

Vehicle Currency Use in International Trade

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Abstract

We explore the major driving forces for currency invoicing in international trade with a simple model and a novel dataset covering 24 countries. We contrast a “coalescing” effect, where exporters minimize the movements of their prices relative to their competitors’, with incentives to hedge macroeconomic volatility and transaction costs. The key determinants of invoice currency choice are industry features and country size, with some role for foreign-exchange bid-ask spreads. The coalescing effect also goes a long way to explaining the well-known dominance of the dollar. Trade flows to the United States are predominantly invoiced in dollar, as foreign exporters face competition with U.S. firms. The use of the dollar in trade flows that do not involve the United States reflects trade in homogenous products where firms need to keep their price in line with their competitors’.

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1. Invoicing in a multi-currency world

In which currency should exporters set the price of their goods? When selling to a foreign market, an exporting firm can invoice the transaction in its own currency, in the currency of the destination country, or in a third “vehicle” currency. This invoicing decision plays a central role for the transmission of shocks across countries, by affecting the extent to which exchange rate movements alter international relative prices. Despite its relevance, the optimal strategy is not straightforward from a theoretical perspective, and the empirical evidence remains piecemeal.

In this paper, we explore the pattern and the determinants of invoicing using a new multi-country data set. We first provide perspective on this issue by using a simple model that encompasses the main driving forces behind invoicing decisions, namely industry characteristics, such as price sensitivity of demand and economies of scale, the volatility in macroeconomic variables, such as wages and aggregate demand, and transaction costs in foreign exchange markets. The model synthesizes arguments advanced in the broader literature and extends them to incorporate the use of a vehicle currency. Our analysis stresses a “coalescing” effect among exporters, with a particular firm invoicing in line with its competitors in order to limit the movement of its relative price. This dimension reflects industry characteristics and is especially relevant when goods are close substitutes and when demand fluctuations raise average marginal costs because of decreasing returns to scale. The stronger this effect, the more likely it is that a single currency takes a dominant role.

Exactly which currency takes this dominant role can reflect several factors. First, the currency of a large country has an advantage, as foreign producers selling to that country aim to limit the movements of their prices relative to that of local producers who dominate the market and invoice in the local currency. The dominant role of a large country’s currency extends further to other markets when firms are restricted to use the same currency for all their exports. Second, a currency with low transaction costs in foreign exchange markets, is also well poised to play a dominant role in invoicing. Third, while theoretical arguments point to a role for macroeconomic variability, it is likely to be more limited and concentrated in the invoicing of differentiated products for which demand is relatively insensitive to prices.

Our simple model provides a background for our novel presentation of extensive empirical evidence on the currency invoicing of international trade for 24 countries. We first

confirm the well-known fact that the U.S. dollar is the primary, albeit not unique, invoice currency choice in flows to and from the United States. In addition, the dollar plays a sizable role for many countries in transactions that do not involve the United States. We also document an increasing role of the euro for European Union and accession countries.

The novel contributions of our empirical analysis are the construction of measures for the invoicing determinants identified in the model, and their use in an econometric analysis of trade invoicing. The model indicates that the coalescing effect is most relevant in industries where buyers can easily substitute between competing producers. We verify this pattern for the few countries with detailed invoicing data at the industry level, with the U.S. dollar being more widely used for trade in more homogeneous products. As only aggregate invoicing data are available for the full sample of 24 countries, we determine the shares of a country's exports and imports that are in homogeneous and high elasticity of substitution goods by applying the Rauch (1999) indices to trade flows.² We find that a larger prevalence of more homogeneous goods (those that are reference-priced and traded on organized exchange) is associated with greater use of dollars in currency invoicing. This is robust to controls for the United States as a direct trading partner. We also find a role for the size of an exporter's country relative to its destination market, especially if "country" is defined from a currency bloc perspective. Similar findings surface in tests of determinants of euro use in invoicing, with export destination, exporter size, export composition and proximity to the euro area being significant factors.

We construct measures of transaction costs in foreign exchange markets from data on bid-ask spread for each currency relative to the U.S. dollar, the euro (or previously the Deutschmark), and the pound. Transacting through the dollar nearly always entails a lower cost, reflecting its prominent role in the turnover of foreign exchange market (BIS 2005).³ We

² As detailed in Rauch (1999), "Organized Exchange" traded goods cover products that have an overt market (i.e. precious metals). "Reference Price" goods are homogeneous goods that do not have a substantial enough volume to have an "official" market (e.g. obscure chemical products), but are homogeneous enough to have "reference" prices that are published in trade magazines.

³ Our theoretical argument can be appropriately critiqued as partial equilibrium: it may be the case that the existence of low transactions costs and high transaction volumes in dollars occur because the dollar is a vehicle currency on trade. We discuss this later in the paper, but note that trade in goods is a small part of total foreign exchange market turnover.

find some exceptions for some smaller European countries in recent years, which help account for their relatively heavy use of the euro. Our empirical analysis nonetheless finds only a moderate role for transaction cost considerations.

Finally, the theory predicts a role for macroeconomic volatility through co-movements between exchange rates and exporters' marginal costs, with exporters having an incentive to invoice in the currency that offers the best hedge against cost fluctuations stemming from movements in aggregate demand and wages. We capture this aspect by regressing exchange rates on a measure of costs that we construct. While this hedging channel is not important for most of the sample of countries studied, a number of countries -- Australia, Japan, Korea, United Kingdom and the United States -- had hedging motives supporting a strong dollar preference for invoicing their exports to the other regions in the 1970s. This role faded subsequently. In the 1990s some euro preference emerged for Korea, Luxembourg, and Poland, while Hungary retained dollar preference.

The paper is organized as follows. Section 2 reviews the related literature, with an emphasis on recent contributions. The various drivers of invoicing are combined in a simple theoretical model in Section 3. Section 4 presents and analyzes the new multi-country dataset that we have assembled. Section 5 concludes.

2. Related literature.

Our analysis builds on a rich history of thought on vehicle currency selection that has highlighted several complementary determinants of invoicing. A first line of research focuses on the role of currencies as medium of exchange, focusing on financial transactions instead of trade. Swoboda (1968, 1969) stressed the role of transaction costs in foreign exchange markets and the benefit of using currencies associated with low transaction costs. Such low costs could reflect a high degree of liquidity in the foreign exchange markets for the currencies in question, as pointed out by Portes and Rey (1999). Rey (2001) elegantly explicated this theme in a three-country general equilibrium model, confirming the importance of a currency's "thick market externalities" that arise from a large presence in global international trade and low transaction costs of exchange. Devereux and Shi (2005) model foreign exchange trading as taking place through trading posts, which are costly to set up, and show that a vehicle currency, through which all trading takes place, can emerge as a way to minimize setup costs.

A second line of analysis focuses on industry characteristics. McKinnon (1979) argued that industries comprised of goods that are homogeneous and traded in specialized markets are likely to have transactions invoiced in a single low transaction cost currency. Since many currencies could potentially serve as the reference currency in these markets, which one plays the role at any specific time may be inertial. Krugman (1980) argued that once a currency is established as the dominant one in a market, a particular firm has no incentive to invoice in an alternative currency as this would lead to higher transaction cost and more volatile sales because of movements in its price relative to its competitors'. Once a currency has acquired a prominent role, it may keep this role even if another currency with similarly low costs emerges.

A third line of argument emphasizes that invoicing currency selection is driven by the role of volatility in macroeconomic variables in different countries. Firms have an incentive to invoice their trade in the currency of a country where the volatility of shocks, such as those arising from monetary aggregates, is moderate, as this will *ceteris paribus* minimize the fluctuations in the exchange rates associated with the currency in questions. Baron (1976) and then Giovannini (1988) were among the first researchers to formalize the role such variability on both producer profit maximization and the selection of either exporter or importer currencies for trade transactions. Empirically, recent work by Wilander (2006) finds a role for exchange rate volatility in the invoicing of Swedish exporters. The most extensive theoretical works in this area are the recent contributions by Bacchetta and van Wincoop (2005) and Devereux, Engel and Storgaard (2004), who provide jumping off points for our simple model.

Bacchetta and van Wincoop (2005), hereafter BvW, stress the role of industry structure as reflected in the price elasticity of demand and the convexity of production cost. They argue that an exporter has an incentive to stabilize the price in the currency of her customers when demand is highly elastic and marginal costs are increasing with output. Intuitively, failing to do so leads to fluctuations in demand, the more so the higher the price elasticity of demand. This raises average marginal cost when production costs are convex. BvW also point to the presence of what we call a coalescing effect through which the exporter has an incentive to invoice in the currency used by the majority of her competitors in order to limit output volatility. We expand on the analysis of BvW, who mainly focused on the exchange rate as the source of volatility, by including fluctuations in factor prices and shifts in foreign demand, as well as a

transaction cost in the foreign exchange market. This allows us to contrast the interaction of the coalescing motive with macroeconomic factors and the role of transaction costs.

Macroeconomic volatility is emphasized by Devereux, Engel and Storegaard (2004), hereafter DES, who examine the role for monetary fluctuations in the invoicing decision using a general equilibrium setup in a two country world. They show that exporters choose to set their prices in the currency of the country where monetary shocks are the least volatile.⁴ Engel (2006) uses a similar setup to highlight the parallels between the choice of invoicing when prices are sticky and the optimal degree of exchange rate pass-through when prices are flexible.

Our illustrative model merges these key insights. We choose to analyze the invoicing choice of a firm in a partial equilibrium approach, in contrast to BvW and DES.⁵ While a general equilibrium approach offers obvious advantages, it comes with two drawbacks that we avoid in a partial equilibrium setting. First, we do not need to take a stance on the exact shocks driving the economy. Both BvW and DES focus on monetary shocks, and their conclusions may be specific to these shocks. Second, we do not need to specify a model of exchange rate determination. Since a well-established literature shows the difficulty of predicting and explains exchange rates over the horizon of the exporter pricing decisions, our approach better reflects a dimension of international economics that regrettably remains unsettled in empirical research.

3. A three-country / three currency model of invoicing

This section provides a concise way to contrast the various drivers of invoicing, and identify major patterns that motivate the empirical exercise of section 4. For brevity we focus on the main intuitive message, with detailed derivations presented in an appendix available

⁴ Donnenfeld and Haug (2003, 2002) look at the role of exchange rate volatility in driving the invoicing decision for Canadian trade transactions. They conclude that a higher volatility makes LCP more attractive, or VCP provided that goods are not too substitutable. These conclusions are in contrast to the ones discussed above. In their model output is preset first, prices are set, and then sales take place. The more standard models have prices set first and then output demand determined. See also Oi, Otani, and Shirota (2004) in which a general equilibrium model of invoice currency choice is presented and applied to Japanese data. Hartmann (1998) explores vehicle currency choice from a market microstructure perspective.

⁵ BvW (2005) undertake a general equilibrium analysis focusing on a model with two currencies. They consider the case of multiple currencies only in a model where exchange rates are the only stochastic variables.

upon request. We start by presenting the key elements and results of the model, before discussing the intuitive interpretation, as well as possible extensions, and deriving testable implications.

3.1. Invoicing in a multi-currency world

Firms post prices for their goods before knowing the realization of various shocks affecting the economy. We assume that the currency used in invoicing is also the one used in the actual payment, in line with the evidence in Friberg and Wilander (2007). Consider an exporter located in country e that produces a brand z and sells it in the destination country d . She sets a price $P_{ed}^k(z)$ in currency k before the realization of the shocks. We consider a flexible and general specification where currency k can be a basket of the various currencies, which provides a simple way to generate a partial pass-through of exchange rate fluctuations to consumer prices, following Corsetti and Pesenti (2005, 2002) and Engel (2006).⁶ Specifically, currency k is a combination of the exporter's currency, e , the currency of her customers, d , and a third vehicle currency, v .⁷ We denote the weights of currencies d and v in the invoicing basket k by β_d^d and β_d^v respectively, with the weight of currency e being $1 - \beta_d^d - \beta_d^v$. For instance a 10 percent depreciation of currency d vis-à-vis currencies e and v leads to a β_d^d percent depreciation of the synthetic currency k against currencies e and v . The invoicing selection exhibits *producer currency stability* if it is dominated by the exporter's currency (with both β_d^d and β_d^v being low), *local currency stability* if it is dominated by the customers' currency (with β_d^d being high), and *vehicle currency stability* if it is dominated by the vehicle currency (with β_d^v being high).

The exporter produces using a technology with decreasing returns to scale and faces a downward-sloping demand for her goods:

⁶ The presence of partial exchange rate pass-through is a desirable feature in light of the empirical evidence by Goldberg and Knetter (1995), Campa and Goldberg (2005), Anderton (2003), Frankel, Parsley and Wei (2004), and Campa, Goldberg and Minguez-Gonzalez (2007).

⁷ The standard producer currency pricing (PCP) case corresponds to the price being set fully in currency e , while the local currency pricing (LCP) case denotes the price being entirely set in currency d .

$$(1) \quad Y_{ed}(z) = (\alpha)^{-1} [H_{ed}(z)]^\alpha \quad ; \quad Y_{ed}(z) = \left[\frac{S_{ek} P_{ed}^k(z)}{S_{ed} P_d} \right]^{-\lambda} C_d$$

where $Y_{ed}(z)$ is the output of z , $H_{ed}(z)$ is an input with a unit cost of W_e in currency e ,⁸ C_d is the aggregate demand in country d , and P_d is the price index across all brands, in currency d . S_{ek} is the exchange rate between currency e and currency k with an increase corresponding to a depreciation of currency e . Two parameters play a central role in our analysis, namely the degree of returns to scale in the production function, $\alpha \in (0,1)$, and the price-elasticity of demand, $\lambda > 1$.

The exporter faces transaction costs which depend on the currency chosen for invoicing. The actual payment involves a conversion of currency d into currency k , followed by a conversion of currency k into currency e . When the exporter brings an amount $P_{ed}^k(z)$ of currency k to the foreign exchange market for conversion into currency e , she gets only an amount $\exp(-\tau_e^k) S_{ek} P_{ed}^k(z)$ of currency e , where $\tau_e^k \geq 0$ is a transaction cost. The exporter sets her price in currency k to maximize discounted expected profits:

$$(2) \quad \Pi_{ed}^k(z) = ED_e \left\{ \exp(-\tau_e^k) S_{ek} P_{ed}^k(z) Y_d(z) - W_e [\alpha Y_d(z)]^\alpha \right\}$$

where D_e is the state-specific discount factor at which profits are evaluated and time subscripts are omitted for expositional convenience.⁹

The profit maximization proceeds in two steps. We first choose $P_{ed}^k(z)$ to maximize (2) subject to (1), taking the invoicing currency k as given. Before proceeding to the second stage, it is useful to define some variables. The impact of invoicing is summarized by the transaction

⁸ The Appendix presents the derivations when the production function uses two inputs, where one of them could be imported with a price affected by the exchange rate. Novy (2006) discusses the role of imported inputs, but focuses on a technology with constant returns to scale.

⁹ We consider that the firm is owned by agents in the exporting country, so profits are discounted using the marginal utility of income for these agents. This is done without loss of generality: while a resident of another country would value profits after converting them in her own currency, this has no impact on the optimal invoicing decision that is the focus of the paper. All we require is that the owner treats her marginal utility of income as independent from the profits of a particular firm, in a similar way as she treats the consumer price index as independent from the price set by a particular firm. This point is discussed in Engel (2006)

costs τ_e^k and the exchange rate between the exporter's currency e and currency k , s_{ek} . Using the weights in the invoicing basket we write:

$$(3) \quad \tau_e^k = \tau_e^e + \beta_d^d (\tau_e^d - \tau_e^e) + \beta_d^v (\tau_e^v - \tau_e^e) \quad ; \quad s_{ek} = \beta_d^d s_{ed} + \beta_d^v s_{ev}$$

where lower case letters denote logs. We assume that a share η_d^d of the aggregate price P_d is invoiced in currency d , while a share η_d^e is invoiced in currency e , and a share $\eta_d^v = 1 - \eta_d^e - \eta_d^d$ is invoiced in currency v . The ex-post impact of exchange rate movements on the relative price between an individual firm and its competitors then reflects any discrepancy between the firm's invoicing shares (β 's) and the aggregate invoicing shares (η 's):

$$(4) \quad s_{ek} - s_{ed} - p_d = (\beta_d^d - \eta_d^d) s_{ed} + (\beta_d^v - \eta_d^v) s_{ev}$$

Full stabilization of the relative price in (4) requires the exporter to invoice in line with her competitors: $\beta_d^d = \eta_d^d, \beta_d^v = \eta_d^v$.

The second stage of the optimization substitutes the optimal price $P_{ed}^k(z)$ in (2), and maximizes the resulting expression with respect to the invoicing shares β_d^d and β_d^v , treating aggregate demand and prices, input prices, and exchange rates as exogenous variables. A technical hurdle is that the profit expression (2) is a highly non-linear function of the invoicing shares. We address this problem by expressing (2) in terms of a quadratic log approximation around a point where the economy is not affected by any shocks.

Three points are to be noted at this stage. First, while invoicing shares are not defined in a situation where there are no shocks, as all currencies are equivalent because exchange rates never move, all other variables are well-defined. Second, a linear approximation of (2) is not enough. Intuitively, the invoicing decision can be understood at a risk-minimizing one, with the firm picking an invoicing strategy that hedges its marginal costs, as detailed below. Such considerations involve the various variances and covariances in the model, and are only captured by a quadratic approximation of (2). These two aspects highlight the similarity between the invoicing decision and the choice of financial portfolios in macroeconomic models, which addresses similar technical issues, as discussed in Devereux and Sutherland (2006) and Tille and vanWincoop (2007).

Third, our analysis is subject to the same shortcoming as all exercises relying on approximation methods, namely that it loses its accuracy if shocks are large. In particular, our assumptions of small shocks and a finite price-elasticity of demand (albeit a possibly large one) ensure that an individual firm always faces a positive demand at the posted price, and that it is profitable to meet this demand as the shock is not large enough to erase its unit margin. Our model then differs from the analysis in Fisher (1989) who considers a case where goods are perfect substitutes and marginal costs are constant. Assuming a Bertrand competition, he shows that exchange rate movements lead some firms to drop out of the market.

The quadratic approximation of (2) leads to an expression where the invoicing strategy only enters through terms that are quadratic in the transaction cost τ_e^k , the exchange rate s_{ek} , and the firm's price relative to its competitors, $s_{ek} - s_{ed} - p_d$. Maximizing this expression with respect to the invoicing shares leads to the following expressions:

$$(5) \quad \beta_d^d = \Omega \eta_d^d + (1 - \Omega) \rho(m_{ed}, s_{ed}) - \frac{1 - \Omega}{\lambda - 1} \frac{(\tau_e^d - \tau_e^e) E(s_{ev})^2 - (\tau_e^v - \tau_e^e) E(s_{ed} s_{ev})}{E(s_{ed})^2 E(s_{ev})^2 - E(s_{ed} s_{ev}) E(s_{ed} s_{ev})}$$

$$(6) \quad \beta_d^v = \Omega \eta_d^v + (1 - \Omega) \rho(m_{ed}, s_{ev}) - \frac{1 - \Omega}{\lambda - 1} \frac{(\tau_e^v - \tau_e^e) E(s_{ed})^2 - (\tau_e^d - \tau_e^e) E(s_{ed} s_{ev})}{E(s_{ed})^2 E(s_{ev})^2 - E(s_{ed} s_{ev}) E(s_{ed} s_{ev})}$$

$$(7) \quad \beta_d^e = 1 - \beta_d^d - \beta_d^v$$

The measure m_{ed} captures the exogenous drivers of marginal costs, namely movements in factor prices and fluctuations in aggregate demand: $m_{ed} = w_e + (1 - \alpha) / \alpha \cdot c_d$. The terms $\rho(m_{ed}, s_{ed})$ and $\rho(m_{ed}, s_{ev})$ reflect the co-movements between m_{ed} and the exchange rates s_{ed} and s_{ev} , with a high value of $\rho(m_{ed}, s_{ed})$ indicating that marginal costs tend to be high when currency e is weak relative to currency d (s_{ed} is high).¹⁰ Industry characteristics are reflected in

¹⁰ Specifically, the ρ 's are the coefficient of a regression of m_{ed} on the two exchange rates:

$$\begin{aligned} \rho(m_{ed}, s_{ed}) &= V^{-1} \left[E(s_{ev})^2 E(s_{ed} m_{ed}) - E(s_{ev} m_{ed}) E(s_{ed} s_{ev}) \right] \\ \rho(m_{ed}, s_{ev}) &= V^{-1} \left[E(s_{ed})^2 E(s_{ev} m_{ed}) - E(s_{ed} m_{ed}) E(s_{ed} s_{ev}) \right] \\ \text{where } V &= E(s_{ev})^2 E(s_{ed})^2 - E(s_{ed} s_{ev}) E(s_{ed} s_{ev}) \end{aligned}$$

the coefficient $\Omega = \lambda(1-\alpha)/[\alpha + \lambda(1-\alpha)] \in [0,1]$ which is large when brands are close substitutes (λ is high) and decreasing returns to scale are pronounced (α is low).

3.2. An intuitive interpretation of the determinants of invoicing.

We discuss the intuition behind (5)-(7) in terms of the deviations from the benchmark where prices are set entirely in the exporter's currency ($\beta_d^e = 1$), which fully stabilizes the price that the exporter receives in her own currency for each unit sold. (5)-(7) show three reasons to deviate from this benchmark.

The first reason, captured by the first term on the right-hand side of (5)-(6), reflects a “coalescing” motive: an exporter has an incentive to follow the invoicing strategy of its competitors as reflected in η_d^d and η_d^v in order to limit output volatility. This consideration is more relevant when the firm faces decreasing returns to scale and operates in an industry where goods are close substitutes (Ω is large). Fluctuations of its price relative to its competitors then translate into sizable movements in output, leading to fluctuations in marginal costs and a higher marginal cost on average due to the convexity of the total cost function.

The second reason, captured by the ρ terms in (5)-(6), reflects the influence of macroeconomic volatility. An exporter wants to invoice in a currency which delivers a hedging benefit by limiting the deviations between marginal cost and marginal revenue. For instance, if the dollar tends to appreciate against the euro when European producers face high cost, invoicing in dollar is appealing for them as their revenue in euro will then tend to increase when their costs are high. Notice that exchange rate volatility per-se does not enter the invoicing decision. The relevant measure is instead the coefficients from a regression of marginal costs on exchange rates, $\rho(m_{ed}, s_{ed})$ and $\rho(m_{ed}, s_{ev})$. Furthermore, there is nothing ‘special’ about invoicing in the currency of the destination country, d , as it is driven by the same considerations as invoicing in any vehicle currency.

The two reasons discussed so far inform the role of the invoicing currency as a unit of account. By contrast the third reason captured by the last terms in (5)-(6), reflects the role of a currency as a medium of exchange, with the exporter preferring a currency with low transaction costs. For instance the exporter puts more invoicing weight on currency v if the foreign exchange market for that currency entails low transaction costs (that is, $\tau_e^v - \tau_e^e < 0$).

The invoicing shares (5)-(6) also highlight the relative magnitude of the three aspects. First, the coalescing motive can play a substantial role. While it is irrelevant when demand is price inelastic ($\lambda = 0$) or marginal costs are constant ($\alpha = 1$), it quickly becomes significant once we move away from this corner case. Taking standard values of $\alpha = 0.65$ and $\lambda = 6$ ¹¹ implies a value of 0.76 for Ω , giving a substantial role to the coalescing motive.

Second, the high volatility of exchange rates relative to marginal costs and demand dampens the role of macroeconomic volatility. The ρ terms in (5)-(7) are ratios between the covariance of the exchange rates with wages and demand, and the variance of the exchange rates. With the magnitude of exchange rate fluctuations being usually much larger than the magnitude of their co-movements with other variables,¹² these terms are likely to be quite small. A caveat is that the hedging dimension can play a larger role in the presence of imported inputs. Consider the extreme case where all inputs are imported from the destination country (or consist of local inputs, such as retail costs) and are paid for in currency d . Abstracting from demand fluctuations, this implies $m_{ed} = s_{ed}$ and invoicing in currency d fully hedges revenue and cost.

Third, the coalescing motive plays a large role compared to transaction costs in foreign exchange markets. Suppose for instance, that $E(s_{ed})^2 = E(s_{ev})^2 = (x)^{-1} E(s_{ed}s_{ev})$, where $x = 0.5$.¹³ The monthly volatility between G3 currencies suggests to a variance of exchange rates of 0.09%. The magnitude of the transaction costs can be proxied by the available evidence on bid-ask spreads in the foreign exchange market, with Hau and al (2002) indicating spreads of about 5 basis points (i.e. $\tau \cong 0.05\%$). Some simple arithmetic shows that a 5 basis point change in the transaction cost is equivalent a 4.7 percentage point change in competitors' invoicing, η , in terms of the impact on the invoicing share β . Therefore a sizable change in transaction costs, of

¹¹ In a model with a constant returns to scale technology in labor and a fixed factor, such as capital, a labor share of 65 % is a standard specification. A value of 6 for the elasticity of substitution corresponds to a 20% markup. Elasticities of this magnitude, or even higher, are a common parametrization.

¹² Frankel and Rose (1995) show that volatility of industrialized countries' exchange rates is an order of magnitude higher than volatility in fundamentals. Engel and West (2004) treat exchange rates as reflective of a discounted stream of expected future fundamentals.

¹³ This corresponds to a model where exchange rates are driven by independent monetary shocks of equal variances.

the same magnitude as their average value, is equivalent to a moderate change in the competitors' invoicing choice.

While our assumption of invoicing in a basket currency k can appear disputable, there is a close parallel between the invoicing shares (5)-(7) and the choice of invoicing fully in one currency. A situation where exporters pick a high share for the vehicle currency β_d^v is a situation where exporters pick that currency when restricted to fully invoice in one currency.

The optimal invoicing shares (5)-(7) are computed from the point of view of a single firm. Our empirical analysis however relies on aggregated data, raising the issue of how the aggregate weights η 's are linked to the firm-specific weights β 's. A particular concern is that while coalescing matters for an individual firm, it could play no aggregate role. Specifically, if all firms are identical, the β 's and the η 's coincide and the invoicing is driven by the last two terms in (5)-(7). While coalescing plays no role in aggregate terms in this specific example, it matters in more general examples. The key point is that when some firms pick invoicing shares that deviate from (5)-(7), other firms have a strong incentive to follow suit.

A particularly relevant aspect is that country size matters. Exporters face competition by local firms in the destination country who set prices fully in their own currency. This tilts the η 's in (5)-(6) towards the currency of the destination market, leading exporters to alter their invoicing accordingly, the more so when the structural features of the industry are conducive to a coalescing effect (Ω is high). We therefore expect exports to a large country to be substantially invoiced in that country's currency. Country size can also have an indirect effect. In deriving (5)-(7) we assumed that the exporter's invoicing decision for a market is not driven by considerations from other markets. We can extend our setup by assuming that exporters sell across many markets and have to pick the same invoicing currency for all sales.¹⁴ The invoicing shares are then of the same form as (5)-(7), except that the shares η , the cost m_{ed} and the transaction cost τ are weighed averages of the corresponding measures in the various export markets, with the weights reflecting market size. The invoicing strategy is then dominated by the larger markets. In particular, if exporters face substantial local competition in a large export market, they give a large weight to that country's currency in the invoicing of all exports.

¹⁴ The detailed steps are presented in an Appendix available on request.

We conclude the discussion of the model by discussing two assumptions. First, we consider that prices are set in advance, instead of being flexible. The essence of our results is robust to this assumption, as we can derive a parallel with the sensitivity of flexible prices to exchange rate movements, along the same lines as Engel (2006) in a two-country setting. For instance, a situation where the invoicing share of the destination currency β_d^d is large is a situation where under flexible prices, the price in the destination currency does not move much with the exchange rate. Furthermore, Eichenbaum and al. (2008) show that while prices often move frequently, they do so around a reference level that is infrequently adjusted.

A second assumption is that we consider firms to be price setters, instead of price takers. If firms are price takers, then the invoicing choice becomes a moot issue from the point of view of a given firm, except possibly for transaction costs reasons. If the market clears at a given dollar price, the firm has no choice but to sell at this price and absorb any exchange rate risk. Nonetheless, we can interpret the price-taker case as the limit of our model when the price-elasticity of demand λ becomes very large. In that case (5)-(7) are dominated by the coalescing motive as Ω becomes very close to one, with the exact currency that ends up dominating the market reflecting the same factors as discussed above.

3.3. Aggregate invoicing and empirical considerations

Our discussion above can be summarized by five testable implications.

Hypothesis 1: the exports of industries where goods are more homogenous should be invoiced in narrower groups of currencies, or even a single one. The exact choice of currency reflects considerations such as low transaction costs. By contrast, invoicing in industries with highly differentiated goods is likely to be spread across the various currencies.

Hypothesis 2: the share of invoicing in the currency of the destination country should be higher for larger countries. Large countries' currencies can also dominate the invoicing of exports to other markets when exporters are constrained to invoice all their exports in the same currency.

Hypothesis 3: the size of the exporter's country also matters. Exporters from small countries are less likely to play a dominant role in the destination market, hence less likely to

invoice in their own currencies. In addition, producers in small countries are more likely to rely on imported inputs than firms in larger economies (Campa and Goldberg 2007). If inputs are then invoiced in a dominant currency, this reduces the propensity of producers in small countries to invoice in their own currency.

Hypothesis 4: macroeconomic volatility should affect invoicing decisions through the correlations between exchange rates and marginal costs, as opposed to the volatility of exchange rate per se. The relevant measures of macroeconomic volatility are the coefficients of a regression of marginal costs on exchange rates.

Hypothesis 5: a currency is more likely to be used in invoicing if it is associated with low transaction costs. This mechanism can feed on itself if the low costs are driven by the liquidity in the foreign exchange market.

4. The use of dollars and other currencies in international trade

4.1. Overview and data

Empirical evidence on the invoicing choices made by agents in specific countries and on specific types of goods is sparse, with notable exceptions the work on Swedish invoicing by Friberg (1998), Wilander (2006) and Friberg and Wilander (2007), Canadian invoicing by Donnenfeld and Haug (2003), and Japan by Oi, Otani, and Shirota (2004). Recently, evidence has become available for euro-area and accession countries (European Central Bank 2002), with Kamps (2006) reviewing the international use of the euro.¹⁵ Yet, no single data source has compiled the information from these studies and various additional sources of information the invoicing of international trade transactions. We compile together cross country, cross industry and intertemporal data and test the alternative influences on invoicing decisions.

There are twenty-four countries for which we have collected invoicing information: the United States, the United Kingdom, eight euro-area countries (France, Germany, Italy,

¹⁵ Between 1999 through 2001Q3, the European Commission (Quarterly Review of the Use of the Euro) published quarterly information on the international transactions of euro area firms. This publication focused on the transition period of the euro, and measured the use of the euro compared with both national currencies (DM, Ffr, etc) and the foreign currencies.

Belgium, Luxembourg, Italy, Spain, and Portugal), nine European Union accession countries (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Poland, Slovakia, and Slovenia), plus Japan, Korea, Malaysia, Thailand, and Australia.¹⁶

Our empirical analysis proceeds in three steps. First, we present the empirical regularities that appear in the cross-country information on the currency invoicing of trade, as a background for the more formal econometric analysis that follows, highlighting the prominent role of the U.S dollar. Second, we construct the indicators needed for testing the theoretical hypotheses of section 3. This includes a new use of the Rauch (1999) network indices, which entails applying these export and import data of countries to identify the shares that are in highly substitutable goods or differential goods. We also construct dummy variables that capture hedging currency preferences. We also provide new insights into transactions costs in foreign exchange markets, and the relative positions of dollar-based and euro-based costs. In our third and final step we test the hypotheses behind the use of dollars and euros in invoicing international trade.

4.2. The Use of the U.S. Dollars in Trade Invoicing

The role of the U.S. dollar is shown in Table 1. The first two columns show the dollar share in the invoicing of exports and imports, with the last two columns showing the shares of the exporter's currency. Two aspects emerge. First, the U.S dollar is the primary invoice currency choice in transactions to and from the United States. Second, the extent to which the dollar is used varies substantially across countries. Typically, it is used in about a third of exports by euro-area countries, and for close to 40 percent of their imports. Its use in U.K. trade transactions is of a similar magnitude, accounting for 26 percent of exports and 37 percent of

¹⁶ The data availability and sources for our study are summarized in our NBER working paper #11127. The availability information varies tremendously across countries in terms of details and time histories. The United Kingdom and Australia have very detailed information on currency invoicing of trade transactions of different commodities or with different country partners. Within Asia, detailed data is available for both Japan and Korea. Data for the United States is drawn from Customs information used in constructing international price series. Within Europe, ECB efforts have made available relatively comparable data across many countries. We are grateful to the agencies that provided this information. Looking across countries, in some cases we cannot definitely state whether the data capture the currency of transaction invoicing or currency of transaction settlement.

imports. The EU accession countries are mixed in the extent to which dollars are used in invoicing their international trade transactions, with dollar use ranging from 9 to 45 percent. Recent ECB data shows rising euro use by accession or acceding countries. In contrast, the dollar remains a dominant currency in the invoicing of both exports and imports by countries outside of Europe. Both Korea and Thailand use it for more than 80 percent of trade transactions. Similarly, Japan, Australia, and Malaysia, use the dollar in more than 50 percent of trade transactions.

Turning to the share of exporter's currency in invoicing (the third column, corresponding to the term β_d^e in the theory section), we observe two main points. First, smaller countries make little use of their own currency on their export transactions. Indeed, a number of small countries do not even report the use of their own currency, suggesting that this activity is limited. An exception to this pattern applies to small euro area countries, where the size of the whole euro area is a better metric than own country size for this hypothesis. Second, euro area countries make a substantial use of the euro, which is the invoice currency on 40 to 50 percent of (extra euro area) exports. Japanese exporters use the yen on about a third of their exports, while U.K. exporters use the pound sterling on about half of their exports. Broadly similar patterns appear in country imports, with the importing country currency being typically less often used in import transactions than in exports.

A closer look at the detailed invoicing data available for the United States reveals that the use of the dollar in U.S. trade depends on the trading partner.¹⁷ U.S. trade flows to and from Latin America, China, Mexico, as well as with most small countries, are almost exclusively invoiced in U.S. dollars. By contrast, foreign currencies appear more prominently in the invoicing of U.S. imports from the European Union, the United Kingdom, and Japan. About 25 percent of U.S. imports from Germany are invoiced in euros; 14 percent of imports from the UK are invoiced in pound sterling, and 12 percent of imports from Japan are in yen.

The prominent role of the dollar is illustrated in Chart 1, where we contrast the dollar invoicing share in export transactions of each country (horizontal axis) with the share of the United States as a direct recipient of a country's exports (vertical axis). Under an extreme case

¹⁷ The extent to which the dollar is used in bilateral trade transactions is often not identical across the two parties reporting currency use in trade transactions. Given the sampling limitations in the U.S.-sourced data, we defer to foreign source data for currency shares when that foreign data is available.

of complete dollar invoicing of trade with the United States and no vehicle currency role for the dollar, all points would lie along the diagonal. The international use of the dollar in trade invoicing is far greater than what would be expected purely on the basis of direct trade flows with the U.S., an aspect that is particularly strong for Korea, Thailand, Australia, the United Kingdom, and Greece.

4.3. Indicators of industry composition, transaction costs, and hedging

We assemble data on the industry composition of countries' exports, the price-sensitivity of demand, λ 's, the foreign exchange transaction costs, τ_e^k and the comovements of exchange rate and marginal cost $\rho(m_{ed}, s_{ek})$ for each country.

Industry composition. All of the twenty-four countries have trade invoicing information for aggregate exports and aggregate imports. Our goal is to determine whether different invoicing patterns are invoked across distinct classes of goods or goods explicitly sorted by price elasticity of demand. To capture industry structure on exports we apply the Rauch (1999) measure to trade data. Rauch (1999) provides a painstaking classification of commodities at the three and four-digit SITC level into one of three categories: "organized exchange" good is anything that has an overt market (i.e. precious metals); a "referenced priced" good is a homogeneous good that nonetheless does not have a substantial enough volume to have an "official" market (e.g. some chemical products), but that because of its homogeneity does have "reference" prices that are published in trade magazines. All other goods are classified as "differentiated", including the bulk of manufactured products. Organized exchange traded goods are those that are most highly substitutable with similar categories of foreign produced goods, and the differentiated products least substitutable. We index exports of differentiated goods by n , exports in organized exchange traded goods by w (for Walrasian), and exports in reference priced goods by r .¹⁸

Ideally, we would test the implications of our theoretical setup by looking at invoicing patterns across the different sectors of the economy. Such detailed data are unfortunately available only for four countries, Australia, Japan, the United Kingdom, and the United States.

¹⁸ Using the detailed sectoral elasticities of substitution computed by Broda and Weinstein (2006) as a consistency check, we find that r and w goods tend to have higher substitution elasticities than n goods.

The invoicing patterns for exports of n , w , or r goods are shown in Table 2. Consistent with our theoretical Hypothesis 1, the exporter’s currency is more commonly used on exports of differentiated goods than on exports of more homogeneous ones. The United States is an exception, as the dollar is used across the board.

Turning to the other countries where detailed invoicing data are not available, we denote the share of a country e ’s exports that are classified as type i by λ_e^i , where $i \in (w, r, n)$. λ_e^{r+w} denotes the share of a country e ’s exports that are classified as more homogeneous (the sum of r plus w types), shown in Table 3. The first column shows the share λ_e^{r+w} for the exports of the various countries, while the second column show the share on exports going to countries other than the United States. The corresponding shares for imports are shown in the last two columns. Australia has the highest share of exchange traded and reference priced goods which account for 70 percent of its exports. Greece, Bulgaria, and Cyprus all have the export share of relatively homogeneous goods at about 40 percent. By contrast, Japan and Germany have low shares of homogeneous goods, on the order of 15-20 percent, with the bulk of their exports in more differentiated manufactured products.

The potential role of exports in homogenous goods in vehicle currency use is illustrated in Chart 2¹⁹ which differs from Chart 1 in that the vertical axis now shows the share of exports going to the United States (as in Chart 1) plus the share of homogeneous goods in exports to countries other than the United States. The pattern in Chart 2 aligns more closely with the 45 degree line, suggesting that the role of the dollar in invoicing tracks the role of the United States as an export destination market plus the dollar’s role as a coalescing currency for export transactions of homogeneous goods to countries other than the United States. Consistent with the industry details available from Australia, the United Kingdom, and Japan, the prevalence of these exports of homogeneous goods appears to “explain” the widespread vehicle currency use of the dollar in most of the countries.²⁰ Yet, clearly industry composition and trade with the United States are not complete explanations for use of dollars in export transactions, as shown

¹⁹ We do an analogous exercise also on the import side for each country, with qualitatively similar findings.

²⁰ In these Charts two country groups stand out. First, the role of the dollar for Eastern European countries is smaller than what their pattern of exports suggests. The second outlier group of countries is in South-East Asia, which may have a downward bias in the measured role of the United States as a trading partner because of trade flows that go through other countries.

by the presence of several outliers around the 45 degree line. Countries that use the U.S. dollar less than “expected” include Estonia, Slovakia, and Slovenia, while countries with a larger role or the U.S. dollar than “expected” include Malaysia, Thailand, Korea and Greece.

Transaction costs. We proxy transaction costs in foreign exchange markets by the pattern of bid – ask spreads of each country currency vis-à-vis the U.S. dollar, the euro, and the pound using monthly data for 1995 through 2007 (the last day of the month from Bloomberg). “Pips”, the basis point spreads between bid and ask exchange rates divided by the average of these two rates, are used to indicate rankings of transaction costs by currency pair and over time.²¹ For our discussion and econometric analysis we use the median difference in pips on using euros versus pips on using dollars over the course of each year.

An analysis of the detailed data, not reported for brevity, reveals that the U.S. dollar is typically the lowest transaction cost currency in foreign exchange markets. This is however not uniformly the case. While the difference in pips across euros and dollars shows that the pips associated with using dollars is generally lower, there are some periods where transacting through euros is temporarily cheaper for a handful of countries (Cyprus, the Czech Republic, Poland, and Thailand). For smaller countries within or around the European Union, the dollar transaction advantage has been eroded or in some cases lost, providing less incentive for using dollars in export invoicing.

Exchange rate and cost covariance. The hedging motive for invoice currency selection reflects the covariances between exchange rates and producer marginal costs $\rho(m_{ed}, s_{ed})$ and $\rho(m_{ed}, s_{ev})$. We focus on the exchange rates vis-à-vis the dollar and the euro, with exchange rates defined as the local currency of exporter e relative to each. We proxy for exporter marginal costs in each country by constructing quarterly values for m_{ed} , where the

²¹ The spreads are measured as a percentage of the exchange rate, i.e. the average of the sum of the bid and ask values. For each currency, we take the end of month values of the spread as reported by Datastream, We excluded cases where bid and ask values were identical, which is likely indicative of no transactions having occurred, and dates where no values were available from this source. For all countries, the data are from the earliest date we were able to obtain series, which was between 1995 and 2000, all ending in 2007.

cost of inputs w_e are the logs nominal wages in exporter's currency, α is set at 0.65, and c_d is the log of real consumption in export destination markets " d ".²²

The period spanned by the available data varies across countries. In all cases the data are available for the recent decade (mid 1990s through 2005), while a subset of the countries (nine of the twenty-four) the data are available starting in 1970. For each invoicing country, we generate hedging motive results for the full sample period (the relevant interval varies across countries due to data availability), and for subperiods of 1970 through 1979, 1980 through 1989, 1990 through 1998, and 1999 through 2005. For each exporter e and each export destination d , we estimate the following OLS specification:

$$(8) \quad m_{ed,t} = \gamma_0 + \gamma_1 s_{e\$} + \gamma_2 s_{e\text{€}} + \varepsilon_t$$

The regression coefficients γ_1 and γ_2 correspond to estimates of $\rho(m_{ed}, s_{e\$})$ and $\rho(m_{ed}, s_{e\text{€}})$. If $\gamma_1 > 0$, and $\gamma_1 > \gamma_2$ the U.S. dollar dominates the euro as a hedging currency in country e exports to destination market d . If $\gamma_1 < \gamma_2$ the euro dominates for hedging purposes.²³

Over the full sample period, hedging preferences appear as statistically significant for only five countries (Greece, Korea, Luxembourg, Thailand and the United Kingdom). Korea and Luxembourg show statistically significant hedge preferences in favor of the euro in transactions with all destination markets,, in part because of a negative correlation between

²² The specific datasources and details are presented in the Appendix of the working paper version of this paper. A potential concern with our specification is that we overlook that reference prices in world markets can be updated at higher frequencies than quarterly, in which case our quarterly measure is not ideally suited. Given the lack of higher frequency wage and consumption data, especially for our broad sample of countries, the quarterly frequency is the highest available one.

²³ This specification does not fully capture the potential sensitivity of costs to exchange rates. Since w_e can be interpreted as broader than wages, an alternative measure could capture the cost of capital and production components in each country. If imported components are sizeable, the covariance computations should also reflect invoicing on capital imports. Recall that to measure $\rho(m_{ed}, s_{ed})$ and $\rho(m_{ed}, s_{ev})$ we first construct quarterly values for m_{ed} . For each country, a richer approach requires specific assumptions about the composition of production, its input output requirements at an industry level, and the partners from which different types of inputs are sourced. We do not expect that incorporating these findings would overturn the empirical results on the role of hedging motives in invoice currency selection.

their marginal cost terms and the dollar. For the United Kingdom, the euro preference is predicted only on exports to Asia. In exports to the euro area, the United States, and the rest of Europe, Thailand and Greece favor the dollar for hedging purposes. For other countries, the statistical significance of the hedging motive is low primarily because of the high volatility of exchange rates relative to the marginal cost.

Interestingly, we observe a time variation in the results for the hedging motive. Our data go back to the early 1970s for nine countries (Australia, France, Germany, Italy, Japan, Korea, Spain, United Kingdom, and United States). A number of countries exhibit a strong dollar preference for invoicing their exports to regions other than Asia, with this preference showing up in the countries that have remained relatively heavy users of dollars in invoicing through current times (Australia, Japan, Korea, United Kingdom and the United States). In the 1980s and 1990s, the spectrum of countries was largely indifferent between currencies in terms of hedging volatility to different export destinations. In the 1990s some euro preference emerged for Korea, Luxembourg, and Poland, while Hungary retained dollar preference. In the more recent period, the regressions suggest that country invoicing preferences for hedging should be neutral, with some exceptions with a dollar preference (Estonia, Hungary and Thailand), while the United Kingdom has developed more of a euro preference on hedging transactions to each region.²⁴

We use these results to construct indicator variables $H\$$ and $Heuro$ that depict when, based on the covariance analysis, the dollar dominates euros or the euro dominates dollars for hedging profit fluctuations. For example, for each country e , $H\$_d^e$ takes a value of 1 when the dollar is a (statistically significant) dominant hedging currency in exporter e sales to destination d , and otherwise takes a value of 0.

Exchange rate regimes. In Charts 1 and 2, some of the outlier countries appear to be participants in *de facto* or *de jure* participation in currency blocs, suggesting a potential role for exchange rate regimes in currency invoicing. In some regression specifications we take explicit account of whether a country is in a *de jure* or *de facto* euro or dollar bloc.

²⁴ The results are interesting to consider in light of inertial decisions in foreign exchange markets, as in Krugman (1980). If countries had strong preferences for dollar use for hedging purposes in the 1970s, it is possible that this reinforced high transaction volumes in dollars, and low transaction costs, early in the sample period. The low transaction costs continued, even after the hedging motive declined in strength and importance.

4.4. Econometrics of herding, coalescing, and transaction costs in currency invoicing

Our discussion of equations (5)-(7) emphasized that the invoicing shares reflect industry structure, the size of the destination market, the structure of correlations between exchange rates, marginal costs and destination market demand conditions, and transaction costs. In this section, we use the measures described above to conduct econometric tests of these aspects for the international use of the dollar and the euro use. The data sample of observations, by exporting country-years, is detailed in table footnotes.

The dollar as an invoicing currency. The first dependent variable examined is the share of a country's exports that are invoiced in dollars, B_s^e . Explanatory variables include the share of the United States as a destination market in country total exports, X_{us}^e ; ²⁵ the share of a country's exports that are in homogeneous goods (reference priced plus organized exchange traded), λ_{rw}^e , both overall and focusing on exports to destinations other than the United States, $(1 - X_{us}^e) \cdot \lambda_{rw}^e$. Both variables are also interacted with the size of the exporting country relative to the United States (with experimentation on whether using euro area size as a proxy for size of countries in the euro area changes results). The variable $pipeuro-us_i^e$ reflects the differential in transaction costs between the euro and the dollar on the exporter country currency, while the dummy variable $H\$_d^e$ reflects whether the dollar is preferred over the euro as a hedging currency on country e exports ²⁶. Some regressions include a *Dollarbloc* dummy variable, with the dollar bloc countries as Australia, Korea, Malaysia, and Thailand. The general specification is:

²⁵ If a euro area country reports its invoicing data in terms of extra euro area trade, we exclude exports from the country to other euro area countries in the export share construction.

²⁶ Some specifications treated the dummy variable as distinctly defined across destinations d , where subscripts *US*, *EA*, *EU-EA*, and *Asia* denote the United States, euro area, rest of European Union, and Asia, respectively, and interacted this dummy with the share of each of those regions in country exports. This distinction was not important for the regression analysis as there were very few countries with significant hedging terms, and there tended to be correlations across covariance significance by region.

$$(9) \quad \beta_{\$,t}^e = \alpha_0 + \alpha_1 X_{us,t}^e + \alpha_2 X_{us,t}^e \frac{Y_t^e}{Y_{us}^e} + \alpha_3 \lambda_{rw,t}^e + \alpha_4 (1 - X_{us,t}^e) \lambda_{rw,t}^e + \alpha_5 (1 - X_{us,t}^e) \lambda_{rw,t}^e \frac{Y_t^e}{Y_{us}^e} \\ + \alpha_6 \cdot H\$_t^e + \alpha_7 pip(\textit{euro} - \textit{dollar})_t^e + \alpha_8 \textit{dollarbloc} + \mu_t$$

Table 4 presents the results from the dollar invoicing specifications. Explanatory variables are introduced separately and then combined across specifications. Column (1) shows that the share of the U.S. in country exports explains about 40 percent of the cross-country and intertemporal variability in dollar use in export invoicing. Column (2) shows that dollar use is less, even on exports to the United States, for countries that are relatively large. Together, these variables explain 49 percent of the sample variation.

Column (3) shows that the share of homogeneous goods in country exports, $\lambda_{r+w,t}^e$, enters significantly and with the expected positive sign. The implication is that countries with a higher share of homogeneous goods in the export bundle tend to be heavier users of dollars. While significant, this feature alone explains only 2 percent of the variation in dollar use in invoicing. The role of this variable is not enhanced by interacting it with the share of country exports to destinations other than the United States or by the relative size of these exporting countries (columns 4 and 5).

The independent role of changing transaction costs in foreign exchange markets, depicted in the pip spread, is not statistically different from zero (column 6). The transaction cost variables are not available for the full sample and restrict the regression coverage to 68 observations. The dummy variable indicating when hedging considerations favor U.S. dollars, $H\$_t^e$, is statistically significant and with the expected positive sign (column 7). This basically shows that Estonia, Hungary and Thailand have a higher than average use of dollar invoicing in their exports. This variable has little independent explanatory power however.

Columns (8) through (14) combine the explanatory variables. Together, the share of the United States in country exports, the size of the exporter relative to the United States market, and the role of homogenous goods in exports explain 62 percent of the cross-country and time-series variability in dollar share of export invoicing, and an even higher share (about 80 percent) if attention is focused on the most recent years only (column 10). Hedging considerations and transaction costs do not add explanatory power to this overall regression

specification. It also is quite interesting that the constant term of the regression is essentially zero in these combined regressions.

A numerical example provides some perspective on the quantitative importance of the various determinants of invoicing. Taking the case of Australia, a one percentage point increase in exports to the United States as a direct destination market, accounting for country size differences, leads to a 2.5 percentage point increase in use of U.S. dollars in invoicing. A one percentage point increase in homogeneous goods exports raises dollar share in invoicing by approximately 0.8 percentage points.

A puzzling aspect of our results is that the coefficient on the share of exports going to the U.S. is well above one, indicating that an increase of exports to the U.S. has a disproportional impact on the use of the dollar in trade invoicing. This puzzle disappears once we introduce controls for dollar bloc countries (columns 11 to 14). The constant terms show that base-case countries have 20 to 30 percent of exports invoiced in dollars. Dollar bloc countries add about 40 to 50 percent more export invoicing in dollars. Given this control in the regression, adding one percentage point of exports to the United States tends to further increase dollar invoicing share by about another percentage point for a country like Australia. When the dollar bloc considerations directly enter the regression, the hedging terms and transaction cost terms are insignificant. A stronger focus on homogeneous goods exports raises dollar use in export invoicing. The inclusion of the dollar bloc terms is of course subject to endogeneity criticisms, as the dollar bloc countries are more likely to be heavier exporters to the United States and larger exporters of homogeneous products.

The euro as an invoicing currency. The next set of tests explain the share of a country's exports that are invoiced in euros. For euro area countries, the exports are defined as extra-euro area for consistency with the treatment in the invoicing reporting (Italy being an exception). Independent variables are the share of the euro area in a country's exports, X_{EA}^e , a dummy variable for whether a country is part of the euro area (value of 0 if no, 1 if yes), the share of homogenous and reference priced goods in a country's exports, λ_{r+w}^e , country size relative to the euro area, hedging terms referring to cases where the euro is a preferred hedging currency on export transactions, indicated by *Heuro*, foreign exchange transaction cost terms, and a dummy variable taking a value of 1 if a member of the European Union. For euro area

countries other than Italy, this export share $X_{EA,t}^e$ is set to zero.²⁷ The general specification is given by:

$$(10) \quad \beta_{\varepsilon,t}^e = \alpha_0 + \alpha_1 X_{ea,t}^e + \alpha_2 X_{ea,t}^e \frac{Y_t^e}{Y_{ea}^e} + \alpha_3 \lambda_{rw,t}^e + \alpha_4 (1 - X_{ea,t}^e) \lambda_{rw,t}^e + \alpha_5 (1 - X_{ea,t}^e) \lambda_{rw,t}^e \frac{Y_t^e}{Y_{ea}^e} \\ + \alpha_6 \cdot Heuro_t^e + \alpha_7 pip(euro - dollar)_t^e + \alpha_8 EuroMember + \mu_t$$

The results are shown in Table 5. Columns 1 and 2 show that a country's exports to the euro area and its size relative to the euro area explain about one third of the use of the euro in invoicing. The coefficients are significantly smaller than in the dollar regressions, so that an increase in the orientation of exports towards the euro area elicits a smaller increase in euro use than was the case for dollar use and exports to the United States. The sign on the homogeneous goods share (column 3-5) is negative and consistently significant, showing that a high share of homogeneous goods in a country's exports is associated with a low use of euros in invoicing exports. The independent explanatory power of this term is significant, at 18 percent of sample variability. As was the case for the dollar, hedging and transaction cost variables do not contribute explanatory power to euro use in invoicing (columns 6-7). Taken together, these variables explain 50 percent of the cross-country use of euros (columns 8-9), with a stronger fit when we focus on recent years (since 1999, column 10).

Controls for whether the exporting country is a member of the European Union are introduced in columns (11) and (12), with this status changing for some countries over the observation period. Specifications with this added control explain three quarters of the euro use in invoicing international trade. The resulting coefficients associated with export shares and country size have the interpretation that invoicing in euros rises one to one with the euro area as a destination market, but less so for countries that are large relative to the euro area, with euro use basically negated for countries as large as the United States. Invoicing in euros declines substantially when homogeneous goods are involved in trade transactions.

Evidence for the five hypotheses. Overall, our econometric analysis provides perspective on the strength of the five hypotheses outlined at the end of section 3 for the cases of the dollar and the euro. We find evidence that homogenous goods are more likely to be

²⁷ Note we allow for the fact that some countries had their status as members change over the time frame we are examining. See <http://europa.eu/scadplus/leg/en/lvb/l25070.htm>

invoiced in a vehicle currency, which in this case is the dollar (Hypothesis 1); that country size matters with exports from relatively small to relatively large countries more likely to be invoiced in the destination currency (Hypothesis 2) and less likely to be invoiced in the exporter's currency (Hypothesis 3). Hedging considerations played only a marginal role (Hypothesis 4), as did transaction costs (Hypothesis 5).

5. Concluding Remarks

Our theoretical analysis combines alternative motives that influence the use of specific currencies in invoicing the trade transactions of countries. We collect and analyze cross-country information on the use of different currencies in such activities, and examine alternative hypotheses in the context of this data, applying the Rauch (1999) indices to trade data. Our analysis shows that the dollar is strongly used on most trade transactions with the United States, especially for smaller countries, and on other transactions that are primarily in goods that are traded on organized exchanges or reference priced. This role of the dollar as a transaction currency in international trade has elements of industry coalescing around a single currency. We find little evidence that the dollar, in recent years, has been used in invoicing trade for the purpose of hedging covariances among macroeconomic fundamentals or that it has been influenced by changing transaction costs in foreign exchange markets. The use of the euro as an invoicing currency is explained primarily by trade closeness with the euro area, or direct participation in the euro area. The use of euros in this trade invoicing is smaller among the countries with more market share relative to total euro area imports and are heavier exporters of homogeneous goods.

Industries with highly substitutable goods have a strong incentive to coalesce in their choice of invoicing currency. The U.S. dollar is important in the invoicing of world trade both because the United States is an important consumer and producer in world markets, because of exchange rate regime considerations where various countries peg their currencies to the dollar, and because relatively homogeneous goods still are an important part of international trade transactions. These forces support a continuation of this role unless such conditions were to be greatly changed. The strength of the euro area as a destination market for trade, and proximity to the euro area, explain most of the invoicing use of euros through the present time.

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Table 1: U.S. Dollar Use in the Export and Import Invoicing of 24 Countries

	Invoicing Observation ^b	US \$ Share in Export Invoicing	US \$ Share in Import Invoicing	Exporter Currency Share in Export Invoicing	Exporter Currency Share in Import Invoicing
United States	2003	99.8	92.8	99.8	92.8
<i>Asia</i>					
Japan	2001	52.4	70.7	36.1	23.5
Korea	2001	84.9	82.2	--	--
Malaysia	1996	66.0	66.0	17.8	17.8
Thailand	1996	83.9	83.9	1.0	1.0
Australia	2002	67.9	50.1	27.6	30.6
<i>European Union</i>					
Belgium ^a	2002	31.9	33.5	54.2	54.2
France ^a	2002	34.2	43.2	55.8	48.6
Germany ^a	2002	32.3	37.9	45.9	45.5
Greece ^a	2002	71.0	62.0	24.1	30.7
Italy	2002	20.5	30.8	70.6	64.1
Luxembourg ^a	2002	35.7	38.0	49.1	37.4
Portugal ^a	2002	33.4	34.5	48.1	57.8
Spain ^a	2002	32.8	39.5	58.1	54.7
United Kingdom	2002	26.0	37.0	51.0	33.0
<i>EU-Accession</i>					
Bulgaria	2002	44.5	37.1	--	--
Cyprus	2002	44.7	34.9	--	--
Czech	2002	14.7	19.5	10.2	8.7
Estonia	2003	8.5	22.0	--	--
Hungary	2002	12.2	18.5	--	--
Latvia	2002	36.2	29.8	6.6	6.6
Poland	2002	29.9	28.6	--	--
Slovakia	2002	11.6	21.2	--	--
Slovenia	2002	9.6	13.3	--	--

^aInvoicing data refer only to the invoicing of “extra euro-area” trade.

^bLatest Observations are annual except for: Japan – January 2001, Germany & Germany^a – 2002Q3, Estonia – Jan-Aug 2003. United States data are for 2003Q1. Malaysia and Thailand figures are for overall trade and are not broken down by exports or imports.

Table 2: Exporter's Currency Use in Invoicing, by Type of Good Exported

Country	Invoicing Observation	Differentiated (N)	Reference priced (R)	Organized exchange (W)
Australia	2002	53.0	16.7	22.4
Japan	1999	35.7	31.0	not available
United Kingdom	2002	56.9	39.7	46.1
United States	2002	97.1	98.7	not available

Table 3: Share of Organized Exchange and Reference Priced Goods in Country Exports and Imports

	Date	Share in Export Transactions		Share in Import Transactions	
		All exports	Non-U.S.	All imports	Non-U.S.
<i>United States</i>	2002	22.7	22.7	24.3	22.7
<i>Asia</i>					
Japan	2001	15.2	12.9	46.0	39.7
Korea	2001	21.1	19.1	49.8	44.9
Malaysia	1996	27.7	26.5	27.5	25.0
Thailand	1996	34.7	30.8	35.5	32.5
<i>Australia</i>	2002	70.8	66.3	22.8	20.5
<i>Euro-Area</i>					
Belgium ^a	2002	39.5	31.4	47.1	40.2
France ^a	2002	23.4	19.9	39.7	36.9
Germany ^a	2002	18.0	15.8	29.8	27.9
Italy					
Greece ^a	2002	41.9	38.7	43.8	42.8
Luxembourg ^a	2002	28.7	24.9	19.4	16.4
Portugal ^a	2002	22.5	18.6	53.2	50.6
Spain ^a	2002	24.1	21.5	46.7	44.0
<i>United Kingdom</i>	2002	25.6	21.9	25.0	23.4
<i>EU-Accession</i>					
Bulgaria	2001	39.7	38.2	26.8	26.1
Cyprus	2002	41.2	40.4	26.8	24.3
Czech	2002	20.2	18.7	32.1	31.5
Estonia	2003	27.6	26.8	29.9	29.5
Hungary	2002	16.4	15.9	23.1	22.7
Latvia	2002	37.3	34.7	31.5	31.2
Poland	2002	24.9	24.3	32.0	31.5
Slovakia	2002	27.2	27.0	32.9	32.7
Slovenia	2002	20.3	19.8	31.4	30.8

Table 4: Dollar Share in Export Invoicing: B_s^e

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
X_{US}^e	1.70 (0.16) ***	2.20 (0.17) ***						2.40 (0.15) ***	2.38 (0.15) ***	3.31 (0.26) ***	0.62 (0.16) ***	0.82 (0.17) ***	1.00 (0.27) ***	1.20 (0.34) ***
$X_{US}^e * \frac{Y^e}{Y^{US}}$		-2.56 (0.44) ***						-1.78 (0.4) ***	-1.72 (0.4) ***	-3.32 (0.56) ***	0.19 (0.36)	0.32 (0.33)	0.34 (0.53)	0.06 (0.6)
λ_{rw}^e			0.36 (0.16) **					0.79 (0.11) ***	0.79 (0.11) ***	0.61 (0.09) ***		0.31 (0.09) ***		0.09 (0.09)
$(1 - X_{US}^e) * \lambda_{rw}^e$				0.12 (0.16)										
$(1 - X_{US}^e) * \lambda_{rw}^e * \frac{Y^e}{Y^{US}}$					-2.49 (1.16) **									
$pip(euro - dollar)^e$						0.04 (0.08)				-0.01 (0.04)			-0.03 (0.03)	-0.03 (0.03)
$H\$\e							0.17 (0.1) *		0.09 (0.06)	< 0.01 (0.06)				-0.01 (0.04)
<i>Dollar bloc</i>											0.43 (0.03) ***	0.40 (0.03) ***	0.44 (0.04) ***	0.40 (0.05) ***
<i>constant</i>	0.25 ***	0.23 ***	0.37 ***	0.43 ***	0.50 ***	0.42 ***	0.47 ***	-0.03	-0.03	-0.03	0.27 ***	0.16 ***	0.18 ***	0.15 ***
<i># observations</i>	179	178	178	174	173	68	190	173	173	68	178	173	68	68
<i>Adj.R²</i>	0.39	0.49	0.02	0.00	0.02	-0.01	0.01	0.62	0.62	0.79	0.76	0.80	0.89	0.89

*, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. Standard errors in parentheses.

Hedging dummy variable equal to 1 if the country has dollar preferences significant at the 15% level for all regions.

Dollar invoicing years: Australia 1997-2004, Belgium¹ 2002-2006, Bulgaria 1998-2005, Cyprus 2002-2004, Czech Republic 1999-2004, Estonia 2003-2004, France² 1988-2006, Germany 2002-2004, Greece¹ 2001-2006, Hungary 1992-2004, Italy³ 1999-2006, Japan⁴ 1992-2003, Rep. of Korea 1976-2005, Latvia 1995-2004, Luxembourg¹ 2002-2006, Malaysia 1995; 1996; 2000, Poland 1994-2004, Portugal¹ 2000-2006, Slovakia 1999-2003, Slovenia 2000-2004, Spain¹ 1998-2006, Thailand 1993-2003, United Kingdom 1999-2002. Total 183.

1/ 2005 missing for both euro and dollar invoicing; 2/ 2004 and 2005 missing for both euro and dollar invoicing; 3/ 2005 missing for euro invoicing, 2004 and 2005 missing for dollar invoicing ; 4/ 1999 missing for both euro and dollar invoicing

Table 5: Euro Share in Export Invoicing: B_{euro}^e

	1	2	3	4	5	6	7	8	9	10	11	12
X_{EA}^e	0.41 (0.06) ***	0.46 (0.06) ***						0.40 (0.05) ***	0.38 (0.06) ***	0.91 (0.06) ***	0.59 (0.05) ***	0.88 (0.06) ***
$X_{EA}^e * \frac{Y^e}{Y^{EA}}$		-2.85 (0.67) ***						-3.55 (0.61) ***	-3.88 (0.68) ***	-2.52 (0.49) ***	-4.07 (0.50) ***	-2.79 (0.50) ***
λ_{rw}^e			-0.86 (0.17) ***					-0.81 (0.14) ***	-0.80 (0.14) ***	-0.24 (0.10) **	-0.54 (0.11) ***	-0.25 (0.10) **
$(1 - X_{EA}^e) * \lambda_{rw}^e$				-0.97 (0.13) ***								
$(1 - X_{EA}^e) * \lambda_{rw}^e * \frac{Y^e}{Y^{EA}}$					-5.26 (1.26) ***							
$pip(euro - dollar)^e$						0.12 (0.10)				>-0.01 (0.03)		-0.01 (0.03)
$Heuro^e$							0.12 (0.08)		0.08 (0.07)	0.03 (0.05)	0.02 (0.05)	0.03 (0.04)
$EU\ member$											0.28 (0.03) ***	0.06 (0.03) *
$constant$	0.33 ***	0.34 ***	0.70 ***	0.65 ***	0.53 ***	0.04 ***	0.45 ***	0.59 ***	0.59 ***	0.10 *	0.32 ***	0.10 **
$\#\ observations$	128	127	122	122	121	69	135	121	121	68	121	68
$Adj.R^2$	0.26	0.35	0.18	0.30	0.12	-0.01	0.01	0.50	0.50	0.88	0.72	0.89

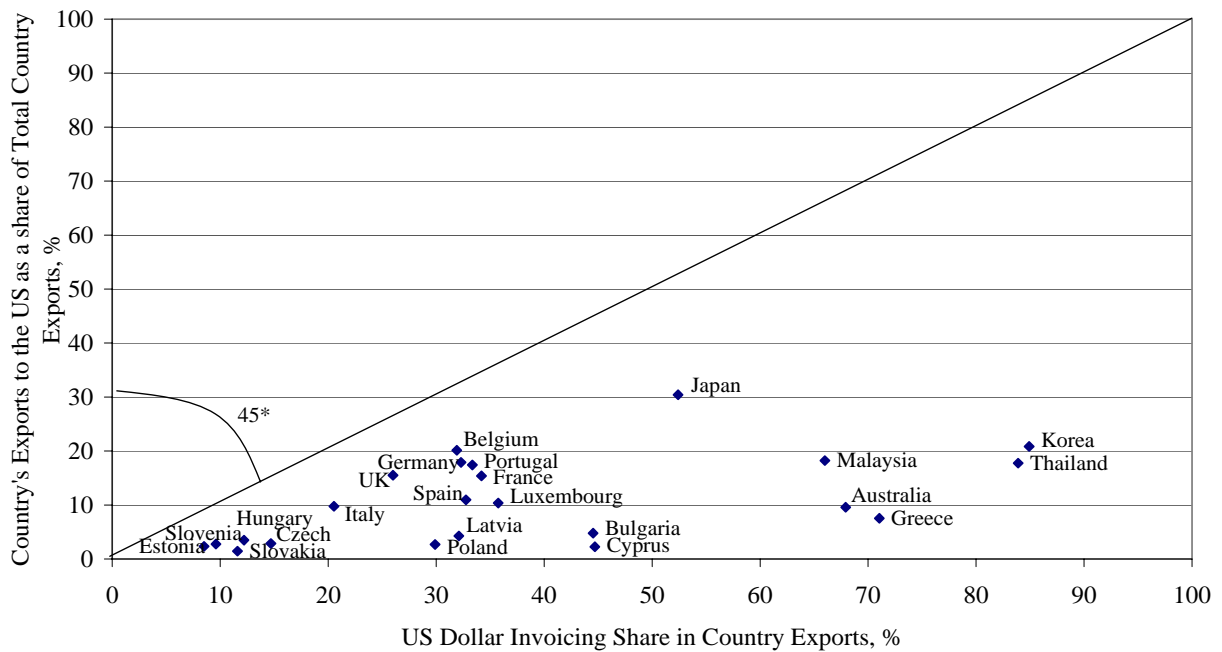
*, **, and *** indicate significance at the 10%, 5%, and 1% level respectively. Standard errors in parentheses. Hedging dummy variable equal to 1 if the country has dollar preferences significant at the 15% level for all regions. Dollar invoicing years: Australia 1999-2004, Belgium¹ 2000-2006, Bulgaria 1999-2005, Cyprus 2002-2005, Czech Republic 1999-2005, Estonia 2001-2005, France² 1999-2006, Germany 2002-2004, Greece¹ 2001-2006, Hungary 1999-2004, Italy³ 1999-2006, Japan⁴ 2000-2003, Rep. of Korea 1999-2005, Latvia 1995-2005, Luxembourg¹ 2000-2006, Poland 1999-2005, Portugal¹ 2000-2006, Slovakia 1999-2003, Slovenia 2000-2005, Spain¹ 1999-2006, Thailand 1999-2005, United Kingdom 1999-2002.

1/ 2005 missing for both euro and dollar invoicing; 2/ 2004 and 2005 missing for both euro and dollar invoicing; 3/ 2005 missing for euro invoicing, 2004 and 2005 missing for dollar invoicing ; 4/ 1999 missing for both euro and dollar invoicing.

United Kingdom 1999-2002.

1/ 2005 missing for both euro and dollar invoicing; 2/ 2004 and 2005 missing for both euro and dollar invoicing; 3/ 2005 missing for euro invoicing, 2004 and 2005 missing for dollar invoicing ; 4/ 1999 missing for both euro and dollar invoicing.

Chart 1: Use of the U.S. Dollar in International Export Transactions



Source: DOTS and various national sources

Euro-area country data, with the exception of Italy data, refer to extra-euro area trade and invoicing

Chart 2: Use of the U.S. Dollar, U.S. Share in Exports, and Homogeneous Goods

