)
	Δ_{07-19} log(HS4 Export to China)			
$\mathbb{1}(s_{RMB,2019} > 0)$	0.699***	0.564***		
	(0.135)	(0.124)		
Δ log(Non-KR Import)		0.558***		
		(0.067)		
Δ log(Non-CN Export)		0.289***		
		(0.074)		
$s_{RMB,2019}$			0.819***	0.221
			(0.255)	(0.261)
Observations	1,039	1,036	1,039	553

Notes: This table presents the estimation results from the long-difference analysis at the product level. The dependent variable is the log difference of Korean exports to China at the product level over the period from 2007 to 2019. The variable '$\mathbb{1}(s_{RMB,2019} > 0)$' is a binary indicator that equals 1 if the product had any RMB invoicing in 2019. The variables 'Δ log(Non-KR Import)' and 'Δ log(Non-CN Export)' represent the log-differences in China's imports from regions other than Korea and Korea's exports to regions other than China, respectively. Finally, '$s_{RMB,2019}$' denotes the share of RMB invoicing for the product in 2019. Column (4) is estimated only on samples with positive RMB share. Heteroskedasticity robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.8: Export Growth of RMB-invoiced Products (Long Difference IV, First Stage)

	(1)	(2)	(3)
	baseline	add. cov.	RMB share
Dependent Variable	$\mathbb{1}(s_{RMB,2019} > 90\%)$		$s_{RMB,2019}$
$\mathbb{1}(s_{USD,2019} > 90\%)$	-0.210***	-0.209***	-0.054***
	(0.030)	(0.030)	(0.016)
Δ log(Non-KR Import)		0.027**	
		(0.013)	
Δ log(Non-CN Export)		0.000	
		(0.012)	
Observations	1,039	1,036	1,039
KP F-Stat	48.00	17.38	11.74

Notes: This table presents the first stage results of the 2SLS long-difference regression at the product level. The dependent variable '$\mathbb{1}(s_{RMB,2019} > 0)$' indicates whether the product had any RMB invoicing in 2019. '$s_{RMB,2019}$' is the share of RMB invoicing at the product level. The instrumental variable, '$\mathbb{1}(s_{USD,2019} > 90\%)$,' is a binary indicator that equals 1 if more than 90% of the product's invoicing is in USD when exported to countries other than China. The variables 'Δ log(Non-KR Import)' and 'Δ log(Non-CN Export)' represent the log-differences in China's imports from regions other than Korea and Korea's exports to regions other than China, respectively. Heteroskedasticity robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.9: Export Growth of RMB-invoiced Products (Long Difference IV, 2SLS)

	(1)	(2)	(3)
	baseline	add. cov.	RMB share
Dependent Variable	Δ_{07-19} log(HS4 Export to China)		
$\mathbb{1}(s_{RMB,2019} > 0)$	1.463**	1.260**	
	(0.625)	(0.569)	
$s_{RMB,2019}$			5.748**
			(2.839)
Δ log(Non-KR Import)		0.539***	
		(0.069)	
Δ log(Non-CN Export)		0.285***	
		(0.075)	
Observations	1,039	1,036	1,039

Notes: This table presents the estimation results from the 2SLS long-difference regression at the product level. The dependent variable is the log difference in Korean exports to China at the product level over the period from 2007 to 2019. The variable '$\mathbb{1}(s_{RMB,2019} > 0)$' indicates whether the product had any RMB invoicing in 2019. The variables 'Δ log(Non-KR Import)' and 'Δ log(Non-CN Export)' represent the log-differences in China's imports from regions other than Korea and Korea's exports to regions other than China, respectively. '$s_{RMB,2019}$' denotes the share of RMB invoicing for the product in 2019. Heteroskedasticity robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Kleibergen-Paap F statistics are reported in the last row of the first-stage regressions.

Table C.10: Export Growth of RMB-invoiced Products (Clustered Standard Error at HS 2-digit Level)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	baseline	weighted	PPML	add. cov.	RMB share	inten. marg.	placebo
Dependent Variable	log(HS4 Export to China)						
$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$	0.429***	0.528***	0.289**	0.386***			0.003
	(0.080)	(0.076)	(0.132)	(0.070)			(0.055)
$s_{RMB,2019} \times 2011+$					0.537***	0.165	
					(0.161)	(0.157)	
log(Non-KR Import)				0.414***			
				(0.043)			
log(Non-CN Export)				0.185***			
				(0.042)			
Observations	14,230	13,746	14,230	14,196	14,230	7,221	14,196
R^2	0.891	0.908		0.896	0.890	0.938	0.945
HS4 FE	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓

Notes: This table presents the results of a difference-in-difference regression analysis based on equation (1). The dependent variable is the log of product-level exports to China in columns (1) through (6), while column (7) uses the log of Korea's product-level exports to regions other than China. The primary independent variable, '$\mathbb{1}(s_{RMB,2019} > 0) \times 2011+$,' is the interaction between a dummy variable indicating positive RMB invoicing in 2019 and a dummy variable representing years after 2011. All regression models include a full set of product and year fixed effects. Clustered standard errors, robust to heteroskedasticity and serial correlation at the HS 2-digit levels, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.