Currency choice in international trade: a new monetarist approach and firm-level evidence

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Abstract

Financial market imperfections severely restrict currency use in international trade. We develop a unified search-based framework with financial frictions to address the determinants for currency choice, emphasizing the roles of trade finance and financial market development, as well as macro, micro and strategic factors. In an open economy monetary search model with financial intermediation, the usage of a particular currency will emerge endogenously and strategic complementaries among exporters, importers and financial intermediation reinforce the status of international currency. With highly disaggregated data from Colombia, we provide firm-level evidence that financial factors significantly affect the patterns of currency usage. We show that exporters prefer the currency with a more developed financial market, especially for small firms in financially vulnerable sectors. In particular, a developing country with medium-level of financial development could enhance its currency usage by more than 10% if it further develops financial market. Meanwhile, bad monetary policy and low bargaining power of exporters will also hurt the popularity of currency, although empirically firm-level bargaining power only has a secondary effect.

Keywords: Invoicing Currency; Trade Finance; Financial Intermediation; Financial Development; Monetary Search.

JEL Classification Numbers: F10, F33, F41

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1 Introduction

The currency chosen by exporters to set price is one of the most important and interesting questions in international macroeconomics. Basically, an exporter can choose its own currency (PCP), the destination country's currency (LCP) or a third country's currency (VCP). This "invoicing currency" choice problem attracted substantial attention among academic researchers and policy makers for several reasons. First, the currency denomination of international trade has real effects on the macroeconomy. It will directly affect how balance of payment and domestic prices react to exchange rate fluctuation when price is sticky.[1] Secondly, invoicing currency choice has important policy implications for the effectiveness of monetary policy and the choice of exchange rate regimes (Devereux and Engel, 2002; Corsetti and Pesenti, 2005). Thirdly, as a starting point, the currency denomination in international trade is usually the first stage of currency internationalization (McKinnon, 1969).Given the importance of this topic, what determines the currency choice? What are the roles played by financial intermediaries, or more generally financial market? How would the financial, macro, micro and strategic factors work together to reinforce each other? What is the relative magnitude of their effects? These are the main questions our paper tries to address.

Trade finance and financial market development have long been recognized as one of the crucial factors in currency choices of international trade, but formal modeling has been illusive. On one hand, the theory that links trade finance and financial market development to invoicing currency choice is sparse.[2] As Gopinath (2015) observed "...it is often suggested that currency invoicing choices in trade transactions are related to the depth of financial markets in currencies, particularly in the provision of trade credit...While this is plausible there is very little formal analysis of this linkage." On the other hand, historical experience clearly shows the essential role played by trade finance and financial markets in currency internationalization.[3] Recently, trade finance still plays an important role in facilitating international trade, especially for

[1]The degree of exchange rate pass-through effects is closely linked to invoicing currency choice as documented in Engel (2006) and Goldberg and Tille (2008).

[2]Previous studies in invoicing currency choices either emphasized macroeconomic factors such as economy size and openness, or focused solely on the industrial or firm level factors. However, the importance of trade finance and financial market development is largely overlooked without formal modeling.

[3]As a recent example, US GDP surpassed Great Britain in 1870s, and U.S. share of world export surged to 22.1% in 1913, but the international role of USD was essentially zero, while Sterling still invoiced over 60% of world trade in early 1900s (Broz, 1997). The establishment of FED is believed to speed up the rise of USD, with its favorable policy towards developing financial market and providing trade credit(Eichengreen, 2011).

developing countries.[4] The key innovation in this paper is to explicitly consider the link between financial market efficiency and endogenous invoicing currency choice.[5]

By integrating financial intermediation to the currency choice in international trade, our paper provides a novel, tractable and unified framework to study how financial, macro, micro and strategic factors jointly affect firm's currency choice.[6] Furthermore, we discipline our theory with empirical evidence using a proprietary dataset of Colombia's export from 2007 to 2013. With multinomial logit (MNL) model, we are able to estimate and rank the effects of various factors on invoicing currency choice.

In terms of model characteristics, we develop an open-economy monetary search model (Lagos and Wright, 2005; Lester et al., 2012; Zhang, 2014), so as to incorporate various determinants of currency choice, especially trade finance and financial development. Goods are assumed to be delivered one period after contract, and the lack of commitment calls for liquidity provision to exporters with the fund of bankers, who would get paid by importers in the next period. Financial intermediation operates at a fixed cost, and exporters receive liquidity at discount, so they would choose the currency with a higher level of profit. Consequently, a currency is never used in international trade if the issuing country does not have a liquid and efficient financial market. Our model features the explicit consideration of time-to-ship friction and the essential role played by trade finance. Strategic complementaries among exporters, importers and bankers illustrate how financial, macro, micro and strategic factors reinforce the status of international currency. In this sense, our paper studies currency choices using the New Monetarist approach as summarized in Lagos et al. (2015).

The theoretic model formulates four testable hypothesis. (i) The currency issued by the destination country with better financial market development is more likely to be used, especially for small firms more dependent on trade finance. This prediction is novel and has not been identified in previous literature. (ii) Bad monetary policy, such as high inflation and excessive exchange rate volatility, would make the currency unattractive for international trades. This is consistent with the theoretic work in

[4]As reported in BIS report, US$6.58 trillion of bank-intermediated trade finance was provided during 2011, supporting around 1/3 of international trade. Higher share for emerging markets.

[5]Despite the relevance of trade finance and financial intermediaries in international currency choice, theoretical work on its implications for invoicing currency choice remains sparse. See Ahn et al. (2011), Schmidt-Eisenlohr (2013) for trade finance related works.

[6]Recently there has been a growing literature on endogenous currency choice and its linkage to exchange rate pass-through (Devereux et al., 2004; Engel, 2006; Goldberg and Tille, 2008; Gopinath et al., 2010; Chung, 2016; Goldberg and Tille, 2016).

Devereux et al. (2004), Engel (2006) and the empirical work in Wilander (2006), Goldberg and Tille (2008) and Chung (2016). (iii) Exporters with higher bargaining power are more likely to use home currency, consistent with the recent empirical work by Goldberg and Tille (2016). (iv) In a three-country model, homogeneous goods tend to rely more on the VCP, consistent with the "coalescing effect" as firstly identified in Goldberg and Tille (2008).

Furthermore, we test these predictions using a novel dataset of Colombia's export firm from 2007 to 2013. Colombia is best described as a developing country heavily relying on trade finance. The dataset covers 6.4 million individual export transactions for around ten thousand exporting firms. Such a detailed transaction-level dataset has not been used to study invoicing currency choice before. The richness of trade information allows us to design empirical strategies to better identify the effects of trade finance and financial market development, as well as other important determinants. In the empirical analysis, we construct new measures for firm's trade finance dependence based on industry character (Manova, 2013) and transportation mode (Ahn et al., 2011). In this way, we are able to provide the first empirical evidence on how trade finance and financial market development affect invoicing currency choices.

Guided by our theoretical framework, a thorough econometric test is performed on the highly disaggregated Colombia dataset.[7] For financial factors, we find strong support for our theory that financial development significantly affects the patterns of currency usage. The MNL estimation shows that exporters tend to use the currency with a more developed and efficient financial market, especially for small firms in financially vulnerable sectors. In particular, a developing country with medium level of financial development could enhance home currency usage by more than 10% if it could further develop financial markets up to the top level.

For macroeconomic factors, we find that bad monetary policy, such as high inflation and excessive exchange rate volatility, would severely hurt the usage of a currency. Specifically, one standard deviation increase in inflation and the coefficient of variation in FX rate will decrease the likelihood of using that currency by 6.8% and 3.8% respectively. As for strategic factors, we also find that low bargaining power of exporters will restrict the popularity of a currency, but the magnitude is relatively smaller. In terms of micro factor, homogeneous goods are found more likely than differentiated goods to be invoiced in VCP relative to PCP.

[7]For a long time little was known beyond several broad stylized facts based mainly on aggregate data. Recently there are a few firm-level studies on Canadian (Goldberg and Tille, 2016) and British (Chung, 2016), but they did not consider financial factors.

Our study has important policy implications for developing countries seeking to internationalize home currency but suffering from backward financial development, volatile monetary policy, and inferior bargaining position of their exporters. The results highlighted the importance of a deep, liquid and efficient financial market. Equally importantly, a stable monetary policy will also help to significantly increase the international use of one currency. In the counter-factual experiment, we find that if China further developed its economy and financial market to the level of Japan, RMB use would be promoted by around 16% in international trades.

The rest of this paper is organized as follows. In section 1.1 we briefly review the related literature. In section 2, we develop an open-economy monetary search model featuring financial frictions to show how financial, macro, micro and strategic factors affect the choices among PCP, LCP and VCP. In section 3, we describe the data and present preliminary empirical evidence among various key factors. A formal econometric methodology and firm-level empirical evidence are discussed in section 4, together with various robustness tests. The empirical results, at both firm and transaction level, strongly support the main predictions of our theory. Section 5 concludes with further discussions on policy implications.

1.1 Related Literature

This paper contributes to the important literature that analyzes the endogenous invoicing currency choice. Our open-economy monetary search framework is closely related to Zhang (2014), which is based on the model of Lagos and Wright (2005) and Lester et al. (2012) in monetary economics. Zhang (2014) provides the important insights that strategic complementarity in portfolio choices between buyer and seller, as well as information acquisition decisions of sellers, generates multiple equilibria with different international currency regimes. The main departure we make is to introduce trade finance and financial intermediation.[8] Monetary search models are particularly suitable for the issue of currency choice, since they explicitly discuss the role of fiat money and allow agents to choose different currencies rather than make exogenous

[8]Search theory has a long history of modeling the rise of international currency (e.g. Matsuyama et al., 1993; Trejos et al., 1996), but suffers from the indivisibility of money and the inability to reach equilibrium. With the breakthrough in Lagos and Wright (2005), such models are now widely applied to provide new insight into topics of international economics (e.g. Lester et al., 2012; Geromichalos and Simonovska, 2014; Jung and Pyun, 2016; Zhang, 2014).

assumptions[9]. Moreover, the tractability of search-theoretic models enables us to comprehensively evaluate the effect of financial, macro, micro and strategic factors.

This paper further contributes to the firm-level empirical analysis on invoicing currency choice.[10] Recently, improved access to custom data allows for more systematic analysis at firm or transaction level. For Canadian import, Goldberg and Tille (2016) synthesized the macro, micro and strategic factors for currency choice, and documented that larger transaction size helps promote LCP. Devereux et al. (2017) also adopted Canadian dataset to show the non-monotone relationship between market share and invoicing currency choice. Our empirical methodology is most close to Chung (2016) that employed UK data in 2011 and found that firms relying more on foreign currency-denominated input are less likely to invoice their export by home currency. This paper adds new firm-level evidence to the empirical literature, with a particular focus on the trade finance and financial factors in determining invoicing currency choices. Furthermore, while the existing empirical literature are mainly for industrial countries, firm-level analysis for developing countries is quite rare, and that would distinguish our paper from others.[11]

This paper is also related with a vast literature discussing the impact of financial frictions on international trade. Amiti and Weinstein (2011) highlighted the collapse of trade finance as an important reason for Japanese financial crisis in 1990s. Feenstra et al. (2014) used Chinese firm data to show that exporters faced a tighter credit constraint than purely domestic firms. The heterogeneous-firm model in Manova (2013) and Chaney (2016) also proved that financial frictions affected both the intensive and extensive margin of international trade. The credit constraint in these works normally refers to working capital loan, which is made before production and mostly in home currency. In our model, however, the trade credit provided by bank is made after

[9]The classical New Open Economy Macroeconomics literature mostly assume PCP (e.g. Obstfeld and Rogoff, 1995). To remove this assumption, some literature, such as Bacchetta and Van Wincoop (2005), Engel (2006), and Goldberg and Tille (2008), allowed exporters to choose currency and preset price to hedge exchange rate risk. Fully appreciating the importance of short-term fluctuation, we consider our model complementary to the previous study by considering other relevant factors such as financial development.

[10]Empirical studies with country-level also proved fruitful in many ways, and the leading research includes Kamps (2006), Goldberg and Tille (2008), Ito and Chinn (2014), and Ito and Kawai (2016) The lack of heterogeneity and variation at micro level, however, limits the significance of their results and makes us prefer firm-level analysis.

[11]The conventional wisdom in classical literature, such as Grassman (1973) and McKinnon (1969), casually observes that developing countries' home currency is seldom used for international trade, because of either their small economic influence, or the large share of homogeneous goods in export. Whether this observation still holds today is open to question. For example, Reiss (2015) convincingly showed that the main exports denominated in Brazilian real are homogeneous goods.

production and could be denominated in various currencies.

Finally, this paper is related to the studies that focused on the pattern of payment method in trade finance but ignored firm's currency choice in this process. Schmidt-Eisenlohr (2013) built a model of contract choice and the equilibrium is determined by financial efficiency and contract environment. The empirical evidence in Schmidt-Eisenlohr and Niepmann (2015) showed that Letter of Credit is mostly employed with intermediate contract environment and riskier destination country. Ahn (2015) took advantage of Colombian and Chilean dataset to document the dominance of post-shipment payment, and explained it in a model featured by account-receivable financing. Although our model assumed trade finance by bank, the implication for invoicing currency choice remains robust with alternative payment methods.

2 Theoretical framework

In this section, we develop a theory that relates invoicing currency choice to financial, macro, micro and strategic factors. We mainly follow the endogenous choice of international currency in Zhang (2014), and add the new channel of trade finance. In international trade, financial restrictions have a large impact, especially for developing countries like Colombia, so the addition of financial intermediary is realistic and reasonable. Different from the information theory in Zhang (2014), our model features time-to-ship friction and emphasizes financial development as an important determinant of invoicing currency choice.[12] The time-to-ship friction is both empirically relevant and theoretically important. In reality, international trade normally takes longer time and involves larger volume than domestic trade, so participants face more risk and uncertainty (Manova, 2013). In theory, the time-to-ship friction has dual effects on our model structure. First, The timing mismatch between shipment and payment, combined with the lack of commitment between exporter and importer, necessitates the existence of financial intermediation to facilitate trade. Second, since exporters need immediate liquidity from bankers, who would get paid by importer only in the next period, so the payment received by exporter would be discounted by nominal interest rate, therefore making a channel for monetary policy to directly influence international trade.

Several papers already noticed this kind of financial friction and tried to incorporate it into monetary search model. For example, Wright et al. (2016) modeled dif-

[12]Here we focus on a partial equilibrium setup for exporter's currency choice. Interested reader could refer to Liu (2016) for the version of general equilibrium.

ferent channels to finance trade credit, both internal and external, and had in-depth discussion on its relationship with monetary policy and banking sector regulation. Our paper, however, diverges from previous literature by focusing on trade finance rather than trade credit. As discussed in Amiti and Weinstein (2011), trade credit is more of an accounting concept, referring to the accounts receivable in balance sheet, regardless of whether it's domestic or international trade. Trade finance, on the other hand, is exclusively for international trade, denoting the loans extended to exporters so that their production cost could be covered in time. Our model is greatly simplified by focusing on trade finance by banks, so that exporters and importers wouldn't worry about default. Meanwhile, the model's implication for international currency choice remains robust for other types of payment method like open account or cash in advance.

2.1 Environment

The following monetary search model is based on Lagos and Wright (2005) and extends the two-country model in Zhang (2014) and Liu (2016). The two-country framework is presented first and then extended to incorporate three-country and VCP. Time is discrete and infinite. There are two countries in the world, 1 and 2, each populated with a unit measure of buyer, seller and banker, who live forever with a discount factor of $\beta \in (0, 1)$. Their identity is fixed over time and their respective population in country $i \in \{1, 2\}$ is σ_i, σ_i, and $(1 - 2\sigma_i)$. Sellers always stay at home while buyers and bankers could go abroad. Each period is divided into three rounds of centralized market (CM), decentralized market (DM), and financial market (FM). For DM transaction, if buyer and seller are from different countries, we would call them importer and exporter. There is divisible and storable fiat money circulating in each country, and its total supply evolves according to $\hat{M}_i = (1 + \mu_i)M_i$, where M_i is the stock of country i's fiat money in current period, and variable with a hat is the level in next period. The growth rate of money supply μ_i is under the control of central bank. To feature scale of economy in financial sector, we assume a fixed total cost for banking industry. To avoid indeterminacy, bankers are further assumed to be specialized in home-currency business.[13]

Here we start with a brief introduction on model, and detailed formulation follows. In DM, sellers are specialized in the production of a perishable differentiated good q but unable to consume it, while buyers are able to consume but couldn't produce.

[13]This assumption is strong but not unreasonable. It just implies that domestic banks are efficient financial intermediaries in their home currency, as discussed in McKinnon (1979) and Eichengreen (2011)

The lack of commitment and double coincidence requires fiat money as medium of exchange. Importantly, q is delivered only at the beginning of next period. For domestic trade, we assume it's always settled by home currency after delivery, and there's no role for banker. Our model is focused on international trade, where agents from different countries don't trust each other. Exporters want to get paid immediately after shipment, but importers promise to pay only after the delivery of goods in the next period. In this case, bankers could facilitate trade by providing financial intermediation: exporters get liquidity from banker at a discount, and importers pay bankers later to get goods. The currency choice is made by exporters, whose profit function depends on gains from trade, monetary policy, and financial efficiency. Goods would be shipped afterwards.

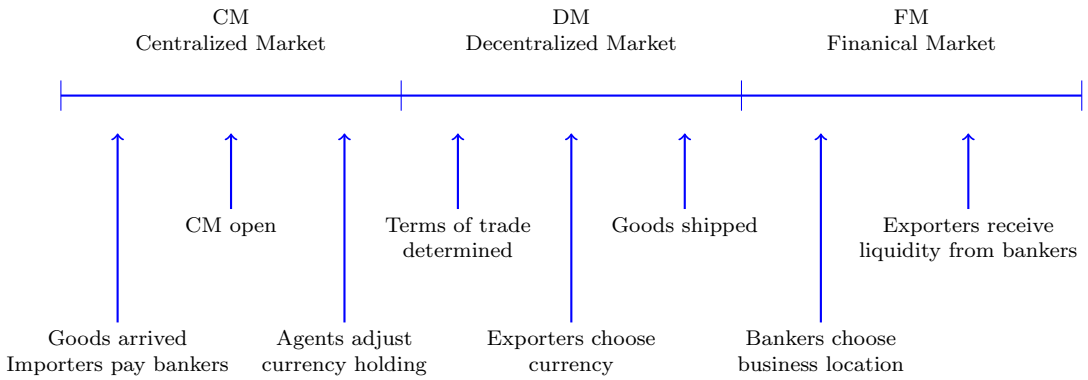
In FM, bankers first select the location of their business based on exporter's currency choice. If country 1 exporters choose home currency to settle international trade, country 1 bankers would pay a fixed total cost to setup financial industry in country 1. On the other hand, if country 1 exporters choose foreign currency, country 2 bankers would enter the market. After the establishment of financial industry, exporters show the proof of shipment and get liquidity from bankers at a discount. At the beginning of next period, goods are delivered, and importers pay bankers to get them. In the following CM, buyer, seller, and banker engage in the production and consumption of numéraire good X and adjust their holdings of fiat money based on the pattern of currency usage in the last period.[14] This CM functions as a frictionless FX market, which is certainly not without loss of generality as discussed in Geromichalos and Jung (2017), but we hold this assumption to simplify the model and focus on financial frictions. The model timing for international trade is depicted in figure 1.

2.2 Model Setup

Now we will begin to formalize the physical environment. For tractability, assume the instantaneous utility function is $U^B = u(q) + U(X) - H$ for buyer, $U^S = -c(q) + U(X) - H$ for seller, and $U^I = U(X) - H$ for banker, where q, X, and H capture the amount of differentiated good, numéraire good, and working hour. Although every agent could produce numéraire good with a linear technology of $X = H$, only sellers could produce differentiated good with the cost function of $c(q)$. We further assume that the optimal consumption in CM is X^*, such that $U'(X^*) = 1$. The conventional assumption on function form also holds, so $u(0) = c(0) = 0, u'(0) =$

[14] To match the model timing, we assume numéraire good is perished at the end of each period, and differentiated good is perished at the beginning of each period.

Figure 1: Model timing



$+\infty, c'(0) = 0, u' > 0, u'' < 0, c' > 0, c'' > 0$. For notations below, $i, j = \{1, 2\}$, $i \neq j$. The real value of country i's fiat money in terms of numéraire good is ϕ_i. This model is focused on stationary monetary equilibrium where the aggregate real balance is constant, therefore $1 + \mu_i = \frac{\phi_i}{\phi_i}$. Central banks adjust home currency supply through lump-sum transfer to domestic agent when CM opens.

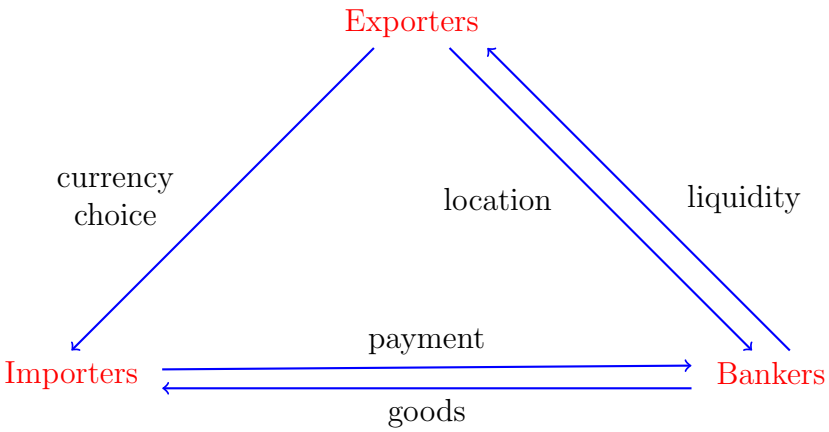
There is separate DM in each country. Buyers could go abroad with a probability of $(1 - \alpha)$ while sellers always stay at home. Buyer and seller meet pairwise and at random, with a matching function of $N_i = N(B_i, S_i)$, where the number of successful matching N_i is a function of buyer and seller's number in country i's DM. From this matching function, the number of meeting between country i buyer and country j seller (n_{ij}), as well as the probability for country i buyer to meet country j seller (p_{ij}) are determined.[15] Banking industry is perfect competitive and specialized in home-currency business. The total cost for country i banking industry to operate in country j is F_{ij}, assumed to be fixed over time. The value of F_{ij} reflects both financial efficiency and openness. If a country's banking sector could operate with low cost and foreign branching is supported or subsidized by government policy, F_{ij} will stay at a low level.

CM is open to buyer, seller, and banker from both countries. This Walrasian market allows agents to freely adjust their holding of currency, so it's similar to a

[15]Here we are not explicit about the matching function, since any $N(B, S) \geq \min(B, S)$ would work. Another reason for ignoring the function form is that our model focused on bargaining power rather than searching friction in exporter's currency choice. Interested reader could refer to Liu (2016) for the importance of searching friction on global imbalance.

frictionless foreign exchange market.[16] In our model, the decision by different types of agents is public information, which incorporates the elements of strategic complementarity. For exporter, his expectation of ultimate profit from DM trade is based on the decision of banker and importer. For banker, his business location is based on exporter's currency choice, and his currency choice is linked to importer's choice in CM. For importer, his optimal decision is tightly related with exporter's currency choice. The strategic complementarity among different types of agents is depicted in the figure 2. The decision of a certain type of agent affects other's choice, and that would reinforce the status of international currency.

Figure 2: Strategic complementarity



2.3 Optimal choice for agents

2.3.1 CM Value function

Agent's CM value function differs according to his type. Buyers want to hold money at the end of CM to buy differentiated good in the next period, therefore the CM maximization problem for country i buyer is

$$W_i^B(\phi_i m_i^i, \phi_j m_j^i) = \max_{\hat{m}_i^i, \hat{m}_j^i, H, X} U(X) - H + \mathbb{E}[V_i^B(\hat{\phi}_i \hat{m}_i^i, \hat{\phi}_j \hat{m}_j^i)]$$
$$\text{s.t.} \quad \phi_i \hat{m}_i^i + \phi_j \hat{m}_j^i + X \leq H + \phi_i m_i^i + \phi_j m_j^i + T_i$$

[16] In the real world, the foreign exchange market is OTC market with bid-ask spreads, and monetary search models are already widely applied in this field. See Lu (2016) for FX market in China.

where m_j^i is country i buyer's holding of country j currency; $V_i^B(\cdot)$ is country i buyer's value function for DM trade; T_i is the lump-sum transfer from country i central bank. Buyer's expectation of DM value function is based on the pattern of currency usage in the last period. With the observation that buyer's value function is linear in his holding of money, this value function could be simplified into

$$W_i^B(\phi_i m_i^i, \phi_j m_j^i) = W_i^B(0,0) + \phi_i m_i^i + \phi_j m_j^i \tag{1}$$

Sellers don't have any incentive to hold money in CM since the liquidity he would get from bank is irrelevant with his money holding. His value function is therefore omitted. For country i banker, the CM value function is

$$\begin{aligned} W_i^I(\phi_i z_i) = \max_{\hat{z}_i, H, X} & U(X) - H + \mathbb{E}\big[V_i^I(\hat{\phi}_i \hat{z}_i)\big] \\ \text{s.t.} \quad & \phi_i \hat{z}_i + X \leq H + \phi_i z_i + T_i \end{aligned}$$

where $V_i^I(\cdot)$ is the value function for banker in financial market, related with his holding of home currency ($\hat{z}_i$). Similarly, this value function could be transformed into

$$W_i^I(\phi_i z_i) = W_i^I(0) + \phi_i z_i \tag{2}$$

2.3.2 Terms of trade in DM

Buyer and seller make a proportional bargaining in DM to determine terms of trade. Buyer's utility maximization problem is

$$\begin{aligned} & \max_{q, d(m)} \{u(q) - \phi d(m)\} \\ \text{s.t.} \quad & \frac{u(q) - \phi d(m)}{\phi d(m) - \frac{c(q)}{\beta}} = \frac{\theta}{1-\theta} \\ & d(m) \leq m \end{aligned}$$

where q is the amount of differentiated good; $d(m)$ is the amount of fiat money buyers pay; θ and $(1-\theta)$ represent the bargaining power of buyer and seller. Since buyers make payment only when q is delivered at the beginning of next period, seller's cost function is adjusted by discount factor. The solution is

$$d(m) = \begin{cases} m^* & \text{if} \quad \phi m \geq (1-\theta) u(q^*) + \theta c(q^*)/\beta \\ m & \text{otherwise} \end{cases}$$

where q^* is the level of consumption that would maximize total surplus such that $\beta u'(q^*) = c'(q^*)$; m^* is buyer's payment when total surplus is maximized, so $\phi m^* =$

$(1-\theta)u(q^*)+\theta\frac{c(q^*)}{\beta}$. It will become clear later that buyer's holding of fiat money would never exceed m^*, because additional money doesn't increase his gains from trade, but incurs a loss from inflation. Therefore, buyer's payment to seller is

$$\phi m = (1-\theta)u(q)+\theta\frac{c(q)}{\beta} \tag{3}$$

with $q \leq q^*,\ \beta u'(q^*) = c'(q^*)$.

2.3.3 Financial constraint and exporter's currency choice

The time-to-ship friction imposed financial constraint on equilibrium. Without trade finance, country i exporter's profit in DM trade with country j importer is simply

$$\phi_i m_i^j - c(q_i^j) \tag{4}$$

where q_i^j is country j buyer's purchase of differentiated good settled in country i currency.

Now with financial friction, the immediate liquidity provided by bank must be able to cover exporter's DM cost. Given a perfect competitive banking sector, zero profit condition holds, so the immediate liquidity is equal to the proceedings from importer's future payment, net of banking sector's fixed cost. Here we assume the fund is equally split among exporters, whose actual profit therefore depends on the ratio between banker's fund available and importer's payment in the next period.

Consider country i exporter's profit for trade settled in his home currency. The total fund of banking industry after CM, net of the fixed total cost, is $[(1-2\sigma_i)\phi_i z_{ii} - F_{ii}]$. Here z_{ij} is country i banker's fund allocated to country j. From banker's optimal currency holding derived later, the rate of return in banking sector should be able to compensate the loss from inflation, so that, in this special case,

$$R_i = \frac{n_{ji}\phi_i m_i^j}{(1-2\sigma_i)\phi_i z_{ii}} - 1$$

where $R_i \equiv \frac{1+\mu_i}{\beta} - 1$ is the nominal interest rate of country i.[17] With the equations above, it's possible to simplify the ratio between the liquidity provided by bank and the payment from importer

[17] This nominal interest rate is derived from Fisher equation. In this model, the real interest rate is approximated by $1/\beta$, and inflation rate is $1+\mu$. So $1+R = (1+\mu)/\beta$ according to Fisher equation.

$$\frac{(1-2\sigma_i)\phi_i z_{ii} - F_{ii}}{n_{ji}\phi_i m_i^j} = \frac{(1-2\sigma_i)\phi_i z_{ii} - F_{ii}}{(1+R_i)[(1-2\sigma_i)\phi_i z_{ii}]} = \left\{1 - \frac{F_{ii}}{(1-2\sigma_i)\phi_i z_{ii}}\right\}\left(\frac{1}{1+R_i}\right)$$

So country i exporter's profit from international trade settled in home currency is

$$\pi_i \equiv \underbrace{\left[1 - \frac{F_{ii}}{(1-2\sigma_i)\phi_i z_{ii}}\right]}_{\text{financial development}} \underbrace{\left(\frac{1}{1+R_i}\right)}_{\text{discount}} \underbrace{\phi_i m_i^j - c(q_i^j)}_{\text{gain from trade}} \tag{5}$$

This profit function could be decomposed into three parts. First and foremost, financial development is negatively related with the fixed cost in banking sector (F_{ii}), and positive in banker's total funding in country i (z_{ii}). Second, the discount factor affected by central bank's monetary policy. Lastly, exporter's gain from trade after the bargaining game with importer. For trade settled in foreign currency, we further assume that exporters suffer additional loss from transaction cost (τ), such as the costs for hedging, which is assumed to be an increasing function of importer's real payment ($\phi_j m_j^j$), so the profit function using foreign currency becomes

$$\pi_i^* \equiv \left[1 - \tau(\phi_j m_j^j)\right]\left[1 - \frac{F_{ji}}{(1-2\sigma_j)\phi_j z_{ji}}\right]\left(\frac{1}{1+R_j}\right)\phi_j m_j^j - c(q_j^j) \tag{6}$$

With these in mind, country i sellers choose settlement currency to maximize profit.

$$\forall i = 1,2 \quad \begin{cases} \text{autarky} & \text{if } \max\{\pi_i, \pi_i^*\} < 0 \\ s_i = 1 & \text{if } \max\{\pi_i, \pi_i^*\} \geq 0,\ \pi_i \geq \pi_i^* \\ s_i = 0 & \text{if } \max\{\pi_i, \pi_i^*\} \geq 0,\ \pi_i < \pi_i^* \end{cases} \tag{7}$$

where s_i is country i exporter's currency choice, equal to 1 when his home currency settles international trade.

2.3.4 Banker's optimal choice in financial market

If exporters find international trade profitable and choose a certain currency for settlement, bankers need to setup business accordingly. Since banking industry is perfect competitive, zero profit condition implies the following optimal choice for country i bankers.

$$\forall i,j = 1,2, i \neq j \quad \begin{cases} R_i = \frac{n_{ji}\phi_i m_i^j}{(1-2\sigma_i)\phi_i z_{ii}} - 1 & \text{if } \ s_i = 1 \\ R_i = \frac{n_{ij}\phi_i m_i^i}{(1-2\sigma_i)\phi_i z_{ij}} - 1 & \text{if } \ s_j = 0 \\ z_i = z_{ii} = z_{ij} = 0 & \text{otherwise} \end{cases} \tag{8}$$

Here z_{ij} is the country i banker's fund allocated to country j, and $z_i = z_{ii} + z_{ij}$. The first condition states that, if country i exporters choose home currency, country i banker would setup business there and allocate z_{ii} to exporters, so that the nominal return in banking industry is equal to the nominal interest rate, which is the marginal cost of holding fiat money. Similarly, if foreign exporters choose country i currency, the banker would provide liquidity with the amount of z_{ij}, also making the rate of return equal to nominal interest rate. If country i currency remained national, i.e. $s_i = 0$ and $s_j = 1$, country i banker wouldn't hold any currency, as stated in the third condition above.

2.3.5 Optimal choice for buyer

For buyer, the optimal holding of real balance is available after combining CM and DM value function. For country i buyer, his DM value function is

$$V_i^B(\phi_i m_i^i, \phi_j m_j^i) = \beta\big(p_{ii}+(1-s_j)p_{ij}\big)\big(u(q_i^i)-\phi_i m_i^i\big)+\beta p_{ij}s_j\big(u(q_j^i)-\phi_j m_j^i\big)+\beta W_i^B(\hat{\phi}_i\hat{m}_i^i, \hat{\phi}_j\hat{m}_j^i)$$

where $(p_{ii} + (1 - s_j)p_{ij})\big(u(q_i^i) - \phi_i m_i^i\big)$ is country i buyer's expected surplus for DM trade settled in country i currency, and $p_{ij}s_j\big(u(q_j^i) - \phi_j m_j^i\big)$ is his expected surplus for trade settled in country j currency.

Substitute this into the expression of buyer's CM value function, then his maximization problem becomes

$$\max_{\hat{m}_i^i, \hat{m}_j^i} \Bigg\{ (\beta\hat{\phi}_i - \phi_i)\hat{m}_i^i + \beta\big(p_{ii} + (1 - s_j)p_{ij}\big)\theta\left[u(\hat{q}_i^i) - \frac{c(\hat{q}_i^i)}{\beta}\right]$$

$$+(\beta\hat{\phi}_j - \phi_j)\hat{m}_j^i + \beta s_j p_{ij}\theta\left[u(\hat{q}_j^i) - \frac{c(\hat{q}_j^i)}{\beta}\right]\Bigg\}$$

Several conventional observation in monetary search model would also apply here. For example, the solution for maximization problem requires $\beta\hat{\phi}_i - \phi_i < 0$ and $m < m^*$. The first order condition for home currency is

$$R_i = (p_{ii} + (1 - s_j)p_{ij})\left[\frac{\theta(u'(q_i^i) - c'(q_i^i)/\beta)}{(1-\theta)u'(q_i^i) + \theta c'(q_i^i)/\beta}\right] \tag{9}$$

This condition states that buyer's marginal cost of holding money (R_i) must be equal to the expected marginal benefit. Notice that buyer's demand for home currency is always positive since his meeting with domestic sellers would always use home currency as medium of exchange. This is not true for foreign currency, which crucially

depends on foreign seller's decision.

$$\forall i,j=1,2,i\neq j \quad \begin{cases} q_j^i=0 & \text{if } \ s_j=0 \\ R_j=p_{ij}\left[\frac{\theta(u'(q_j^i)-c'(q_j^i)/\beta)}{(1-\theta)u'(q_j^i)+\theta c'(q_j^i)/\beta}\right] & \text{if } \ s_j=1 \end{cases} \tag{10}$$

With agent's optimal choice and money market clearing condition, it's possible to define a general equilibrium allowing for international currency. The formal definition is relegated to appendix.

2.4 Three-country model and VCP

The model could be easily extended into three-country case to account for the emergence of international vehicle currency (IVC) and vehicle currency pricing (VCP). Related details and equilibrium conditions are derived in appendix. The currency choice is similar to two-country model with the following profit function for exporters.

$$\pi_{ij}^k=\left(1-\tau_j(\phi_k m_k^i)\right)\left(1-\frac{F_{kj}}{(1-2\sigma_k)\phi_k z_{kj}}\right)\left(\frac{1}{1+R_k}\right)\phi_k m_k^i-c_j(q_k^i),\ \forall i,j,k\in\{1,2,3\} \tag{11}$$

In this profit function, π_{ij}^k stands for country j seller's profit with country i buyer if trade is settled by country k currency, and other notations follow the two-country model above. The determinants of currency choice still include financial development, discount factor, and gains from trade. This profit function provides one explanation for the wide use of USD in international trade: stable monetary policy and supreme financial efficiency make USD attractive even for trade not involving United States. By the same token, if the issuing country of a currency has a highly developed financial market, the invoicing currency of its international trade would have a better chance to deviate from VCP.

Another main finding from three-country model is that homogeneous goods tend to rely more on VCP. This is from the observation that sellers are mainly distinguished by their gains from trade, i.e., the financial development and discount factor in profit function are less relevant with seller's nationality. For homogeneous goods with standard exchange, sellers are very similar in bargaining power, so their choice is focused more on the financial premium of a currency, which leads to the rise of a single IVC to invoice international trade. Therefore, the model predicts that homogeneous goods use more of USD due to its financial supremacy, which is consistent with the empirical finding in Goldberg and Tille (2008).

2.5 Currency choice determinants and testable hypotheses

Through the above discussions, we focus on partial equilibrium analysis for exporter's currency choice and summarize the theoretical results in Proposition 1-4.

For international trade settled by home currency, exporter's profit function is

$$\pi = \underbrace{\left[1 - \frac{F}{(1-2\sigma)\phi z}\right]}_{\text{financial development}} \underbrace{\left(\frac{1}{1+R}\right)}_{\text{discount}} \underbrace{\phi m - c(q)}_{\text{gain from trade}} \tag{12}$$

where F stands for the total fixed cost of home banking sector, $(1-2\sigma)\phi z$ for the liquidity provided by bankers, ϕm for importer's real payment, and R for the nominal interest rate of home currency, controlled by central bank through the growth rate of money supply, $R = \frac{1+\mu}{\beta} - 1$. On the other hand, if international trade is settled by foreign currency, exporter's profit function is

$$\pi^* = \left(1 - \tau(\phi^* m^*)\right)\left[1 - \frac{F^*}{(1-2\sigma)\phi^* z^*}\right]\left(\frac{1}{1+R^*}\right)\phi^* m^* - c(q^*) \tag{13}$$

where asterisk denotes foreign variables. Exporters choose the settlement currency that brings him a higher level of profit. With these in mind, there are four main determinants of currency choice, regarding to the following four propositions.

First, a higher level of financial market development makes a currency more attractive. This observation is straightforward from the profit function decreasing in the fixed cost of banking sector (F) and increasing in the financial market liquidity $(1-2\sigma)\phi z$. This leads to Proposition 1:

Proposition 1: (Financial) The currency issued by a country with better development in financial market is more likely to be used for international trade.

Second, currency with lower level of inflation is preferred. This intuitive result is also obvious from the profit function decreasing in nominal interest rate (R). Similarly, if we consider monetary policy uncertainty, the currency with higher foreign exchange rate volatility will be less likely to be used. In our model, the effect of monetary policy works both directly and indirectly on exporter's profit function. Directly, nominal interest rate would affect discount rate, which arises due to time-to-ship friction and the lag between payment and shipment. Indirectly, the growth rate of money supply and nominal interest rate would influence the currency holding by banker and buyer, as explicitly shown in equation 8, 9, and 10. The detailed proof for Proposition

2 is in appendix.

Proposition 2: (Macro) Bad monetary policies, such as high inflation and excessive exchange rate volatility, would make the currency unattractive for international trade.

Thirdly, the bargaining power between exporter and importer affects currency choice. Here we take advantage of partial equilibrium analysis and propose that exporters with higher bargaining power prefer home currency under very general assumptions. The formal proof is relegated to appendix.

Proposition 3: (Strategic) Exporters with higher bargaining power would prefer to use their home currency in trade.

Fourthly, as argued in the previous subsection, the model predicts that homogeneous goods are more likely to use VCP.

Proposition 4: (Micro) Homogeneous goods are more likely to use VCP.

3 Data, Facts and Determinants of Invoicing Currency Choices

In this section, we start by describing the dataset used for the empirical analysis. First, we describe the Colombia dataset in details and show various firm-level descriptive statistics. *The key message is: in the Colombia dataset, there are a large number of exporting firms that are selling to a large number of destination countries in a variety of industries and products, using many invoicing currencies.* Next, we demonstrate that there are substantial variations in invoicing currency choices in Colombia export, among destination countries and industries. These cross-sectional and time-series variations in invoicing currency choices are crucial for econometric analysis in the next section. Then we provide a broad preliminary assessment of the various factors behind invoicing currency choice for Colombia exporters, highlighting the key factors emphasized in the theoretic model. We end up this section with discussion on the advantages and limitation of Colombia dataset.

3.1 Data Source and Descriptive Statistics

Our primary data source covers daily export transactions from the Colombian Customs Office for the 2007-2013 period.[18] This novel database covers 6.4 million individual export transactions for Colombia exporters, from January 2007 to December 2013. Each transaction is recorded in a custom invoice containing information on the date, exporter's name, exporter's ID, country of destination, currency of invoicing, industry and product code (up to HS10), transportation method (by sea, by air, by railway, etc.), FOB value in US dollar (USD), quantity, and gross weight. We complement the export data with a detailed import data. [19]

Table 1: Summary Statistics: Colombia's Export (2013)

Number of exporters	9,898
Number of HS6 digit code exported	3,582
Number of destination country	137
Number of Currency	24
Number of transactions	907,153
Percent of transactions shipped by sea	43.4%
Average shipment value (thousand USD)	60,327
Median shipment value (thousand USD)	2,375.2
Colombia Export Value (billion USD)	54.7

Table 1 gives a snapshot of Colombia's exports in 2013. Other years are similar. Nearly 10,000 Colombia firms export to more than 130 countries. In sum, 24 different currencies are used. The total transaction number is 907,153 and 43.4% were shipped by sea. There are 3,582 varieties of HS6 products in 2013. Overall, a large number of exporters sell various products to different countries with multiple invoicing currencies. Table 17, 18 and 19 in the appendix take a further step to look at distribution over destinations, industries and destination-industry pairs respectively.

The broad composition of exports to 16 different industries and 5 regions is present in table 2. We find Colombia's trade partner is mainly Latin America countries, with 58.9% in count share. In contrast, North America has a smaller count share of 20.75%, which means United States doesn't play a dominant role as in the previous literature.[20]

[18]The data is obtained from Datamyne, a company that specializes in documenting import and export transactions in the Americas. For more detail please see www.datamyne.com.

[19]Although the import data is much richer than export, it does not have invoicing currency information.

[20]The trade share with U.S. was 58.9% in Goldberg and Tille (2016) and 29% in Chung (2016).

Table 2: Colombia Exports Distribution across industries and regions (2007-2013)

	Region share (by count)					Industry share	
Industry Category	North America	Latin America	Euro	Asia	Other	Count	Value
Animal Products	27.15%	35.35%	14.71%	14.05%	8.74%	0.93%	1.26%
Vegetable Products	56.01%	3.43%	17.61%	3.82%	19.13%	19.52%	9.71%
Foodstuffs	17.37%	56.62%	6.30%	1.36%	18.34%	6.37%	2.99%
Mineral Products	19.34%	53.27%	6.53%	6.83%	14.03%	1.41%	57.85%
Chemicals	1.92%	85.19%	1.08%	0.36%	11.45%	18.95%	4.24%
Plastics/Rubbers	8.84%	76.63%	3.26%	0.58%	10.68%	7.74%	3.30%
Leathers/Furs/Hides	30.96%	43.20%	8.58%	6.07%	11.19%	1.58%	0.63%
Wood Products	8.53%	75.76%	2.23%	1.37%	12.11%	5.80%	1.63%
Textiles	15.46%	73.19%	3.99%	0.49%	6.86%	16.67%	3.04%
Footwear/Headgear	11.93%	76.54%	3.92%	0.16%	7.45%	0.95%	0.23%
Stone/Glass	27.53%	57.72%	3.07%	0.94%	10.75%	4.90%	5.91%
Metals	15.85%	59.51%	4.43%	9.89%	10.31%	5.10%	4.46%
Machinery/Electrical	12.95%	77.01%	2.95%	0.91%	6.17%	5.19%	2.07%
Transportation	9.17%	86.13%	1.01%	0.51%	3.18%	1.20%	1.82%
Miscellaneous	13.33%	68.30%	6.21%	2.52%	9.64%	0.63%	0.18%
Service	14.45%	70.62%	4.09%	0.47%	10.37%	3.03%	0.69%
Region total	20.75%	58.92%	6.20%	2.07%	12.06%		

Some industries account for a large share of Colombia exports. In terms of counts, Vegetable Products, Chemicals and Textiles account for a large share of exports. In terms of value, mineral products accounts for half of the total exports value. This is not surprising given that Colombia is a developing country rich in natural resources.

3.2 Characteristics of Invoicing Currency Choices

Next we report some patterns related to currency choice for Colombia exporters. We first discuss the cross-sectional variation of currency choices in table 3 and 4. Then we look at the time series variation in Figure 3, 4, 5 and 6 in the appendix.

Table 3 displays the currency distribution (PCP, LCP, VCP) over major trade partners. USD has a dominant role in exports to Unites States. While the PCP and LCP are lower relative to VCP, there are still substantial variations. For example, Euro area enjoys a substantial share of LCP in Colombia's export, but individual countries has distinct shares. France has 13.52% of transactions invoiced in LCP while Netherlands has only 6.79%. This variation is also obvious when we look at

Table 3: Invoicing currency by destination countries (2007-2013)

	Count share			Value share		
	PCP	LCP	VCP	PCP	LCP	VCP
United States	0.25%	99.73%	0.03%	0.37%	99.62%	0.00%
France	0.79%	13.52%	85.70%	0.03%	2.99%	96.97%
Spain	1.02%	12.25%	86.73%	2.30%	2.26%	95.44%
Netherlands	0.37%	6.79%	92.84%	0.05%	0.72%	99.23%
Germany	0.03%	9.27%	90.71%	0.01%	2.40%	97.58%
UK	0.03%	1.60%	98.37%	0.05%	0.23%	99.72%
Canada	0.03%	0.07%	99.90%	0.16%	0.01%	99.83%
Venezuela	0.14%	1.85%	98.01%	0.52%	2.56%	96.92%
Peru	0.19%	0.00%	99.81%	0.56%	0.01%	99.43%
Mexico	0.23%	0.24%	99.53%	1.75%	0.18%	98.07%
China	8.55%	0.00%	91.45%	0.47%	0.00%	99.53%
Korea	0.03%	0.02%	99.95%	0.00%	0.03%	99.97%
Japan	0.00%	1.36%	98.64%	0.00%	1.11%	98.89%
Australia	0.02%	0.06%	99.92%	0.04%	0.10%	99.86%

other regions such as Asia. For Colombia export to China, 8.55% is invoiced by Colombia Peso (COP) and Chinese Yuan (RMB) is rarely used. When Colombia firms are exporting to Japan, 1.36% is denominated in Japanese Yen (JPY) and COP is almost never chosen. In the case of South Korea, it is in the middle. Table 4 shows the variations of currency choices at industry level. The share of PCP is relatively larger (15.87%) in mineral products whereas the share of PCP falls to almost zero in food industry.

The currency choice also has considerable variation over time, as shown in Figure 3, 4, 5 and 6 in the appendix. Before the 2008 global financial crisis, the usage of USD is very high and stable. During 2008, its share started to decline and the share of Euro and COP started to increase. This could partially reflect that during the great trade collapse, USD-based trade finance was disturbed and exporters in Colombia started to look for alternative currencies. After August 2011, the share of USD further decreased and other currencies gained more ground.

Table 4: Invoicing currency by industry (2007-2013)

	Count share			Value share		
	PCP	LCP	VCP	PCP	LCP	VCP
Animal Products	0.02%	25.67%	74.31%	0.36%	6.53%	93.11%
Vegetable Products	0.01%	52.76%	47.24%	0.04%	46.28%	53.69%
Foodstuffs	0.00%	19.82%	80.17%	0.01%	18.77%	81.22%
Mineral Products	15.87%	17.43%	66.70%	0.67%	45.74%	53.59%
Chemicals	0.06%	4.56%	95.38%	0.14%	5.95%	93.92%
Plastics/Rubbers	0.04%	11.53%	88.43%	0.01%	11.67%	88.33%
Leathers/Furs/Hides	0.10%	33.62%	66.28%	0.04%	21.53%	78.43%
Wood Products	0.03%	12.39%	87.58%	0.02%	7.48%	92.50%
Texiles	0.02%	17.25%	82.74%	0.01%	20.35%	79.63%
Footwear/Headgear	0.05%	13.54%	86.42%	0.01%	5.97%	94.02%
Stone/Glass	0.03%	29.48%	70.50%	0.00%	60.37%	39.63%
Metals	0.04%	18.92%	81.04%	0.01%	13.07%	86.91%
Machinery/Electrical	0.06%	13.76%	86.18%	0.15%	16.46%	83.39%
Transportation	0.04%	9.56%	90.40%	0.01%	7.21%	92.78%
Miscellaneous	0.51%	14.27%	85.23%	0.39%	20.08%	79.53%
Service	0.07%	16.66%	83.27%	0.23%	17.27%	82.50%

3.3 Broad assessment of the currency choices of Colombia Trade

Here we start a broad assessment of currency choices and show how it is related to financial, macro, micro and strategic factors. The major variables we consider involve financial development, inflation, exchange rate volatility, product differentiation, and firm-level bargaining power. All related graphs are present in the appendix. Note that United States is not included in these graphs.

Financial Factor

For financial factors, we consider financial market development as a key measure. Our model predicts that if the destination country has a higher level of financial development, its currency will be more likely to be used. Private credit over GDP is selected as proxy for financial development.

Figure 7, 8 and 9 in appendix show these patterns. The countries with higher financial development level are more likely to have its own currency chosen for trade

Table 5: Currency Choices and Product Differentiation (2007-2013)

	Heterogeneous Goods	Homogeneous Goods
VCP	73.62%	82.33%
LCP	26.06%	17.52%
PCP	0.32%	0.14%

Table 6: Invoicing Currency by Firm Size and External Finance Dependence (2007-2013)

	Firm Size (Top 10 Percentile)			Firm Size (Other Percentile)		
External Finance Dependence	PCP	LCP	VCP	PCP	LCP	VCP
Low	0.00%	12.4%	82.5%	0.00%	17.4%	87.6%
Medium	0.0%	35.7%	64.3%	0.02%	28.2%	71.7%
High	1.4%	41.4%	57.1%	0.1%	20.9%	79.0%

invoicing ,which also makes COP less likely to be used. Meanwhile, the vehicle currency (mainly USD) has less chance to be chosen if the destination country has a higher level of financial development.

Macro Factor

Inflation and foreign exchange rate volatility are among the two most important macro factors for invoicing currency choices. Figure 10, 11 and 12 in the appendix show the relationship between CPI and currency choice. If the country has a higher inflation, its currency will be less likely to be used. At the same time, the vehicle currency will be more likely to be used. Figure 13, 14 and 15 in the appendix show the relationship between foreign exchange volatility and currency choice. Here we capture the volatility by the coefficient of variation calculated from monthly nominal exchange rate. If the a currency has a higher volatility against COP, it is less likely to be used, and the vehicle currency enjoys a better chance.

Micro Factor

For micro factor, we consider the product differentiation categorized by Rauch (1999). Table 5 shows that homogeneous goods are more likely to rely on VCP for invoicing, while differentiated goods use more of PCP. This stylized facts are consistent with Goldberg and Tille (2008).

Strategic Factor

At last, we consider the strategic factor, i.e., firm's bargaining power. As emphasized by Goldberg and Tille (2013), the firm size is a key measure of bargaining power. Chung (2016) used Top 10 percentile of exporter's size as a dummy for big size exporting firms. Table 6 shows the relationship between currency choices, firm sizes and financial dependence. We can see that larger firms tend to have a lower share of VCP compared to small firms.

3.4 Advantages and limitation of Colombia Data

Throughout the discussions above, our dataset has four advantages compared with the recent firm/transaction-level study such as Chung (2016) and Goldberg and Tille (2013):

(i) The diversity in trade partners and industries. From 2007 to 2013, the total number of trade partners (destination countries) was more than 130 for exporters. The share of US is less dominant than the case of Canada and UK. The industries are also diversified, at both HS4 and HS6 level. This dataset therefore represents a small open economy exposed to a large number of trade partners.

(ii) Data quality. Our transaction record contains the firm ID of Colombia exporter/importer, so we can do both firm-level and transaction-level analysis. It is also easy to identify importing and non-importing exporters. More importantly, our data document a lot of detailed dimensions of each international trade transaction, especially the transportation mode rarely employed in previous study. This information can help us measure the dependence on trade finance proposed in Ahn et al. (2011).

(iii) Time frame. Our dataset includes Colombia's international trade both before and after the financial crisis (thus great trade collapse and trade finance collapse), making it feasible to identify how financial market turmoil and trade finance collapse affect currency choices. The previous studies used either a single year such as 2011 in Chung (2016), or several years before financial crisis as in Goldberg and Tille (2016).

(iv) Currency choices in developing countries. In contrast to the previous literature focused more on industrial countries, our exploration of Colombia dataset is among the first few to study a developing country more dependent on trade finance, and how that would affect the invoicing currency choice.

Of course this dataset also has its own limitations. One is that we do not have currency choices information for Colombia import. In addition, we do not directly observe the trade finance information such as whether the exporters get trade credit or not. In the subsequent section, we use various measures to proxy the trade finance dependence of firms.

To summarize, we provide the descriptive statistics of Colombia dataset in this section. We report substantial cross-sectional and time series variations in invoicing currency choices. We also assess the pairwise link between invoicing currency choices and various drivers, including financial, macro, micro and strategic factors. While Colombia dataset has obvious limitations, it provides a unique opportunity to study the invoicing currency choice for a small open economy heavily reliant on trade finance.

4 Empirical Evidence

In this section we employ MNL model to estimate the effects of different factors and measure their economic significance. We first introduce the econometric model specification and the construction of variables. Then we present the main empirical results. A series of robustness checks are also performed, including the transaction-level tests.

4.1 Econometric Model and Construction of Variables

We take the entire sample of Colombia export to all the destination countries (6.4 million transactions) and reduce it to the firm-product-destination-year level (0.55 million observations). As in Chung (2016), the dimension eliminated is the frequency of shipping for each exporter (at the product-destination level) within a year. We denote the exporter by superscript i, the product (at the HS6 level) by superscript j, and the destination country by superscript e. Furthermore we use k to denote industry in HS4 level.

In our baseline MNL regression, the categorical dependent variable is an indicator L_t^{ije} taking into account all pricing strategies. We assign $L_t^{ije} = 0$ for PCP, $L_t^{ije} = 1$ for LCP and $L_t^{ije} = 2$ for VCP. As these three invoicing alternatives are mutually exclusive and exhaustive for each firm-product-destination-year observation, we can use MNL estimation to analyze the probability of each currency choice. We take PCP as

the baseline option. Thus the MNL estimations yield two sets of results: LCP versus PCP and VCP versus PCP. Our baseline specification is

$$L_t^{i,j,e} = \text{MNL}(\text{FD}_t^e, \text{FD}_t^e \times \text{TFD}_t^{i,k}, \text{FirmTop10}^{i,k}, \text{CountryShare}_t^{k,e}, \text{CPI}_t^e, \text{FXcov}_t^e, \delta_r, \delta_s, \delta_t)$$

where the superscripts i, j, e, k, t denote firm, HS6 product, destination country, HS4 industry and year. δ_r, δ_s and δ_t denote fixed effects for region, SITC1 industry and year respectively, where the region includes Latin America, Euro, Asia, North America and others. Standard errors are also clustered at HS4 level.

The first explanatory variable FD_t^i measures the destination country's financial development relative to Colombia. It is measured as the amount of financial resources provided to private sector by financial intermediary as a share of GDP. This measure has been used extensively in the finance, growth and international trade literature. In our sample, the financial development varies a lot by country. The bottom three countries are Congo, Equatorial Guinea and Iraq, while the top three are Japan, Iceland and Denmark. We expect a higher level of financial development in destination country to induce more use of LCP for trade invoicing.

To further identify the effect of financial development, we consider the industry's external dependence on finance. Specifically, we use ExtFian^k to identify which industry is more reliant on external finance (including trade finance) as in Manova (2013), which constructed this measure based on data for all publicly listed US-based companies from Compustat's annual industrial files.[21] External finance dependence is the share of capital expenditures not financed with cash flows from operations. Most of the external finance are from banks in a variety of ways, including short-term loan like letter of credit and trade credit.[22] The firm-level trade finance dependence is not directly observed, so we construct an indirect measure based on Manova (2013). It is calculated as[23]

[21] Manova (2013) also considered asset tangibility as another measure of financial vulnerability. Asset tangibility records the share of net property, plant and equipment in total book-value asset. We use this alternative measure in the robustness check and our results remain similar.

[22] As stated in Manova et al. (2015) constructing the industry measures from US data is motivated by three considerations. First the US has one of the most advanced and sophisticated financial systems in the world. The behavior of US firms thus plausibly approximates their optimal asset structure and use of external finance. Second, using US as the reference country is convenient because of limited data for many other countries, but it also ensures that the measures are not endogenous to financial development. Finally, identification does not require that sectors have the same financial sensitivity as US but rather that their ranking remains relatively stable across countries.

[23] We thank Stefan Weiergräber for pointing out this novel measure.

$$\text{TFD}_t^{i,k} = \text{ExtFina}^k \times (-\text{FirmSize}_t^i)$$

We interact the external finance dependence with the negative of firm size in terms of absolute export value. When the export firm is smaller in size and engaged in an industry more dependent on external finance, it will rely much more on trade finance. A large value of $\text{TFD}_t^{i,k}$ signifies more dependence on trade finance for small firms in financially vulnerable sectors.

For strategic factors, we construct a firm-level measure for exporter's bargaining power.[24] Following Chung (2016) we use the firm size in export value and focus on the top 10 percentile. FirmSizeTop10 is 1 if the firm size is at the top 10 percentile of HS4 industry, and 0 otherwise. For the importer's bargaining power, we use the market share of the importing country in HS4 industry as Goldberg and Tille (2016) and denote it as CountryShare. We expect that if the exporting firm has more bargaining power, it has a better chance to use home currency.

For macroeconomic variables, we look at the inflation rate in the destination country CPI_t^i. Our theory predicts that a currency with high inflation is unappealing to exporters. We also look at exchange rate volatility, which might be influenced by the monetary policy in the destination country. FXcov_t^e is the exchange rate volatility involving the destination country's currency against COP. Our theory, as well as other literature such as Devereux et al. (2004) and Engel (2006)), predicts a currency with more volatile exchange rate is less likely to be chosen. We also add the real GDP per capita to control for economy size.

The data source and construction methodology of these and other variables in our MNL regression are summarized in table 13 in the appendix.

4.2 Main empirical findings

In table 7 and 8, we summarize the outcome of baseline MNL regression. To ensure the robustness of our result, we also con. Keep in mind the coefficient estimates from MNL regressions are odd ratios rather than marginal effects, so we could not directly compare the coefficient value. Instead, the signs of the coefficients should only be interpreted as the direction of deviation from the baseline options. We will compute and discuss the average marginal effects (AME) later.

[24]Since we do not observe the importer's firm level information, we can not construct a similar measure for importers.

Column (1) and (2) in table 7 and 8 include only financial factors. The positive and significant coefficient of FD_t^e in table 7 (LCP vs PCP) implies that if the destination country's financial development is higher than Colombia, Colombia firms are more likely to use the destination country's currency. Similarly, the negative and significant coefficient of FD_t^e in table 8 (VCP vs PCP) implies that if the destination country's financial development is higher than Colombia, it will make Colombia firms less likely to use the vehicle currency. This result strongly supports our Proposition 1.

We have two additional variables to further evaluate the effect of financial factors. For firm-level trade finance dependence (TFD), its coefficient estimations are negative and significant in both tables. This means small Colombia exporters in financially vulnerable sectors prefer PCP, which is reasonable since these firms are not in a good position to deal with the risk and uncertainty associated with international trade. However, the importance of financial development shows up in the interaction term of FD and Firm TFD, whose coefficients are positive and significant in both tables. This suggests that when firms export to a destination with better financial development, they are more likely to choose LCP or VCP, consistent with our argument that trade finance is an important channel for invoicing currency choices. In sum, the MNL regression outcome demonstrates that exporters tend to use the currency with a more developed and efficient financial market, especially for small firms in financially vulnerable sectors, confirming the importance of financial market development in currency choices.

In column (3) the strategic factors are added. We use FirmSizeTop10 for export firm's bargaining power, and CountryShare for import country's bargaining power. The negative and significant coefficient of FirmSizeTop10 implies that bigger firms tend to shift the currency choices away from LCP/VCP towards PCP, lending support to our Proposition 3. In most specifications, import country share has a statistically significant impacts on currency choices. In particular, it increases the likelihood of LCP and reduces the probability of VCP, also consistent with our expectation.

In column (4) we further add macroeconomic factors, namely the inflation level and exchange rate volatility. The coefficient estimations of CPI_t^e and FXcov_t^e are significantly negative in table 7, which suggests that if the firm is exporting to a destination with high inflation or volatile exchange rate, PCP is preferred over LCP. By the same token, the significant and positive coefficients in table 8 mean bad monetary policy increases the likelihood of VCP relative to PCP, also confirming our Proposition 2.

We also control for real GDP per capita of destination country in model (5). The

effects from financial development are still statistically significant and all the other key explanatory variables still have the expected effects. Overall, these results strongly support the predictions of our model.

Table 7: Baseline empirical results for invoicing currency choice (LCP vs PCP)

LCP vs PCP	(1)	(2)	(3)	(4)	(5)
Financial Development	5.15***	4.86***	3.82***	1.94***	1.19***
	(0.33)	(0.4)	(0.23)	(0.16)	(0.17)
Firm TFD		-4.47***	-3.83***	-5.05***	-5.16***
		(1.28)	(1.17)	(1.37)	(1.47)
FD × Firm TFD		2.84***	2.32***	3.37***	3.54***
		(0.92)	(0.85)	(1.00)	(1.11)
Firm Size Dummy			-1.36***	-1.33***	-1.22***
			(0.35)	(0.35)	(0.36)
Importer Country Share in HS4			3.66***	2.16***	1.98***
			(0.63)	(0.52)	(0.56)
Inflation				-0.38***	-0.30***
				(0.04)	(0.05)
Exchange Rate Volatility				-74.28***	-49.2***
				(5.09)	(5.22)
GDP per capita					0.39***
					(0.05)
Observations	545,022	545,022	545,022	545,022	545,022
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Geographic FE	Yes	Yes	Yes	Yes	Yes

Notes: Observations are at the firm-product-destination-year level. The default option is PCP and estimates of LCP versus PCP are reported. Column (1) to Column (5) consider all samples while Column (6) consider non-U.S. destinations. Fixed effects: δ_r for region level including North America, Latin America, Euro Area, Asia and others; δ_s are for SITC-1 industry. Standard errors are clustered at the HS4 level (1098 clusters) and are reported in parenthesis.
*** indicates significance at 1% level.
** indicates significance at 5% level.
* indicates significance at 10% level.

4.3 Robustness

We consider two sets of robustness test: including additional control variables proposed in the previous literature, and performing the transaction level tests as Goldberg and Tille (2016). In sum, our baseline outcome remains robust with various specifications of regression.

Table 8: Baseline empirical results for invoicing currency choice (VCP vs PCP)

VCP vs PCP	(1)	(2)	(3)	(4)	(5)
Financial Development	-0.81***	-0.74***	-0.81***	-0.57***	-0.73***
	(0.10)	(0.10)	(0.12)	(0.09)	(0.09)
Firm TFD		-0.28***	-0.28***	-0.27***	-0.26***
		(0.08)	(0.08)	(0.08)	(0.08)
FD × Firm TFD		0.22***	0.23***	0.23***	0.23***
		(0.09)	(0.09)	(0.09)	(0.09)
Firm Size Dummy			-1.15***	-1.20***	-1.19***
			(0.34)	(0.35)	(0.33)
Importer Country Share in HS4			-0.81***	-1.07***	-0.2
			(0.39)	(0.36)	(0.4)
Inflation				0.05***	0.06***
				(0.01)	(0.01)
Exchange Rate Volatility				13.73***	23.9***
				(4.33)	(4.78)
GDP per capita					-0.16***
					(0.04)
Observations	545,022	545,022	545,022	545,022	545,022
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Geographic FE	Yes	Yes	Yes	Yes	Yes

Notes: The default option is PCP and estimates of VCP versus PCP are reported. Other details are as in Table 7.

Table 9: Baseline empirical results for invoicing currency choice (VCP vs LCP)

VCP vs LCP	(1)	(2)	(3)	(4)	(5)
Financial Development	-5.96***	-4.86***	-4.73***	-2.5***	-1.99***
	(0.32)	(0.40)	(0.19)	(0.17)	(0.17)
Firm TFD		4.47***	3.33***	4.35***	4.78***
		(1.28)	(1.12)	(1.16)	(1.45)
FD × Firm TFD		-2.84***	-2.0**	-2.8***	-3.22***
		(0.92)	(0.80)	(0.81)	(1.07)
Firm Size Dummy			0.25**	0.13	0.03
			(0.11)	(0.12)	(0.11)
Importer Country Share in HS4			-4.5***	-2.97***	-2.1
			(0.6)	(0.48)	(0.46)
Inflation				0.52***	0.39***
				(0.04)	(0.05)
Exchange Rate Volatility				70.25***	67.9***
				(3.2)	(3.7)
GDP per capita					-1.5***
					(0.05)
Observations	545,022	545,022	545,022	545,022	545,022
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Geographic FE	Yes	Yes	Yes	Yes	Yes

Notes: The default option is PCP and estimates of VCP versus LCP are reported. Other details are as in Table 7.

4.3.1 Additional Controls

Macro Factors

In addition to GDP per capita, we add two dummy variables to capture exchange rate regimes. *Dpeg* and *Epeg* denote the USD peg and EUR peg respectively. This is the variable considered in both Goldberg and Tille (2016) and Chung (2016). If a destination country pegs its home currency to USD or Euro, it's a signal of disciplined monetary policy, and we expect that to increase LCP and decrease VCP. Column (1) in table 10 and 11 present the estimation result. Colombia exporters are more likely to use LCP when the destination countries have currency peg. They are also less likely to choose VCP when the destination countries peg currency to Euro. Importantly, the key explanatory variables from our baseline empirical model still have the expected and significant results as before.

Micro Factors

First we try to capture the degree of product differentiation. The standard in Rauch (1999) helps divide SITC4 level into two groups: homogeneous goods with reference price or standard exchange, and differentiated goods. We construct a dummy variable such that it is equal to 1 if the goods are homogeneous and 0 otherwise. Both our theory and Goldberg and Tille (2008) predict that international trade of homogeneous goods relies more on VCP, although with different mechanism.[25] This dummy is therefore expected to be positive in both regressions.

Another control variable at micro level is the status of exporter. Chung (2016) convincingly showed that importing exporters tend to use foreign currency to denominate their export of final goods, in order to hedge their currency exposure in imported intermediate goods. We follow this finding and construct a dummy equal to 1 if the exporter is also doing import in the same year. This is possible in our dataset since Colombia firms share the same ID in their custom invoice for export and import.

Column (2) in table 10 and 11 is the MNL regression outcome, mostly within our expectation above. The exporter are more likely to use LCP/VCP when the goods are homogeneous. For the differentiated goods, PCP is more likely. As for importing

[25] According to Goldberg and Tille (2008), exporters of homogeneous goods are expected to place a relatively higher weight in limiting their price fluctuation relative to that of their competitors, leading invoicing to coalesce around USD. Our search theory argues that, exporters of homogeneous good would be similar in their gain from gain, so the crucial determinants of currency choice are financial and macro factors, which makes USD a better candidate.

Table 10: Robustness with additional controls (LCP vs PCP)

LCP vs PCP	(1) Macro	(2) Micro	(3) Strategic	(4) All Controls	(5) Non-US
Financial Development	1.68***	2.14***	1.88***	0.62***	0.76***
	(0.35)	(0.18)	(0.16)	(0.16)	(0.11)
FD × Firm TFD	2.97**	3.80***	2.85*	3.67**	3.93**
	(1.20)	(0.99)	(1.46)	(1.53)	(1.74)
Firm Size Dummy	-1.05***	-1.60***	-1.40***	-1.20***	-1.22***
	(0.41)	(0.34)	(0.35)	(0.12)	(0.40)
Inflation	-1.19***	-0.38***	-0.38***	-0.31***	-0.32***
	(0.09)	(0.04)	(0.04)	(0.04)	(0.05)
Exchange Rate Volatility	-226.3***	-83.72***	-73.19***	-6.70	6.67
	(22.04)	(6.28)	(4.90)	(11.2)	(13.8)
GDP per capita	0.6***			1.10***	1.09***
	(0.09)			(0.07)	(0.10)
Dollar Peg	4.96***			5.05***	5.19***
	(0.40)			(0.30)	(0.39)
Euro Peg	0.86*			0.89*	0.79*
	(0.46)			(0.46)	(0.44)
Homogeneous goods		0.34***		0.32***	0.36***
		(0.06)		(0.10)	(0.10)
Importing Exporters		0.31***		0.74***	0.81***
		(0.11)		(0.11)	(0.17)
Firm Herfindal Index in HS4			-0.28	0.13	0.05
			(0.22)	(0.25)	(0.26)
Firm Size (Absolute Value)			0.65	-0.04	-0.07
			(0.82)	(0.06)	(0.06)
Importer Country Share in HS4			2.13***	1.33**	1.57**
			(0.52)	(0.60)	(0.73)
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Geographic FE	Yes	Yes	Yes	Yes	Yes

Notes: The default option is PCP and estimates of LCP versus PCP are reported. Other details are as in Table 7

exporters, they are more likely to use LCP/VCP relative to PCP. Again, the key explanatory variables from our baseline empirical model still have the expected and significant estimation results.

Strategic Factors

Alternative measures are also added to better represent firm's bargaining power. Following Sokolova (2015), we construct another firm-level bargaining power for the exporters $\text{Herfindal}_t^{i,e}$, which is the Herfindal index at HS4-country level. A large value of this variable means a higher degree of market concentration, implying more bargaining power on firm's part. Additionally, We also capture firm size by the total FOB value within a year, only to complement with the previous dummy variable calculated from quantiles. This variable is also considered in Goldberg and Tille (2016).

Table 11: Robustness with additional controls (VCP vs PCP)

VCP vs PCP	(1) Macro	(2) Micro	(3) Strategic	(4) All Controls	(5) Non-US
Financial Development	-0.83***	-0.60***	-0.62***	-0.86***	-0.82***
	(0.18)	(0.08)	(0.08)	(0.17)	(0.14)
FD × Firm TFD	0.47**	0.53***	-0.01	0.38*	0.40**
	(0.18)	(0.17)	(0.94)	(0.22)	(0.16)
Firm Size Dummy	-0.96**	-1.33***	-1.25***	-1.16***	-1.17***
	(0.34)	(0.32)	(0.33)	(0.36)	(0.10)
Inflation	0.018	0.03***	0.05***	0.02	0.002
	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)
Exchange Rate Volatility	29.03***	14.80***	14.77***	29.5***	26.77***
	(10.07)	(4.04)	(4.09)	(9.9)	(5.8)
GDP per capita	-0.42***			-0.41***	-0.31***
	(0.07)			(0.07)	(0.06)
Dollar Peg	-0.15			-0.12	0.16
	(0.23)			(0.24)	(0.20)
Euro Peg	-1.48***			-1.52***	-1.50*
	(0.41)			(0.41)	(0.24)
Homogeneous goods		0.30***		0.34***	0.37***
		(0.07)		(0.08)	(0.10)
Importing Exporters		0.33***		0.69***	0.76***
		(0.07)		(0.15)	(0.10)
Firm Herfindal Index in HS4			-0.11	-0.69**	-0.79***
			(0.21)	(0.25)	(0.25)
Firm Size (Absolute Value)			0.62	0.07	0.06
			(0.81)	(0.06)	(0.05)
Importer Country Share in HS4			-1.10***	0.41	0.17
			(0.36)	(0.53)	(0.46)
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Geographic FE	Yes	Yes	Yes	Yes	Yes

Notes: The default option is PCP and estimates of VCP versus PCP are reported. Other details are as in Table 7

The results are present in Column (3) in table 10 and 11. Compared to the firm size measured in Top 10 percentile, both the absolute firm size and firm's Herfindal index fail to deliver a robust result.

All Controls: All Countries and Non-US Countries

Column (5) and (6) consider all the control variables for the whole sample and non-US destinations respectively. The main results still hold. We also could notice that CPI has robust and significant effects on the LCP vs PCP, the $FXcov$ has robust and significant effects on the VCP vs PCP when we add all controls.

4.3.2 Transaction-level Tests

In this section we perform robustness test at transaction level. For additional strategic factors, we create a trade size dummy equal to 1 for top 5th percentile transaction by value. For trade finance dependence, the following measure is included.

$$\text{TFD}_t = \text{Trans}_t \times (-\text{Firm}^i_{\text{Size}})$$

Notice that Trans_t is the transportation mode for each transaction. We assign $\text{Trans}_t = 1$ if it is shipped by sea, while $\text{Trans}_t = 0$ for other transportation modes. This is motivated by Ahn et al. (2011): although we can not observe the trade finance dependence on each transaction, the goods shipped by sea will need a longer time to deliver and tend to use more trade finance. Moreover, we also assume smaller firms tend to rely more on trade finance. We also consider a financial crisis dummy Crisis equal to 1 if the transaction happened between June 2008 and June 2009 following Ahn et al. (2011). We interact the crisis dummy with transaction mode dummy to see the effect of great trade collapse and its influence on currency choices.

The transaction-level empirical test is present in table 14 where we report three different specifications. The model (1) consider all the main explanatory variables plus a trade size dummy. Model (2) consider the interaction between financial development and transaction-level trade finance dependence. Model (3) consider the crisis dummy and test how great trade collapse affect the currency choices.

The results in model (1) shows the main results still hold in transaction level data. We find that when the transaction size is large, it tends to shift toward PCP. We consider the transaction-level trade finance dependence in model (2) and the results show that trades that are more dependent on trade finance will be more likely to be used in VCP. Results in model (3) shows that during the financial crisis when the trade finance in USD was disrupted, the currency choice shifts away from VCP toward PCP and LCP.

4.4 Economic Significance

In MNL regression, the coefficients can not be compared directly, so we need to calculate average marginal effects (AME). Table 12 shows the result. The AME in baseline model is measured as one standard deviation increase in the key independent variable. We find that the two most important determinants in AME are monetary policy and financial development. For inflation level and exchange rate volatility, an increase of one standard deviation would lower LCP by 6.8% and 3.8%. Financial

development also demonstrates considerable magnitude: one standard deviation increase brings up LCP by 3.4%. The effects of other drivers are relatively smaller: less than 1% for strategic factors and around 2% for GDP per capita.

For counter-factual analysis, if a country with medium-level financial development successfully upgrades financial market to the top level like Japan (3 standard-deviation increase), its home currency usage in international trades will be promoted by more than 10% (3.4%*3=10.2%). For China, its current levels of financial development and GDP per capita are both around medium level. So, if China could successfully improve both to the top level, RMB use will be promoted by around 16% (3/4%*3+1.9%*3=15.9%).

Table 12: Average Marginal Effect (AME)

	FD	CPI	FXcov	Firm Size	Country Market Share	GDP per capita
LCP vs PCP	+3.4%	−6.8%	−3.8%	−0.1%	+0.9%	+1.9%
VCP vs PCP	−3.5%	+6.8%	+3.9%	−0.4%	−0.9%	−2.0%

5 Conclusion

This paper is focused on financial market's influence on invoicing currency choices at firm level. First of all, we build a unified framework with financial frictions to address the determinants of currency choice, emphasizing the roles of financial market development, as well as monetary policy and firm's bargaining power. In an open economy monetary search model, the usage of a particular currency will emerge endogenously, and strategic complementaries among exporters, importers and bankers reinforce the status of international currency. Next, with highly disaggregated data from Colombia exporters, we provide firm-level evidence that financial factors significantly affect the patterns of currency usage. The MNL regressions show that exporters tend to use the currency with a more developed and efficient financial market, especially for small firms in financially vulnerable sectors. In particular, a median developing country could enhance its home currency usage by more than 10% through financial market development. Furthermore, bad monetary policy and low bargaining power of exporters will severely restrict the popularity of a currency. These results have important policy implication for currency internationalization in developing countries.

Although it is the first step to add financial intermediary in the open-economy monetary search model to study endogenous currency choices, a promising future work

is to endogenize financial intermediary. Also, it would also be very interesting to test the model's predictions using China's firm-level data to see whether our empirical results still hold in other developing countries. A structural estimation of our model also has hope to deliver more novel results.

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A Appendix

A.1 Monetary equilibrium of international trade

A.1.1 Two-country model

Given agent's optimal choice, money market should clear. Here we focus on monetary equilibrium allowing for international trade. $\forall i, j = \{1, 2\}, i \neq j$

$$\begin{cases} \sigma_i \phi_i m_i^i = \phi_i M_i & \text{if } \{s_i, s_j\} = \{0, 1\} \\ \sigma_i \phi_i m_i^i + (1 - 2\sigma_i)\phi_i z_{ij} + F_{ij} = \phi_i M_i & \text{if } \{s_i, s_j\} = \{0, 0\} \\ \sigma_j \phi_i m_i^j + (1 - 2\sigma_i)\phi_i z_{ii} + F_{ii} = \phi_i M_i & \text{if } \{s_i, s_j\} = \{1, 1\} \\ \sigma_i \phi_i m_i^i + \sigma_j \phi_i m_i^j + (1 - 2\sigma_i)\phi_i (z_{ii} + z_{ij}) + F_{ij} + F_{ii} = \phi_i M_i & \text{if } \{s_i, s_j\} = \{1, 0\} \end{cases} \tag{14}$$

With agent's optimal choice and money market clearing condition, now it's possible to define a stationary monetary equilibrium allowing the existence of international trade.

A stationary monetary equilibrium that allows for international trade is a list of time-invariant values including trade volume $\{q_j^i\}_{i,j=1}^2$*, banker's holding of real balance* $\{\phi_i z_i\}_{i=1}^2$*, and seller's currency choice* $\{s_i\}_{i=1}^2$ *such that, given other agent's behavior,*

1. *Seller's choice of* $\{s_i\}_{i=1}^2$ *solves 7 ;*

2. *Banker's choice of* $\{\phi_i z_i\}_{i=1}^2$ *solves 8;*

3. *Buyer's choice of* $\{q_j^i\}_{i,j=1}^2$ *solves 9 and 10 ;*

4. *Money market clears so that 14 holds.*

A.1.2 Three-country model

Since our main interest in three-country model is to explain the rise of IVC, here we consider a special case of hegemony in which all international trade is settled in country 1 currency. The following equilibrium condition is in order.

For seller

$$\pi_{ij}^1 = J_j^1 \phi_1 m_1^i - c(q_1^i) > 0, \quad \forall i, j \in \{1, 2, 3\}, i \neq j \tag{15}$$

Here $J_n^m \equiv (1 - \frac{F_{mn}}{(1-2\sigma_m)\phi_m z_{mn}})(1+R_m)^{-1}$ is the financial premium for country n seller to choose country m currency. The seller's equilibrium conditions state that international trade should be profitable for all exporters if they choose country 1 currency.

For banker

$$1 + R_1 = \frac{(n_{12}+n_{13})\phi_1 m_1^1 + (n_{21}+n_{23})\phi_1 m_1^2 + (n_{31}+n_{32})\phi_1 m_1^3}{(1-2\sigma_1)\phi_1 z_1} \tag{16}$$

Here $z_1 \equiv z_{11} + z_{12} + z_{13}$ is the total liquidity held by country 1 banker.

For buyer

$$\begin{cases} R_1 = (p_{11}+p_{12}+p_{13})L(q_1^1) = (p_{21}+p_{23})L(q_1^2) = (p_{31}+p_{32})L(q_1^3) \\ R_2 = p_{22}L(q_2^2) \\ R_3 = p_{33}L(q_3^3) \end{cases} \tag{17}$$

Money market

$$\begin{cases} \phi_1(\sigma_1 m_1^1 + \sigma_2 m_1^2 + \sigma_3 m_1^3) + (1-2\sigma_1)\phi_1 z_1 + F_{11} + F_{12} + F_{13} = \phi_1 M_1 \\ \sigma_2 \phi_2 m_2^2 = \phi_2 M_2 \\ \sigma_3 \phi_3 m_3^3 = \phi_3 M_3 \end{cases} \tag{18}$$

Similar to the two-country model above, the definition of monetary equilibrium condition is the following.

A stationary monetary equilibrium in three-country model with country 1 currency as the single IVC is a list of time-invariant values including trade volume $\{q_j^i\}_{i,j=1}^3$*, banker's holding of real balance* $\{\phi_i z_i\}_{i=1}^3$*, and all exporter's choosing country 1 currency such that, given other agent's behavior,*

1. *Seller's profit level satisfies 15*

2. *Banker's choice of* $\{\phi_i z_i\}_{i=1}^2$ *solves 16*

3. *Buyer's choice of* $\{q_j^i\}_{i,j=1}^2$ *solves 17*

4. *Money market clears so that 18 holds.*

The incumbency advantage applies here: as long as individual sellers enjoy positive profit from international trade, they have no incentive to deviate from the existing equilibrium of single international currency.

A.2 Proof of Proposition 2

A.2.1 Inflation and Currency Depreciation

Proposition 2.1 High inflation and currency depreciation would lower the international use of currency.

Notice that inflation level is tightly linked with nominal exchange rate in search model. If Law of One Price (LOP) holds for numéraire good, the determinant equation for exchange rate is

$$e_t = \phi_{j,t}/\phi_{i,t} = \frac{1+\mu_{i,t}}{1+\mu_{j,t}}$$

where e_t is the nominal exchange rate of currency i against currency j at time t, and the last equation holds if two countries had identical money growth rate in the last period. Obviously, a high level of inflation caused by rapid growth rate of money supply would also lead to currency depreciation.

From the FOC of buyer, high inflation and currency depreciation reduces his holding of real balance. Recall that, for country i buyer's holding of home currency, his FOC is the following.

$$R_i = (p_{ii} + (1-s_j)p_{ij})\frac{\theta(u'-c'/\beta)}{(1-\theta)u' + \theta c'/\beta}$$

Given that buyer's liquidity premium is decreasing in trade volume, an increase of nominal interest rate from high inflation would increase the marginal cost of using money, thus lowering buyer's holding of real balance.

On the part of bankers, if country i exporters choose home currency, the FOC for country i banker is the following.

$$1 + R_i = \frac{n_{ji}\phi_i m_i^j}{(1-2\sigma_i)\phi_i z_{ii}}$$

Higher level of nominal interest rate would therefore decrease the currency holding by both buyer and banker in this case.

On the part of sellers, the profit function for country i exporters to choose home currency is the following.

$$\pi_i = \left(1 - \frac{F_{ii}}{(1-2\sigma_i)\phi_i z_{ii}}\right)\left(\frac{1}{1+R_i}\right)\phi_i m_i^j - c(q_i^j)$$

High inflation would directly reduce exporter's profit through discount factor. It also has the indirect effect in lowering the currency holding by both buyer and banker, further decreasing exporter's incentive to choose this currency. In sum, high inflation and currency depreciation would lower the international use of currency.

A.2.2 Monetary Policy Volatility

Proposition 2.2 If the gross nominal interest rate follows a log-normal distribution, the increase of monetary policy uncertainty would lower the international use of currency.

Proof
We introduce the uncertainty of monetary policy by assuming the gross nominal interest rate follows a log-normal distribution, i.e., $\ln(1+R_{i,t}) \sim \mathcal{N}(x_i, \sigma_i^2)$, where $i \in \{1,2\}$ stands for the issuing country of currency and t indicates period. If we further assume the law of one price holds for numéraire good and monetary policy in two countries is identical in the last period, the nominal exchange rate would then follow a log-normal distribution.

$$e_t \equiv \frac{\phi_{2,t}}{\phi_{1,t}} = \frac{1+\mu_{1,t}}{1+\mu_{2,t}} = \frac{1+R_{1,t}}{1+R_{2,t}} \Rightarrow \ln e_t = \ln(1+R_{1,t}) - \ln(1+R_{2,t}) \Rightarrow$$

$$\ln e_t \sim \mathcal{N}(x_1 - x_2, \sigma_1^2 + \sigma_2^2)$$

The impact of uncertainty on buyer could be derived from his first order condition on currency holding. First consider country i buyer's optimal holding of home currency.

$$E(R_{i,t}) = (p_{ii} + (1-s_j)p_{ij})\frac{\theta(u' - c'/\beta)}{(1-\theta)u' + \theta c'/\beta}, \quad i,j \in \{1,2\}, \quad i \neq j$$

Given the log-normal distribution of gross nominal interest rate, buyer's expectation would be related with volatility, i.e., $\mathbb{E}(R_{i,t}) = \exp(x_i + \sigma_i^2/2) - 1$. Therefore, a rise of monetary policy volatility would also increase buyer's expectation of nominal interest rate, which is also his cost of holding money. After some transformation, we rewrite the FOC as

$$A\left[\exp(x_i + \sigma_i^2/2) - 1\right] = G(q) \equiv \frac{u' - c'/\beta}{(1-\theta)u' + \theta c'/\beta} \tag{19}$$

where $A \equiv [(p_{ii} + (1-s_j)p_{ij})\theta]^{-1}$. The volatility of monetary policy would decrease trade volume and buyer's currency holding as long as $G(q)$ is a decreasing function, i.e. $G'(q) < 0$. Given the assumption on function form such that $u' > 0, c' > 0, u'' < 0, c'' > 0$, it's easy to show that

$$G'(q) = \frac{1}{\beta}\left[(1-\theta)u' + \theta c'/\beta\right]^{-2}(u''c' - u'c'') < 0 \tag{20}$$

The procedure and result are similar for country i buyer's holding of foreign currency.

For bankers, his optimal currency holding is linked with buyer's decision through FOC. For example, in the case of PCP, banker's optimal choice is given by the following condition.

$$\mathbb{E}(1+R_{i,t}) = \frac{n_{ji}\phi_i m_i^j}{(1-2\sigma_i)\phi_i z_{ii}} \Rightarrow \exp(x_i+\sigma_i^2/2) = \frac{n_{ji}\phi_i m_i^j}{(1-2\sigma_i)\phi_i z_{ii}}$$

If both buyers and bankers perceived a higher level of monetary policy uncertainty, LHS of the above equation would increase. Given the results on buyer's optimal choice, his currency holding would decrease corresponding to the rising uncertainty. Consequently, banker's currency holding would decrease by a larger degree. Therefore, banker's response to volatility is in the same direction as buyer's.

Lastly, seller's profit from international trade is given by

$$\pi_i \equiv \underbrace{\left[1-\frac{F_{ii}}{(1-2\sigma_i)\phi_i z_{ii}}\right]}_{\text{financial development}} \underbrace{\left(\frac{1}{1+R_i}\right)}_{\text{discount}} \underbrace{\phi_i m_i^j - c(q_i^j)}_{\text{gain from trade}}$$

The drop of other agent's currency holding would lower exporter's profit ($\frac{\partial \pi_i}{\partial \phi_i z_{ii}} > 0$, $\frac{\partial \pi_i}{\partial \phi_i m_i^j} > 0$), thus reducing his incentive to use this currency. In sum, under general assumptions on function form, the increase of monetary policy uncertainty, such as inflation fluctuation and exchange rate volatility, would reduce the international use of a currency.

A.3 Proof of Proposition 3

Here we prove the relationship between exporter's bargaining power and his currency choice. As shown previously, exporter's profit function is the following if trade is settled by his home currency.

$$\pi = \left[1-\frac{F}{(1-2\sigma)\phi z}\right]\left(\frac{1}{1+R}\right)\phi m - c(q)$$

In contrast, if exporter settles international trade with foreign currency, he would suffer additional loss τ from cross-border transaction, which is assumed to be an increasing function of the real payment amount, i.e. $\tau = \tau(\phi m)$, $\frac{\partial \tau}{\partial(\phi m)} > 0$. His profit therefore becomes

$$\pi^* = \left(1-\tau(\phi^* m^*)\right)\left[1-\frac{F^*}{(1-2\sigma)\phi^* z^*}\right]\left(\frac{1}{1+R^*}\right)\phi^* m^* - c(q^*)$$

where superscript of asterisk denotes foreign variable. Here we focus on partial equilibrium analysis, so that production level q and variables in financial market such as

F, ϕz, and R are fixed from the perspective of exporter. This means exporter's bargaining power would affect real payment amount (ϕm) directly through bargaining and cross-border transaction cost ($\tau(\phi m)$) indirectly.

Proposition 3.1 *In partial equilibrium, exporters with higher bargaining power prefer to use home currency if transaction cost is elastic in real payment amount, i.e.* $\frac{\partial(1-\tau)}{\partial(\phi m)}\frac{\phi m}{1-\tau} < -1$.

Proof Recall the following equation from the proportional bargaining game between exporter and importer

$$\phi m - c(q)/\beta = (1-\theta)\big[u(q) - c(q)/\beta\big]$$

Keep q fixed and take differentiation with respect to exporter's bargaining power $(1-\theta)$.

$$\frac{\partial(\phi m)}{\partial(1-\theta)}\Big|_{q=\bar{q}} = u(q) - c(q)/\beta > 0 \tag{21}$$

This intuitive result means importer's real payment is increasing in exporter's bargaining power. Given that trade settled with home currency doesn't have transaction cost, so we have in a partial equilibrium

$$\frac{\partial \pi}{\partial(1-\theta)}\Big|_{q=\bar{q}} = \left[1 - \frac{F}{(1-2\sigma)\phi z}\right]\left(\frac{1}{1+R}\right)\frac{\partial(\phi m)}{\partial(1-\theta)} > 0 \tag{22}$$

with the obvious interpretation that exporters with high bargaining power would gain more profit if the trade is settled by home currency. For trade settled with foreign currency, however, transaction cost would make the analysis complicated. Again take differentiation of exporter's profit with respect to his bargaining power

$$\frac{\partial \pi^*}{\partial(1-\theta)}\Big|_{q=\bar{q}} = \Big(1-\tau\Big)\left[1-\frac{F^*}{(1-2\sigma)\phi^* z^*}\right]\left(\frac{1}{1+R^*}\right)\left[\frac{\partial(\phi^* m^*)}{\partial(1-\theta)}\right]\left[1+\frac{\partial(1-\tau)}{\partial(\phi^* m^*)}\frac{\phi^* m^*}{1-\tau}\right] \tag{23}$$

Given that $\frac{\partial(\phi^* m^*)}{\partial(1-\theta)} > 0$ in partial equilibrium, exporters with high bargaining power might experience profit decrease if transaction cost is elastic in real payment amount, i.e.

$$\left[1 + \frac{\partial(1-\tau)}{\partial(\phi^* m^*)}\frac{\phi^* m^*}{1-\tau}\right] < 0 \Rightarrow \frac{\partial(1-\tau)}{\partial(\phi^* m^*)}\frac{\phi^* m^*}{1-\tau} < -1 \Rightarrow \frac{\partial \pi^*}{\partial(1-\theta)}\Big|_{q=\bar{q}} < 0 \tag{24}$$

In summary, for exporters with high bargaining power, they always enjoy better profit if trade is settled by home currency, but they might experience profit loss if trade is

settled by foreign currency and transaction cost is elastic in real payment amount, and this would lead to exporters more likely to choose home currency.

A.4 Complementary Tables and Graphs

Table 15 shows the time series of different currency choice. Before the financial crisis, 63.1 % of the transactions are invoiced in vehicle currency (mainly USD). After the financial crisis, the share of VCP declined and then bump up after 2010. Although PCP is small in proportion, it is increasing in the sample years.

Table 16 reveal the currency denomination of exports for all industries. We also observe a significant variation in invoicing currency across industries. The use of LCP is very low in Machinery industry and relatively hight in food industry.

Table 17 shows per exporter distribution of the number of HS 4/6-digit product exported, the number of transactions, the number of destination countries, the number of currencies and total export value. In 2013, in terms of HS 6-digit products, the median firm exports 1 product while the top one percent exporters sell 44 products. Similarly, if we focus on destination country, the median firm exports to 1 country while the top one percent exporters sell products to more than 22 countries. Most of the firms are using one currency for trade invoicing while some of them are using more than 2 different currencies. This skewed distribution is typical in the international trade data. Table 18 shows the per HS 4-digit product distributions of total exports, and the number of exporters, destination countries, currencies and transactions. More than 25% of the industries use more than 2 currencies while 10% use more than 3 currencies. Again, these distributions are skewed, with the median number of exporters and destination countries being much smaller. Table 19 shows distributions over exporter-HS4-digit Industry pairs, which are particularly skewed so that the vast majority involves an exporter selling a given product to a single country in USD value. For more than 50% of the export-product pairs, however, the exporter sells the same HS 4-digit product to multiple countries and in large USD value. More importantly, for each exporter-HS4 industry pair, only one single currency will be used in most of the cases.

Table 13: Variable construction and Data Source

Name	Description	Source
FD (financial development)	Private credit over GDP relative to Colombia level	World Bank
Inflation	Import country's YOY change of CPI	IMF
FX volatility	Coefficient of variation for monthly bilateral exchange rate in a year	IMF
Real GDP	Import country's real GDP, in log	World Bank
EFD (external finance dependence)	Share of capital expenditures not financed by operation cash flow	Manova (2013)
Firm Size	FOB value of firm's total export in a year, in absolute value	Colombia Export Database
TFD (trade finance dependence)	TFD=EFD×(-Firm size)	Author's calculation
Firm size dummy	Equal to 1 if firm size is at top 10% of HS4 industry	Colombia Export Database
Country share	Share of import country in HS4 industry	Colombia Export Database
USD/EUR Peg	Equal to 1 if import country's currency is pegged to USD or EUR	IMF
Homogeneous good	Equal to 1 if reference-priced or the commodity has standard exchange	Rauch (1999)
Importing exporters	Equal to 1 if export firm is also importing in the same year	Colombia Export Database
Herfindal (Industry)	Index for Firm share in HS4 industry (measure competitiveness)	Colombia Export Database
Herfindal (Country)	Import country share in HS4 industry (measure competitiveness)	Colombia Export Database
Trade size dummy	Equal to 1 if transaction size is at 5% of total transaction in a year	Colombia Export Database
Trans	Equal to 1 if transported by sea	Colombia Export Database
TFD (transaction level)	TFD (transaction level)=Trans ×(-Firm size)	Author's calculation
Crisis	Equal to 1 if transaction happens between June 2008 and June 2009	Ahn et al. (2011)

Table 14: Transaction Level Tests

	(1)		(2)		(3)	
Variables	LCP	VCP	LCP	VCP	LCP	VCP
FD	2.8***	-1.1***	3.4***	-0.7***	4.1***	-0.7***
Firm Size Dummy	-3.7***	-3.0***	-5.3***	-4.7***	-5.4***	-4.3***
CPI	-0.69***		-0.65***		-0.24***	
FXcov		23.6***		15.3**		14.4***
Trade size dummy	-1.4**	-0.5***				
FD × TFD			4.5	9.4***		
Trans × Crisis					-1.12*	-1.06***
Observations	4,490,473	4,490,473	4,490,473	4,490,473	4,490,473	4,490,473
Year FE	Yes	Yes	Yes	Yes	No	No
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Geographic FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 15: Currency of invoicing in Colombia exports (percent %)

	VCP	PCP	LCP
2007	63.127	0.008	36.865
2008	60.969	0.319	38.713
2009	58.803	0.309	40.888
2010	56.073	0.362	43.565
2011	60.491	0.449	39.060
2012	62.447	0.503	37.050
2013	67.128	0.610	32.262

Table 16: Currency of invoicing by industry (percent %)

SITC	VCP	PCP	LCP
0: Food and live animals	46.628	0.756	52.616
1: Beverages and tobacco	97.004	0.000	2.996
2: Crude materials	66.829	0.002	33.169
3: Mineral fuels	96.893	0.578	2.529
4: Animals and veg.oils	84.470	0.025	15.505
5: Chemicals	91.178	0.016	8.807
6: Manufactured goods	67.431	0.032	32.537
7: Machinery	100.000	0.000	0.000
8: Miscellaneous	80.845	0.107	19.048
9: Unclassified	90.917	0.097	8.986

Table 17: Distribution over Exporters (2013)

	p25	p50	p75	p90	p99	mean
Number of HS4 exported	1	1	3	7	30	3.331
Number of HS6 exported	1	1	4	9	44	4.446
Number of Transactions	1	4	21	117	1,421	91.65
Number of Destinations	1	1	2	6	22	2.746
Number of Currency	1	1	1	1	2	1.05
Export value (thousand USD)	6	36	269,738	1,796	50,910	5,529

Table 18: Distribution over HS-4 Industry (2013)

	p25	p50	p75	p90	p99	mean
Number of Exporters	4	11	32	73	311	30.73
Number of HS6 exported	1	2	4	7	14	3.338
Number of Transactions	12	69	363	1,427	10,273	845.4
Number of Destinations	4	10	21	34	68	14.59
Number of Currency	1	1	2	3	5	1.5
Export value (thousand USD)	90	868	5,839	29,550	447,500	51,000

Table 19: Distribution over Exporter and HS-4 Industry Pairs (2013)

	p25	p50	p75	p90	p99	mean
Number of HS6 exported	1	1	1	2	5	1.335
Number of Transactions	1	2	7	28	434	27.52
Number of Destinations	1	1	2	4	15	2.076
Number of Currency	1	1	1	1	2	1.02
Export Value (thousand USD)	0.7	5.5	40	280	11,010	1,660

Figure 3: Share of Currency: US Dollar

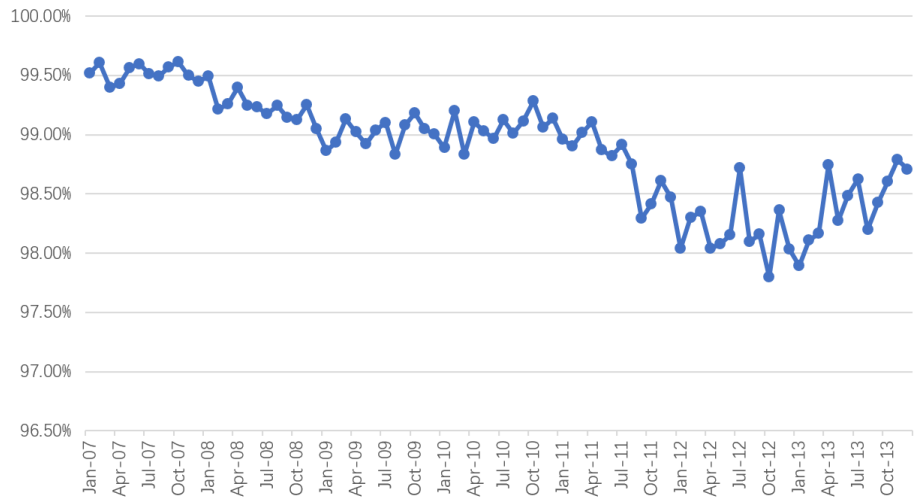

Figure 4: Share of Currency: Euro

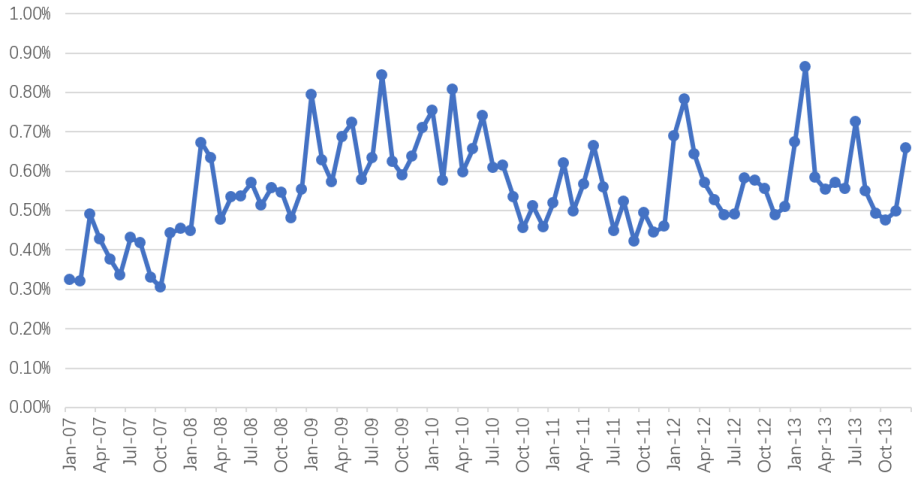

Figure 5: Share of Currency: Colombia Peso

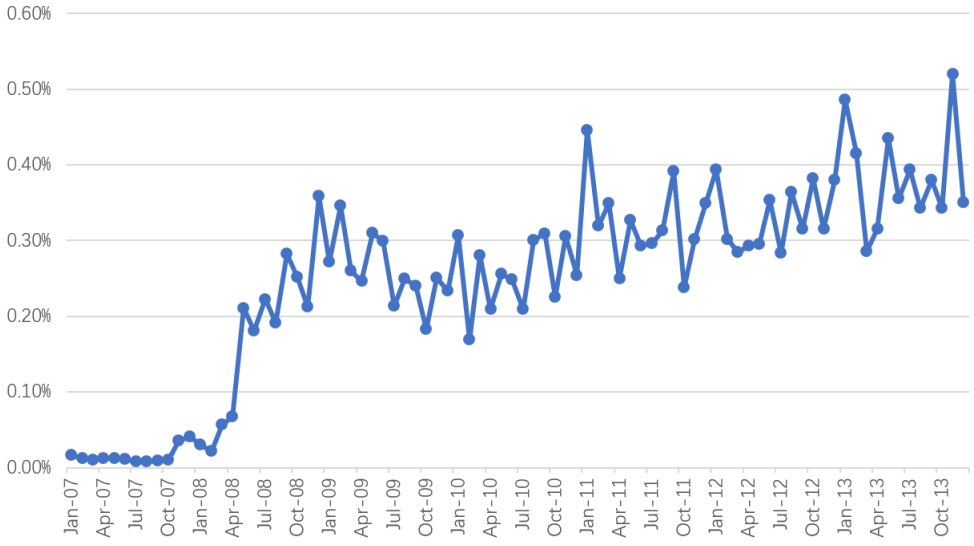

Figure 6: Share of Currency: Other Currencies

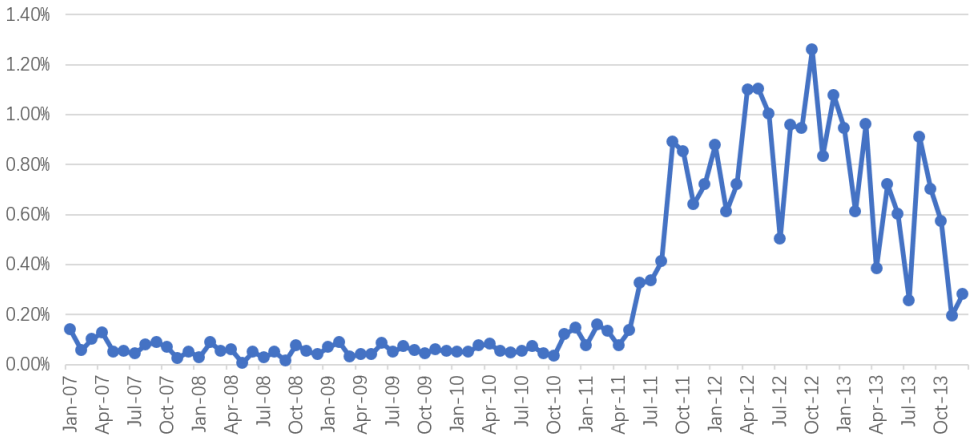

Figure 7: LCP and Financial Development

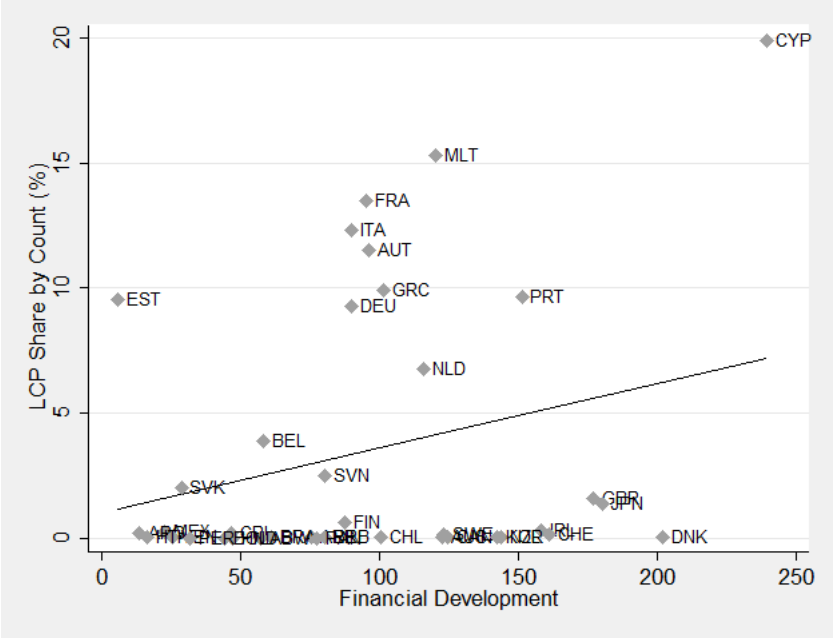

Figure 8: PCP and Financial Development

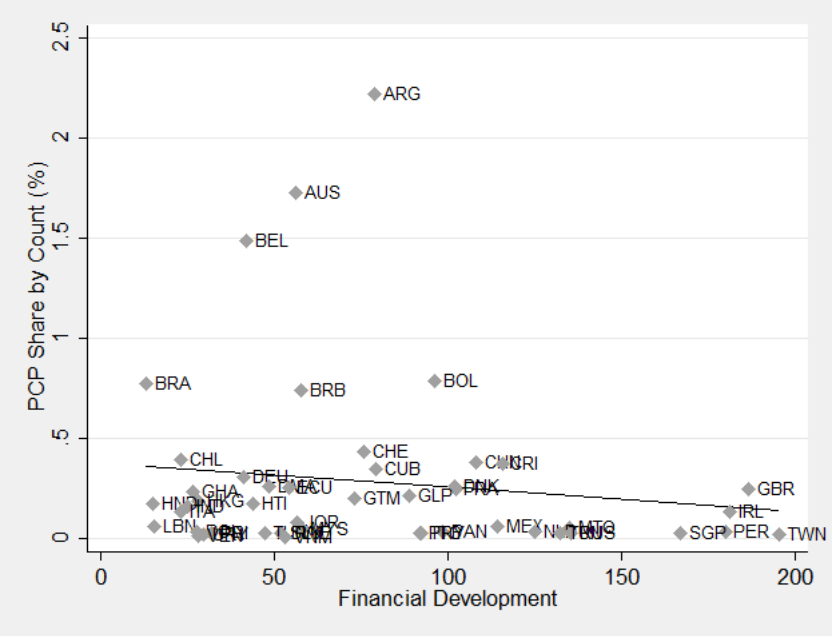

Figure 9: VCP and Financial Development

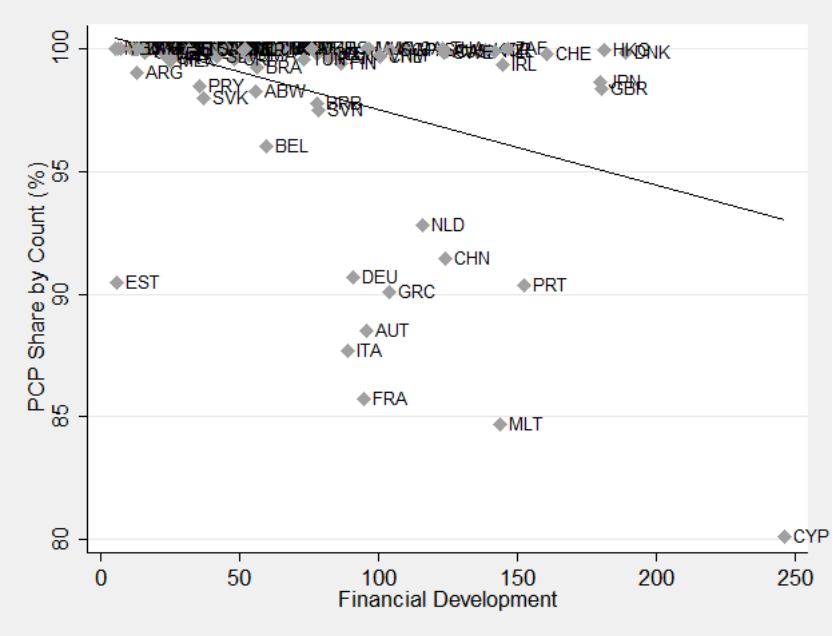

Figure 10: LCP and Inflation

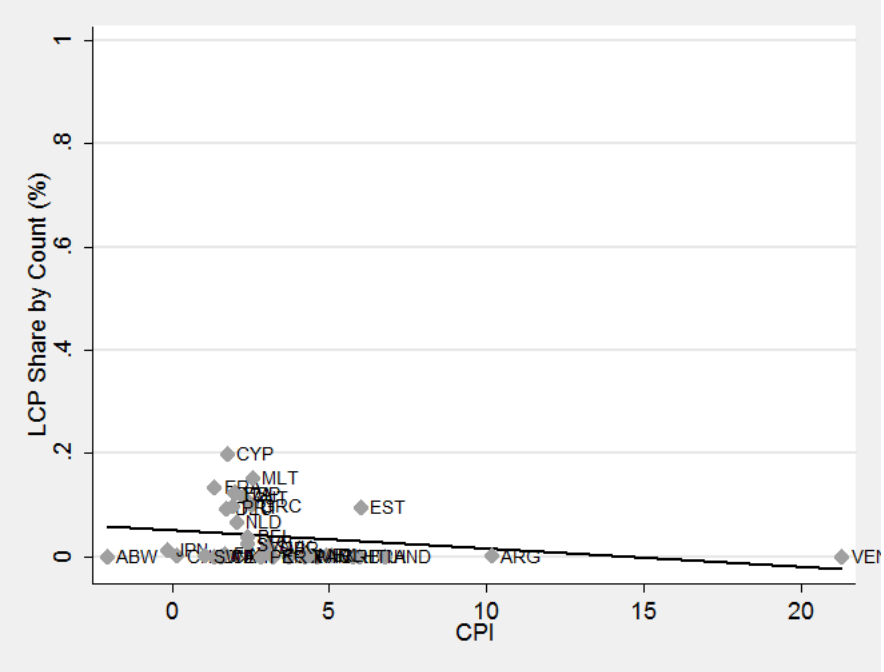

Figure 11: PCP and Inflation

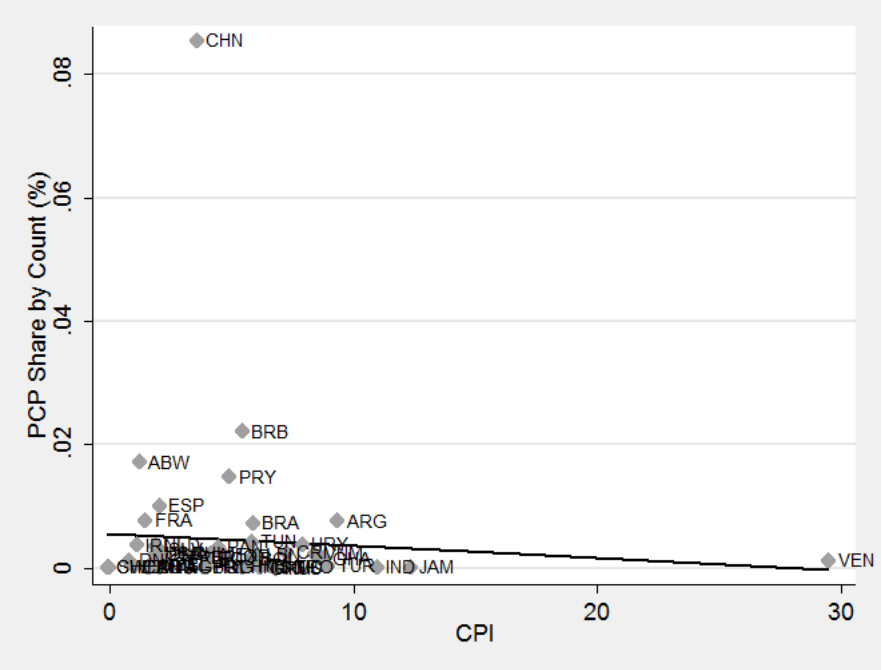

Figure 12: VCP and Inflation

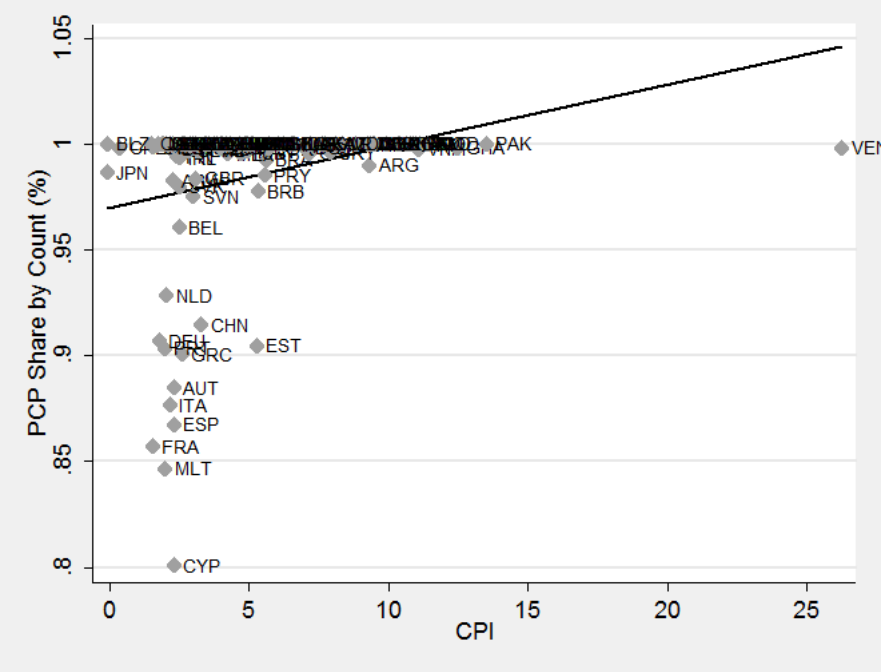

Figure 13: LCP and Exchange Rate Volatility

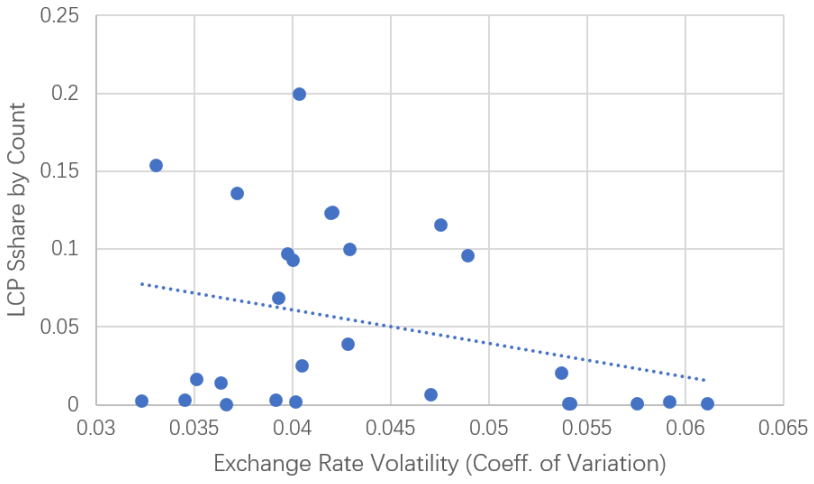

Figure 14: PCP and Exchange Rate Volatility

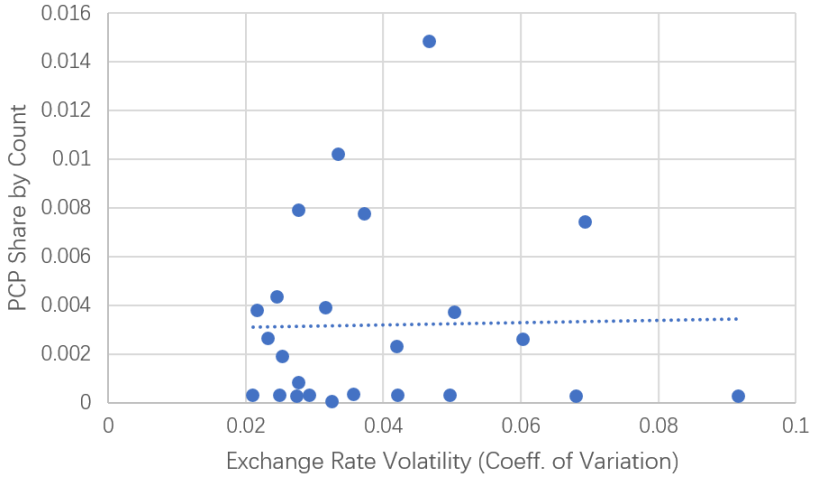

Figure 15: VCP and Exchange Rate Volatility