Currency Invoicing of U.S. Imports

Shabtai Donnenfeld and Alfred A. Haug
York University

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Abstract

This paper provides an explanation for the choice of currency of invoice of exports to the U.S. We find an empirical relationship between the riskiness of the exchange rate and the fraction of imports invoiced in the importer's currency, the exporter's currency, and a third country currency. The higher the volatility of the exchange rate, the larger is the fraction of imports invoiced in the importer's currency. Consequently, the fraction of invoicing in the exporter's or a third country currency is inversely related to the volatility of the exchange rate.

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Please send correspondence to:
Shabtai Donnenfeld
York University
Department of Economics
4700 Keele Street
Toronto, ONT M3J 1P3
Canada

Phone: (416) 736-2100 ext. 22407 Fax: (416) 736-5987
E-mail: donnenfd@yorku.ca

Alfred Haug
York University
Department of Economics
4700 Keele Street
Toronto, ONT M3J 1P3
Canada

Phone: (416) 736-2100 ext. 77030 Fax: (416) 736-5987
E-mail: haug@dept.econ.yorku.ca

1 Introduction

International transactions are affected by exchange rates fluctuations. The extent to which changes in the exchange rate are transmitted to import and export prices depends on the choice of currency of invoice that governs international trade, i.e., whether the prices are set in the exporters', the importers' or a third (vehicle) currency. The share of trade invoiced in national currencies or foreign currencies varies across countries and across time periods. For example, the share of exports and imports invoiced in the national currencies of several OECD countries during 1996 is as follows: for the U.S. 98% and 88%, for France 51.7% and 48.4%, for Germany 76.4% and 53.3%, for Italy 40% and 37%, for Japan 35.9% and 22.5%, and for the U.K 62% and 51.7%.[1] These aggregate numbers hide the diversity of invoicing patterns for any given country across its trading patterns.[2]

Recently more detailed data on U.S. imports invoiced in one of three possible currencies, the exporter's, the importer's or a third currency became available. These observations, reported in Table 1, lead us to the following question: Is there any plausible set of explanations that can shed light on the diversity of the patterns of currency invoicing of trade across countries and across industries within any country ?

One plausible reason was advanced by Donnenfeld and Zilcha (1991) who argue that the exporter's invoicing decision is influenced by the degree of exchange rate risk. Given that certain conditions hold, they show that an exporter will prefer to set the price of exports in the importer's national currency rather than its own currency when the exchange rates fluctuate. Johnson and Pick (1997) and Friberg (1998) extended Donnenfeld and Zilcha's analysis to incorporate the option of invoicing in a third currency or a vehicle currency. They established that under fluctuating exchange rates the exporter will prefer to set the price in the importer's currency rather than in a third (vehicle) currency.[3]

Before proceeding to a systematic theoretical and empirical analysis, we have a look at our data. In Figures 1 to 3 we plot the relationship between, on the one hand, the fraction of the value of U.S. imports invoiced in the importer's, the exporter's, or in a third currency, and, on the other hand, the riskiness of the bilateral U.S. dollar exchange rate for each of the sixteen

[1] See Tavlas (1997).

[2] For a more detailed account on the invoicing patterns of U.S. aggregate imports see Alterman (1992).

[3] Another plausible explanation for the choice of the currency of invoice was recently put forward by Devereux and Engel (2001). They argue that while two countries trade, exporters will set their prices in the currency of the country with the more stable monetary policy.

exporting countries listed in Table 1. To make the comparison of the invoicing practices across exporting countries to the U.S., we compute the standard deviation of the measure of exchange rate risk as defined in Section 4 for the currency of each of the sixteen countries. The scatter diagrams seem to reveal a possibly positive correlation between the fraction of U.S. imports invoiced in the domestic currency and exchange rate risk, whereas the fraction invoiced in the exporter's currency and exchange rate risk seems to be likely negatively correlated. It also appears that there is no obvious relationship between the fraction of U.S. imports invoiced in a third currency and exchange rate risk. A systematic empirical analysis should allows us to discern more precise relationships.

The methodology adopted in this paper is similar to Donnenfeld and Haug (2001) who investigated the invoicing patterns of Canadian imports. In that paper data limitations required to conduct the empirical tests for each industry separately rather than across all industries as we do in this paper. Furthermore, this investigation is more comprehensive since it encompasses a larger set of industries and it incorporates exchange rate pass-through.

The remainder of the paper is organized as follows: in section 2 we discuss the framework and present the testable hypotheses. In the following section, we present the empirical model of invoicing and the estimation methods and estimate the pass-through coefficients to be used. In section 4 we present the data and their sources. In section 5 we discuss the empirical results and in the final section we provide a summary.

2 The Theoretical Framework

A firm produces and sells its product in the domestic and foreign markets. Due to market segmentation the monopolist can set different prices across markets. Decisions are made based on the following sequence of events: First the firm selects output (or capacity). Then, upon arrival of new information, prices are set. The domestic price is always set in the firm's own currency. After the exchange rate is fully known, buyers place their orders and the goods are shipped. We examine the behavior of the firm under three pricing-cum-invoicing strategies of exports: first, when export prices are set in the buyer's (or equivalently, the importer's) currency; second, when export prices are set in the seller's/exporter's currency; third when export prices are set in a third (vehicle) currency. In all cases the firm precommits to a price at the time that the actual exchange rate is not known.

The basic set up outlined above is based on the presumption that forward markets are absent. This does not affect the main conclusions in any meaningful way since the exporting firm cannot avoid the effects of exchange rate uncertainty by hedging in forward currency markets. This stems from

the fact that when the price is set in the exporter's currency the quantity that will be sold in the foreign market depends on the uncertain exchange rate. This in turn implies that the exporter does not know in advance what amount of foreign currency should be hedged to avoid exchange rate risk. Furthermore, even if unbiased forward markets were available, the exporter would not engage in hedging activities since we assumed that he or she is risk neutral.

Invoicing in the Importer's Currency. Consider the case where the price of exports is set in the currency of the importer. The firm precommits to prices for both domestic and foreign sales. At this stage output has been already determined. The firm observes the signal α and chooses the price for exports in foreign currency, $p^*(\alpha)$, and the price for domestic sales in domestic currency $p(\alpha)$.[4] Since the foreign demand depends on the foreign price only, $q^*(\alpha) = h^*(p^*(\alpha))$, and since the domestic demand depends only on the domestic price, $q(\alpha) = h(p(\alpha))$, it follows that the precommitment to prices fully determines the quantities to be delivered regardless of the actual value of the exchange rate.

On the assumption that the firm is risk neutral, its objective is to choose output and the optimal pricing rules according to the program

$$\max_{\{Q,p(\alpha),p^*(\alpha)\}} E_e[p(\alpha)h(p(\alpha)) + ep^*(\alpha)h^*(p^*(\alpha)) - C(Q)] \tag{1}$$

subject to the constraint

$$h(p(\alpha)) + h^*(p^*(\alpha)) = Q. \tag{2}$$

where e is the exchange rate, units of the exporter's currency per unit of the importer's currency, Q is the total output, $C(Q)$ denotes the total cost of production incurred in the exporter's currency and E is the expectation operator over the random exchange rate. Since $R(Q-h^*(p^*(\alpha))) = p(\alpha)h(p(\alpha))$ and since $R^*(h^*(p^*(\alpha))) = p^*(\alpha)h^*(p^*(\alpha))$, we can rewrite the maximization problem as follows:

$$\max_{\{Q,p^*(\alpha)\}} E_e[R(Q - h^*(p^*(\alpha))) + eR^*(h^*(p^*(\alpha))) - C(Q)]. \tag{3}$$

The maximization problem stated in (3) yields the following necessary and sufficient conditions for optimality:

$$E[R'(Q_0 - h^*(p^*(\alpha))) - C'(Q_0)] = 0 \tag{4}$$

[4]The signal is based on newly arrived information regarding the current account deficit or surplus, announcements about the interest rates or other information that may affect the expectations about the exchange rate.

$$R'(Q_0 - h^*(p^*(\alpha))) - (\alpha + \bar{\theta})R^{*\prime}(h^* p^*(\alpha)) = 0, \quad \forall\alpha. \tag{5}$$

The optimal solution to (4)–(5) is denoted by $[Q_0, p^*(\alpha)]$. By (4) the firm chooses the level of output Q_0 in a way that equates the marginal cost of production with the expected marginal revenue from domestic sales (which depend on the realization of α through the quantity to be exported). From (5) we see that for each realization of α, the firm selects the price of exports, $p^*(\alpha)$, in a manner that equates marginal revenue from domestic sales with expected marginal revenue from exports.

Invoicing in the Exporter's Currency. As in the previous section the firm first chooses its total output. In the subsequent stage, once the realization of α is known, the firm sets its export price $\hat{p}(\alpha)$, where now the price is quoted in the exporter's currency. In contrast to the previous case, the exporter does not know the actual quantity that will be demanded by the importers. This quantity is contingent upon the realization of the exchange rate $\tilde{\theta}$ that will determine the actual price in the importer's currency, i.e., $\hat{p}^*(\alpha)/(\alpha + \tilde{\theta})$.

The firm's optimization problem is

$$\max_{\{\hat{Q}, \hat{p}^*(\alpha)\}} E_e[R(Q - h^*(p^*(\alpha)/(\alpha + \theta)) + p^*(\alpha)h^*(p^*(\alpha)/(\alpha + \theta)) - C(Q)]. \tag{6}$$

Necessary and sufficient conditions of the problem stated above are

$$E_e[R'(Q - h(\hat{p}^*(\alpha)/(\alpha + \theta))) - C'(Q)] = 0 \tag{7}$$

$$\begin{aligned} &E_\theta[-h^{*\prime}(\hat{p}^*(\alpha)/(\alpha + \theta)R'(Q - h^*(\hat{p}^*(\alpha)/(\alpha + \theta))) \\ &+h(\hat{p}^*(\alpha)/(\alpha + \theta)) + \hat{p}^*(\alpha)/(\alpha + \theta)[h^{*\prime}(\hat{p}^*(\alpha)/(\alpha + \theta))] = 0 \quad \forall\alpha. \end{aligned} \tag{8}$$

We denote by $[\hat{Q}, \hat{p}^*(\alpha)]$ the solution to (7) and (8). It is noteworthy that this solution yields a level of total output and a pricing rule that differ from those obtained in (4) and (5). When the firm invoices exports in its own currency, as seen in (7) and (8), both total output and the allocation of sales across markets are affected by the distribution of $\tilde{\theta}$. In contrast, when the firm sets the price of exports in the importer's currency, the demand for exports is independent of the realization of θ. It does, however, depend on the expected value of θ. This result has significant implications for the impact of exchange rate volatility on pricing and the level of exports.

A Comparison of Pricing-cum-Invoicing Strategies. We highlight the conditions that lead to the dominance of one invoicing strategy over the other.

Proposition 1. *Invoicing exports in the importer's currency rather than in its own currency is more desirable if the foreign total revenue function* $R^*(h^*(p^*))$ *is concave in* p^*.

Proof: See Donnenfeld and Zilcha (1991).

The concavity of the foreign revenue function holds for a wide class of demand functions. Clearly it holds when $h^*(p^*)$ is concave or linear. It holds also if $h^*(p^*)$ is convex, but not too convex, so that the marginal revenue does not swing wildly as the price p^* varies. This condition is equivalent to the following requirement $-ph^{*\prime\prime}(p)/h^{*\prime}(p) \leq 2 \quad \forall p$.

The effects of changes in the riskiness of the exchange rate are stated in the proposition below.

Proposition 2. *Assume that the foreign marginal revenue* $R^{*\prime}(\cdot)$ *is linear. An increase in the exchange rate risk makes the choice of invoicing in the importer's currency more desirable than invoicing in the exporter's currency.*

Proof: See Donnenfeld and Zilcha (1991).

The intuitive explanation for this result is as follows: When exports are invoiced in the exporter's currency, the seller's profit function is concave in the exchange rate. Consequently, as the exchange rate risk increases the expected value of profits declines, due to the concavity of the profit function. For the case when exports are invoiced in the importer's currency, the profit function is linear in the exchange rate. Hence, an increase in the exchange rate risk has no effect on the seller's expected profits.

We turn now to the case where the exporting firm is pricing its exports in a third currency, a vehicle currency. As before the price of exports is set before the realization of the exchange rate is known. Unlike the two previous cases, setting the export price in a vehicle currency entails risk in both quantities of exports and domestic sales.

Proposition 3. *Invoicing in a third (vehicle) currency is less desirable than invoicing in the importer's and the exporter's currency.*

Proof: This proposition follows from the proof presented by Johnson and Pick (1997).

Intuitively, invoicing foreign sales in a third currency leads to fluctuations in the foreign price. In addition, this also induces fluctuations in the domestic price since the quantity sold in the domestic market is the residual

of total output. Since, the profit function is concave in the foreign price, less fluctuations in foreign and domestic revenue is more desirable. Since the fluctuations are largest when exports are invoiced in a third currency, invoicing in either the importer's or the exporter's currency dominates the strategy of invoicing in a third currency.

Based on the theoretical approach developed by Donnenfeld and Zilcha and others we can derive specific predictions concerning the exporters choice of currency of invoicing, which can be subjected to empirical test. The theoretical model predicts that in a regime of exchange rate uncertainty exporters will prefer to set export prices in the importer's currency if the foreign revenue function is concave in the foreign price.[5]

In addition to the predictions coming out of Donnenfeld and Zilcha (1991), Johnson and Pick (1997) we shall also consider several alternative explanations for the choice of currency of invoice in international transactions based on some empirical regularities. Krugman (1984) argues that the currency chosen to execute transactions by agents (firms) located in different countries is determined by country-size differences; the currency of the larger country is the one that is usually used. This is because firms in small countries are more experienced and more sophisticated in dealing with foreign exchange than their counterparts in large countries. Acquiring sophistication involves hard to measure fixed cost and thus a large country exporter leaves the small country importer to worry about the exchange rate.

Tavlas (1991) stressed the importance of a country's share in world trade in affecting the likelihood of invoicing international transactions in its currency. The more important is a country in world trade the more likely it is that its currency will be chosen for invoicing international transactions with countries that have a smaller share in world trade.

We now state the following hypotheses that we shall test empirically:

Testable Hypotheses. *Under fluctuating exchange rates exports will be invoiced in the currency of importers rather than in the exporter's currency or in a third currency if (i) the total revenue function is concave in foreign prices (ii) the exporter's source country is smaller relative to the importer's country and (iii) the exporter's country share in world trade is smaller than the importer's country.*

Furthermore, (iv) the more volatile the exchange rate is, the larger is the frac-

[5]When exports are invoiced in the exporter's currency the revenue function is concave in foreign prices. When the export price is set in a third currency the revenue function is also concave in foreign prices. Thus an increase in exchange rate risk reduces the exporter's expected profits. On the other hand when the exporter sets foreign prices in the importer's currency the revenue function is linear in the exchange rate and an increase in the riskiness of the exchange rate has no effect on expected profits.

tion of exports invoiced in the importer's currency relative to the exporter's and the vehicle currency.

To implement the empirical test we need to make one adjustment to part (i) of the above hypotheses. Due to unavailability of data we cannot verify empirically the concavity of the exporter's revenue function in foreign prices. However, in a recent paper Friberg (1998) showed that for exchange rate pass-through to be incomplete it is sufficient that a demand elasticity condition, which implies concavity of the revenue function in price, holds. Based on this result we can use the exchange rate pass-through coefficient as a proxy for the unobservable concavity of the revenue function in foreign prices. Specifically, a low degree of exchange rate pass-through implies that the revenue function is concave in foreign prices. To implement the empirical test we posit that the lower is the degree of pass-through the more concave is the revenue function. This in turn implies a negative (positive) relationship between the likelihood of invoicing in the exporter's (importer's) and the pass-through coefficient.

3 The Empirical Model

We consider in the invoicing regressions the following dependent variables: the fraction of invoicing in the exporter's currency, in US dollars (importer's currency), and in a third country currency. The explanatory variables are: a measure of the exchange rate risk, the distance to the U.S.,[6] GNP of the exporter's country relative to U.S. GNP, the world trade share of the exporter's country relative to U.S. world trade share, and the exchange rate pass-through coefficients that are estimated by pass-through regressions. We turn to this task first.

[6]The delivery lags vary across countries within the same industry and also across industries. Magee (1974) investigated the length of the period of contract for exports from Japan and Germany to the U.S. and found that on average it takes 141 days from the time of the exporter's acceptance of orders to delivery of imports from Japan and 96 days for imports from Germany. The distribution of contract lengths was skewed to the right, with a maximum length of 22 months for imports from Japan and 10 months for imports from Germany. Carse, Williamson, and Wood (1980) looked at the overall average length of the period of contract of exports and imports of U.K. and found it to be six months for exports and four months for imports. This evidence suggests that the further away is the exporter's country of origin from the U.S. market the longer is the time of delivery and thus the higher is the exposure to exchange rate risk. We use distance as a proxy to capture this source of risk.

3.1 Estimation of Exchange Rate Pass-Through Coefficients

We estimate the extent to which exchange rate changes are passed through to import prices. For this purpose we consider each industry, and within each industry , each country separately. We therefore carry out for each industry, or rather commodity group, sixteen separate pass-through regressions.

We follow Feenstra (1989), among others, and use unit values for import prices due to a lack of availability of other price data. Because of the well known problems associated with unit values, we smooth each unit value series with a first order autoregressive process. The invoicing regression takes the following form:

$$\ln p_t = \alpha_0 + \alpha_1 \ln s_t + \alpha_2 \ln w_t^* + \alpha_3 \ln q_t + \alpha_4 \ln I_t + \varepsilon_t,$$

where $\ln p_t$ is the natural logarithm of the smoothed import price in U.S. dollars for a given commodity group in period t, s_t is the spot exchange rate, w_t^* is the wage index of the foreign source country, q_t is the U.S. price for competing commodities, and I_t represents U.S. expenditures on the given commodity (group). The term ε_t is a mean-zero white-noise error term. Because of possible endogeneity of q_t and I_t, we applied instrumental variable techniques. The instrumental variables used are lags on the endogenous variables, and also the U.S. wage index and U.S. consumer price index. Furthermore, we experimented with lags on s_t instead of current period s_t but this had no material effect on the results.

The coefficient α_1 of the spot exchange rate measures the extent of pass-through and will be used in the invoicing regressions. The other explanatory variables control for changes in the cost of production in the source country and for changes in demand for the given commodity. We employed the usual proxy variables found in the pass-through literature. Wages in the source country are the proxy for factor prices. Changes in wages are responsible for most of the changes in production costs. Demand conditions are captured by U.S. expenditures in each industry. U.S. import competing prices are included to account for changes of prices of substitutes.

The pass-through regressions involve variables that are possibly integrated of order one, denoted by I(1), i.e., the variables have unit roots. Two or more of the variables included in the pass-though regression equation may also be cointegrated with each other.[7] Other variables in the pass-through regression may be integrated of order zero [I(0)], i.e., be covariance stationary. Sims, Stock, and Watson (1990) proved that least squares estimates are

[7]Estimating the pass-through equation in first differences, when cointegration is present, would lead to inconsistent estimates.

consistent when some variables are I(1) and possibly cointegrated.[8] However, the asymptotic distribution is in general not normal so that standard t- and F-tests cannot be applied when least squares are used. This is not a problem in our case because we are only interested in the coefficient estimates. Further, instrumental variable techniques can be applied in the standard fashion when cointegration is present, as Hsiao (1997) has proven. In this case, even Wald tests are asymptotically χ^2 distributed.

In section 5, we subject all data to augmented Dickey-Fuller unit root tests, choosing the lag augmentations with Akaike's information criterion (AIC). We find empirical support for unit roots in the spot exchange rates and, in addition, for cointegration of the spot exchange rate with one or more of the other included variables in the pass-through regressions.[9]

Cointegration methods allow to separate short run and long run effects of pass-through.[10] However, we are only concerned about the long run pass-through effect, i.e., the degree of pass-through after all adjustments have taken place. The reason for this is that we use pass-through as a proxy measure of concavity of the exporter's revenue function in foreign prices. In addition, if there is cointegration in the regression equation, and the exchange rate is part of this relationship, then the estimate of the coefficient is super-consistent (see Engle and Granger, 1987, and Stock, 1987). In this case, the estimate can be used in the invoicing regressions without the problems that are usually encountered with generated regressors.

3.2 Estimation of the Invoicing Model

There are different ways to measure exchange rate risk. We follow the approach of Hooper and Kohlhagen (1978) and use the percentage difference between the 90 day forward exchange rate and the ex-post spot exchange rate 3 months later. We experimented with two variants of this measure, the squared percentage difference and the absolute value of the percentage difference. It did not matter to our results which measure we used. The advantage of a measure of risk based on the spot and forward exchange rates is that it is based on market outcomes.[11] It does not require a model of how firms form expectations about exchange rate movements. The difference between ex-post spot and forward rates captures unexpected changes in exchange rates and a risk premium. A constant risk premium would not affect our results.

[8] See also Stock and Watson (1988), and Stock and West (1988). Feenstra (1989) used the same arguments for his pass-through regressions.

[9] We test for cointegration with the Engle and Granger (1987) test, using again AIC.

[10] See Gross and Schmitt (2000) for a study on cars imported into Switzerland.

[11] It is also consistent with the interpretation of excess returns on forward contracts as a measure of the innovation in exchange rates, as suggested by Froot and Frankel (1989).

Whether a time varying risk premium exists is controversial and it may be very small and negligible in magnitude.[12]

An alternative measure of exchange rate risk that has been used in the literature is that of volatility based on conditional variances, a GARCH processes. In general, there is empirical evidence of some form of GARCH effects in exchange rates but usually only with high frequency daily or intra-daily data and not with lower frequency monthly data, as discussed for example in Baillie and Bollerslev (1989). The time horizon relevant for our purposes is longer than a few days and 3 months seem a good approximation to the average delivery lags after a contract for exports is signed. The literature has also used a measure of volatility based on a moving average of standard deviations of past spot rates, however, such a measure is in general not consistent with rational expectations as proven by Pagan and Ullah (1988).

We include in our invoicing regressions a proxy to capture different delivery lags. The distance of the exporter's country of origin to the US is positively correlated with the delivery time. The longer the delivery time, the greater is the exposure to exchange rate risk. The distance is therefore an additional variable to capture exchange rate risk.

The size of a country in term of GNP relative to U.S. GNP may affect invoicing decisions. The same holds true for a country's share in world trade. We include these two variables in our regressions to test alternative hypotheses of invoicing advanced by Krugman (1984) and Tavlas (1991). The larger a country and the higher its share in world trade, the more likely it is that invoicing will be in its own currency.

We model the choice faced by an exporter as a multinomial logit model. We use a specification for the probability of invoicing in currency j based, for example, on the model in Greene (2000), Chapter 19.7, but add a time dimension to his pure cross-section model:[13]

$$Prob(Y_{imt} = j) = \frac{exp(\beta_j' \mathbf{x}_{imt})}{\Sigma_{k=0}^{2} exp(\beta_k' \mathbf{x}_{imt})}$$

The index $j = 0$ refers to invoicing in the exporter's currency, $j = 1$ to invoicing in the importer's currency, and $j = 2$ denotes invoicing in a third country currency. The index $i = 1, 2, \ldots, 16$ refers to the 16 countries considered and $m = 1, 2, \ldots, 43$ denotes the 43 industries. The index $t = 1, 2, \ldots, 24$ refers to the time periods in our panel.

The model needs to be normalized. We assume for that purpose that

[12] See Baillie and Bollerslev (2000).

[13] Greene also discusses the issue of the independence of irrelevant alternatives which is not a problem in our application.

$\beta_0 = 0$ for $j = 0$, being the choice of the exporter's currency, so that:

$$Prob(Y_{imt} = j) = \frac{exp(\beta_j' \mathbf{x}_{imt})}{1 + \Sigma_{k=1}^{2} exp(\beta_k' \mathbf{x}_{imt})}$$

for $j = 1, 2$. The maximum likelihood model is formed from:

$$lnF_t = \Sigma_{k=1}^{43} \Sigma_{i=1}^{16} \Sigma_{j=1}^{2} d_{ijmt} ln[Prob(Y_{imt} = j)],$$

where d_{ijmt} is the proportion of imports from country i invoiced in currency j for industry m in period t. The vector $\mathbf{x}_{imt}$ contains the exchange rate risk for country i currency versus the US dollar at time t, the pass-through degree (elasticity) of imports in industry m from country i, the distance of country i from the U.S., the size of country i in terms of relative GNP, and the world trade share of country i. The world trade share and GNP share of the exporter is relative to that of the U.S. world trade and U.S. GNP, respectively. In the estimations, we account for unbalanced panels (see Hsiao, 1986).

The coefficient estimates β_j in the logit function do not have the usual interpretation. We calculate therefore the marginal effects of the $\mathbf{x}_i$ on the probabilities and report these in the tables. Our interest is not in the magnitude of the estimates but rather in the sign.

According to our Testable Hypotheses, we expect the probability of invoicing in the importer's currency (the U.S. dollar) relative to the exporter's currency, to be positively related to the riskiness of the exchange rate and to the distance of the exporter's country of origin from the U.S. We expect a negative relation between invoicing in the importer's currency and the pass-through elasticity. The exporter's country world trade share and its GNP, relative to the U.S. world share and GNP, respectively are both expected to be negatively (positively) related to the probability of invoicing in the importer's (exporter's) currency.

The probability of invoicing in a third country currency instead of in the importer's, relative to the exporter's currency, has different implications for the expected signs. According to the model of Johnson and Pick we expect that the probability of invoicing in a third country currency is negatively related to the exchange rate risk and distance. On the other hand, Krugman's and Tavlas' models predict that only size and world trade share should have a significant relation. The sign should be again negative based on our definition of the size and trade share variables. The pass-through elasticity is expected to be negatively related to invoicing in the third country currency.

4 Data Sources

We turn now to describe the data and their sources.

• Invoicing of U.S. imports: This monthly data is a record of the fraction of imports invoiced in U.S. dollars, in the currency of the exporter or in a third currency by country of origin at the 4-digit SIC level of classification. The Bureau of Labor Statistics (BLS), Division of International Prices, only recently started to gather data on invoicing of U.S. imports.[14] The choice of industries is limited by the data available from the BLS. Details on the industries are given in the appendix.

• U.S. import competing: This is a monthly index series of the domestic producers price index at the 3 or 4-digit SIC level of classification, obtained from the Bureau of Labor Statistics, Producer Price Index Series, 1999.

• Unit value of imports. This is a monthly data series by country of origin at the 4-digit SIC level of classification. The composition of the 4-digit product category may vary over time. The source is the U.S. Census Bureau, Foreign Trade Division.

• U.S. Expenditures: To construct this variable we combined total industry expenditure with total imports at the 4-digit SIC level. We obtained data on total industry shipments from the U.S. Census Bureau, 1999, and data on total imports from the U.S. Census Bureau, Foreign Trade Division.

The remaining data are from the International Financial Statistics (IFS) data base distributed by the IMF:

• Consumers price index - U.S.

• Forward exchange rates - all countries, foreign currency per U.S. dollar.

• GNP - all countries

• Spot exchange rates - all countries, foreign currency per U.S. dollar.

• Total trade -all countries.

• Wages in the manufacturing sector - U.S.

• Wage, labor cost, or earnings index - all countries, except for Australia, Belgium, Denmark, Germany, New Zealand, Norway, Singapore, Spain, and Switzerland, where we used a wholesale, producer price, or related index instead, depending on the availability of data.

All data are available at a monthly frequency, except for GNP, which is only available at quarterly frequency. However, we were able to get monthly figures for the industrial production index from IFS. We used this index to construct from the quarterly GNP figures a monthly series. For this purpose, we assumed that monthly GNP percentage changes are the same as those of monthly industrial production. The data on capital city distances to Chicago (Illinois) are from Fitzpatrick and Modlin (1986).

The data used in the regressions cover the period from 1996:08 to 1998:07 and are monthly observations. This is the longest period for which we could obtain continuous data. Since not all currencies in our sample have forward foreign exchange markets, we restricted our analysis to the follow-

[14]We thank William Alterman from the BLS for providing this data.

ing countries: Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, and the UK.

We used the econometric package TSP 4.4 to carry out all tests and estimations. The maximum likelihood problem is solved with the ML procedure and reported t-statistics are based on standard errors computed from analytic second derivatives with the Newton method.

5 Empirical Results

First we carry out the estimation of the pass-through coefficients, before proceeding to the invoicing regressions. The variables involved in the pass-through regressions are likely to exhibit I(1) behavior, as found in past empirical studies. We test every time series for unit roots and find rather mixed results since no variable is uniformly I(0) or I(1) across countries and industries.[15] However, we find mostly evidence in favor of I(1), especially for the exchange rate. In addition, we tested for cointegration as outlined in section 3.1. We find empirical support in every pass-through regression for at least one cointegrating relationship that involves the exchange rate. This allows us to view the estimated pass-through coefficients as super-consistent.

For the pass-trough regressions, we apply instrumental variables estimation. A few of the estimates are unreasonably large and we therefore restrict our analysis to those countries and industries (commodities) where the pass-through coefficient takes on values between -1.26 and +1.26. This way we obtain 273 pass-through coefficient estimates, which represent elasticities.[16]

We now turn to our results for the invoicing regressions. We start with a general specification. Table 2 reports results for the model normalized on the exporter's currency, with the exchange rate risk, the pass-through elasticity, the GNP and trade shares, and the distance as explanatory variables. For the choice of invoicing in the importer's currency, relative to the exporter's currency, the exchange rate risk has the expected positive marginal effect and the pass-through elasticity has the expected negative marginal effect. Also, the second variable that captures exchange rate risk, distance, has the expected positive sign, whereas the GNP and trade shares have the wrong coefficient sign for the marginal effect on invoicing. The distance variable enters the regressions very significantly. The other variables have the correct sign but do not enter significantly. This is likely due to multi-collinearity among the included variables. It suggests to exclude some of the insignificant

[15] We tested also for two unit roots but rejected the hypothesis of two unit roots in all cases.

[16] The pass-through regression results are available upon request.

variables and to re-estimate the model.

In Table 2 we also present the results for invoicing in a third country currency, relative to the exporter's currency. The coefficient estimates have the predicted sign for all variables. The pass-through elasticity, the GNP share and the distance enter the regression significantly, whereas the exchange rate risk and the trade share are both insignificant. The GNP share is not very significant. These results do not provide much support for the theories of Krugman (1984) and Tavlas (1991). On the other hand, the results provide support to the Testable Hypotheses (i) and (iv) which are derived from the theoretical models of Donnenfeld and Zilcha (1991), Johnson and Pick (1997), and Friberg (1998).

We delete the insignificant trade share variable from our regressions and experiment with a specification that allows for interaction between the exchange rate risk and the distance. This new variable seems to capture risk better than either one when included separately in our regressions. We therefore use this specification and report results in Table 3. The GNP–share is no longer significant in this specification, whereas it was a borderline case before. The coefficient of the interaction variable for exchange rate risk and distance, and the pass-through elasticity have both the predicted sign for the marginal effect and both coefficients show significance.

We move next to a specification without the insignificant GNP–share variable and list results in Table 4. The risk interaction variable is highly significant and has the predicted relation to invoicing in the importer's and third country currency (relative to the exporter's currency). It has a positive relation to invoicing in the importer's currency and a negative relation to invoicing in the third country currency. The pass-through variable is significant too and also has the predicted influence on invoicing. It shows a negative relation to the probability of invoicing in the importer's currency and a positive relation to invoicing in the third country currency. The results reported in Table 4 provide strong support for the explanations of invoicing stated in the Testable Hypotheses (i) and (iv). The concavity of the exporter's revenue function in foreign prices, captured by the pass-through variable, and the exchange rate risk play an important role in explaining the invoicing pattern observed for U.S. imports. Krugman (1984) and Tavlas (1991) explanations are, however, not supported by our empirical evidence.

6 Conclusions

There is no general theory that explains in what currency the prices of exports and imports are set. Several empirical regularities are usually highlighted but

they are not derived from well established theoretical foundations. More recently, attempts were made to derive predictions about the choice of currency of invoice from acceptable theoretical foundations, although in a partial equilibrium framework. Despite their narrow focus, these models were capable to generate sharp predictions: under fluctuating exchange rates exporters will prefer to set export prices in the importer's national currency rather than the exporter's national currency.

This paper tested this prediction in conjunction with two somewhat ad hoc explanations. One is that the currency of important players in world trade is mostly used for invoicing. The other is that the relative size of the trading countries is an important factor.

We tested these hypotheses regarding the choice of the currency of invoice of U.S. imports and found that the share in world trade and the relative size of a country (in terms of GNP) do not have a significant effect on choosing the currency of invoice. On the other hand, the exchange rate risk and distance have a positive and significant impact on invoicing in the importer's currency, relative to the exporter's currency. Also, the exchange rate pass-through elasticity is negatively and significantly related to invoicing in the importer's currency, relative to the exporter's currency. The probability of invoicing in the third country currency, relative to the exporter's currency, shows a negative relation to exchange rate risk and a positive relation to the pass-through elasticity. Both relations are significant. These empirical results are consistent with the theoretical models recently advanced by Donnenfeld and Zilcha (1991), Johnson and Pick (1997), and Friberg (1998).

Appendix: List of SIC-4 industries:

0913 Shellfish
1011 Iron ores
1311 Natural gas hybrid
2035 Pickled fruit and vegetables
2311 Men's and boys' suits and coats
2321 Men's and boys' shirts
2323 Men's and boys' neck-ware
2331 Women's blouses
2385 Waterproof garment
2421 Lumber and other sawmill products
2621 Paper mill products
2731 Books and pamphlets
2791 Printing and typesetting
2833 Medicinal and botanical drugs
2861 Gum and wood chemicals
2999 Petroleum and coal products
3011 Tires and inner tubes
3143 Men's footwear, except athletic
3161 Luggage
3299 Non-metallic mineral products
3423 Hand and edge tools
3429 Hardware, nspf
3452 Bolts, nuts, screws
3491 Industrial valves
3511 Turbine and generator sets
3519 Internal combustion engines
3523 Farm machinery and equipment
3531 Construction machinery
3534 Elevators and moving stairways
3561 Pumps and pumping equipment
3577 Computer peripheral equipment
3612 Transformers and parts
3613 Switchgear and switchboard apparatus
3621 Motor and generator parts
3634 Electric housewares and fans
3639 Household appliances
3645 Residential electric lighting fixtures
3650 Household audio equipment
3651 Radio and TV receiving sets
3652 Pre-recorded records and tapes

3661 Telephone and telegraph apparatus
3663 Radio and TV communication equipment
3669 Other communication equipment
3674 Semiconductor and related devices, parts
3679 Electronic components
3695 Recording media
3714 Motor vehicles, parts and accessories
3715 Truck trailers
3724 Aircrafts engines
3861 Photographic equipment
3873 Watches, clocks
3911 Jewelry of precious metals
3944 Games, toys
3949 Sporting and athletic goods
3999 Manufactured articles, nspf

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	Exporter's Currency	Importer's Currency	Third Currency
Australia (1)	4.7	94.0	1.3
Austria (2)	22.6	77.3	0.1
Belgium (3)	13.3	85.9	0.8
Canada (5)	4.8	92.8	2.4
Denmark (7)	2.4	97.5	0.1
Germany (10)	41.2	58.8	0
Italy (12)	17.3	82.7	0
Japan (13)	1.4	85.3	13.7
Netherlands (15)	5.4	94.5	1.0
New Zealand (16)	0	100	0
Norway (17)	0	100	0
Singapore (19)	7.6	92.4	0
Spain (21)	28.0	62.2	9.8
Sweden (22)	28.0	68.6	0.9
Switzerland (23)	58.4	40.8	0.8
U.K (25)	17.2	82.8	0

Table 1. Currency of invoicing by a group of major exporters to the U.S. during 1996-1998. Source: U.S. Bureau of Labor Statistics, International Trade Division. The numbers in parentheses refer to the country codes used in the figures.

Table 2. The Multinomial Logit Model for Invoicing: Maximum Likelihood Results for the Model with all Variables

	Exchange Rate Risk	Pass-through Elasticity	GNP Share (Exporter's)	Trade share	Distance
Invoicing in exporter's currency	Normalized on				
Invoicing in importer's currency	**.01D-6** (.11)	**-.36D-5** (.04)	**.**79D-5 (4.09)	.16D-5 (.81)	**.00006 (6.50)**
Invoicing in third currency	**-.10D-7** (.03)	**.27D-5 (2.66)**	**-.60D-6 (1.30)**	**-.13D-5** (.88)	**-.000046 (2.22)**

Note: Absolute values of t-statistics are given in parentheses. Boldfaced coefficient estimates indicated that the sign is consistent with the theoretical predictions. Boldfaced t-statistics indicate significance at the 5% level when the sign is consistent with theory.

Table 3. The Multinomial Logit Model for Invoicing: Maximum Likelihood Results for the Model without Trade Shares

	Exchange Rate Risk*distance	Pass-through Elasticity	GNP Share (Exporter's)
Invoicing in exporter's currency	Normalized on		
Invoicing in importer's currency	**.014D-4 (1.26)**	**-.98D-5 (1.62)**	.000014 (.65)
Invoicing in third currency	**-.11D-4 (1.33)**	**.73D-5 (1.33)**	**-.000011** (1.20)

Note: See Table2.

Table 4. The Multinomial Logit Model for Invoicing: Maximum Likelihood Results for the Preferred Model

	Exchange Rate Risk*distance	Pass-through Elasticity
Invoicing in exporter's currency	Normalized on	
Invoicing in importer's currency	**.000048 (3.72)**	**-.000015 (1.78)**
Invoicing in third currency	**-.00038 (5.09)**	**.000011 (1.67)**

Note: See Table 2.