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Currency Invoicing in International Trade: A Panel Data Approach*

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Abstract

The paper empirically investigates the determinants of currency invoicing in Dutch goods trade with OECD countries. To this end, a currency-share systems approach is employed, which is applied to quarterly panel data for 1987–1998. One of the key findings is that a country's share of producer currency pricing falls if demand in the foreign export market falls. In addition, we find that the better developed the partner country's banking sector and the larger its share in world trade, the lower is the share of Dutch guilder invoicing. A higher expected rate of inflation in the partner country increases Dutch guilder invoicing. The depth of the foreign exchange market of a currency, a country's share in world trade, and a country being part of the European Union are key determinants of vehicle currency use.

JEL codes: F14, F31

Keywords: invoicing currency, Grassman's law, exchange rate risk, local currency pricing, producer currency pricing, vehicle currencies

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1 Introduction

The last decade has witnessed a resurgence of interest in analyzing invoicing currency use in international goods trade. Two developments drive this. In 1999, the euro was introduced in 11 European Union (EU) countries.[1] Consequently, from the side of policy makers, the question was raised as to whether the euro can take on the role of key international currency in goods trade. On a theoretical level, Obstfeld and Rogoff's (1995) paper ignited a new branch of literature,[2] which models firms' pricing decisions explicitly. Recent work by Betts and Devereux (2000) shows that Obstfeld and Rogoff's key finding—i.e., cross-country output correlations are negative following a monetary impulse—depends crucially on firms setting export prices in their home currency (known as producer currency pricing or PCP). If firms set export prices in the currency of the importing country (local currency pricing or LCP), however, a monetary impulse causes strong comovements of outputs across countries.

Our paper investigates the determinants of the choice of invoicing currency in Dutch goods trade. To this end, we carry out both descriptive and econometric analyses, employing data on quarterly Dutch trade payments (including currency use) during 1987–1998. The data used in the descriptive analysis cover industrialized countries and a broad range of developing countries. But in the econometric analysis, we restrict ourselves—reflecting the limited availability of quarterly data for developing countries—to OECD countries only. We calculate the share of each of three types of currencies (i.e., home, partner, and third), which allows us to estimate three equations with identical sets of explanatory variables (all pertaining to the partner country).[3] More specifically, we estimate a seemingly unrelated regression (SURE) model, featuring panel data in each equation, for exports and imports separately.[4] We take this approach because of cross-equation constraints on parameters—causing error terms across equations to be correlated—and nonspherical disturbances. This paper is the first to apply such a systems panel-data approach in the invoicing currency literature. Unlike

[1]The euro was introduced on January 1, 1999 in Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Greece joined on January 1, 2001, bringing the total to 12 euro-area countries.

[2]This literature is known as the "New Open Economy Macroeconomics" (NOEM), which employs dynamic general equilibrium models to analyze the macroeconomic effects of policy changes.

[3]Generally, we refer to the "old-style" nomenclature "home, partner, and third currency," where the home currency is the Dutch guilder. On the export side, the ordering of the currency types in the old-style nomenclature corresponds to the more recent one, that is, "PCP, LCP, and VCP," where VCP denotes vehicle currency pricing. But on the import side, the ordering of currency types does not match. Use of the home currency implies LCP by foreign exporters, whereas use of the partner currency gives rise to PCP by foreign exporters.

[4]Donnenfeld and Haug (2003) focus on the import side of the trade account and Wilander (2005) analyzes the export side of the trade account and thus cannot investigate the potentially differing effects of invoicing determinants on the trade account of the country under study.

multinomial logit models, which have been employed in micro-based invoicing studies (see below), our approach allows for a direct interpretation of the estimated parameters of the variables of interest.

There exists a mature theoretical literature on the determinants of currency choice.[5] The empirical literature remains relatively small, reflecting a lack of publicly available data. Most analyses are conducted at an aggregate level and are descriptive in nature, following the pioneering work of Grassman (1973, 1976).[6] Econometric work is still in its infancy. Donnenfeld and Haug's (2003) paper is the first to formally analyze the determinants of currency invoicing in goods trade. They employ Canadian import payments data (covering 16 countries) over the 1989–1994 period. Using both a multinomial and binomial logit analysis, Donnenfeld and Haug (2003) find that the probability of Canadian imports being invoiced in the Canadian dollar decreases, the bigger is the size of the trading partner's economy (as measured by its Gross National Product) and the less volatile is the currency of the trading partner. In addition, Wilander (2005) studies currency invoicing employing Swedish export data for nine industries and 69 countries for the 1999–2002 period. Besides these micro-based country studies, a number of authors—cf. Goldberg (2005), Goldberg and Tille (2005), and Kamps (2006)—study the choice of invoicing currency in a cross-country setting.

In addition to the new econometric approach, our macro-based analysis contributes to the literature in the following ways. First, we employ a unique data set for the Netherlands, which throws light on Dutch invoicing practices in goods trade.[7] The Netherlands is an interesting case study because it features a high degree of openness, being more open than Canada or Sweden (which are covered by the two other invoicing studies).[8] Furthermore, the Netherlands adopted the euro in 1999. Preceding the euro's introduction, the Netherlands informally pegged the Dutch guilder to the German mark. This regime of pegging has brought down inflation and exchange rate uncertainty, which are hypothesized to affect currency invoicing.

[5]Early formal contributions are those by Magee (1973), McKinnon (1979), Cornell (1980), Rao and Magee (1980), Giovannini (1988), Donnenfeld and Zilcha (1991), and Viaene and De Vries (1992). More recent work is that of Johnson and Pick (1997), Friberg (1998), Deverau, Engel, and Storgaard (2004), and Bacchetta and Van Wincoop (2005).

[6]See Magee (1974), Page (1977), Carse and Wood (1979), Carse, Williamson, and Wood (1979), Van Nieuwkerk (1979), Page (1981), Van der Toorn (1986), Melvin and Sultan (1990), Hartmann (1998), and Dominguez (1999).

[7]Our work builds on the unpublished report of Ligthart (1991), who employs a systems-panel data approach for the Netherlands to study the determinants of the choice of invoicing currency. Ligthart's work is extended by: (i) employing a larger panel data set (i.e., a higher data frequency, a longer time span, and a larger number of countries); and (ii) testing for a larger set of potential determinants.

[8]Openness is defined as the ratio of the sum of exports and imports to Gross Domestic Product (GDP). The average degree of openness of the Netherlands during our sample period is 102.3 percent compared with 65.2 percent and 60.8 percent for Canada and Sweden (Summers, Heston, and Aten, 2006).

A relatively low Dutch rate of inflation is likely to induce preferences for LCP by foreign firms exporting to the Netherlands. Consequently, in contrast to Grasmann's (1973, 1976) proposition, PCP is not necessarily dominant in trade between the Netherlands and other industrialized countries.

A second characteristic of our study is that it tests for a broad set of potential determinants. Besides more commonly used variables—such as a country's share in world trade, the strength of its currency, and foreign currency risk—we include variables describing the degree of development of a country's domestic financial market, the depth of a currency's foreign exchange market, a country's share of raw materials in goods trade, and whether or not a country is a member of the European Union (EU). In addition, we study the effect of demand conditions in the export market on an exporting firm's bargaining power in currency negotiations. The idea is that exporters facing an economic downturn in the export market abroad have less bargaining power. Because they are eager to protect their market share, exporters are more willing to meet the foreign importer's currency preferences. To our knowledge, no one has so far studied empirically the role of the business cycle in firms' invoicing decisions.

Last, but far from least, in contrast to most of the literature, we analyze the determinants of third currency use. Our innovative systems-panel data approach allows us to do so. Specifically, we are interested in knowing whether the set of determinants of third currency use is substantially different from the one affecting home and partner currencies. We show that the depth of the foreign exchange market of the partner country's currency increases third currency use in Dutch exports, whereas a greater world trade share of the partner country and the partner country's participation in the European Union reduce Dutch guilder invoicing. We further demonstrate that home and partner currency invoicing are affected by a larger set of determinants than third currency invoicing. Dutch guilder invoicing is negatively influenced by: (i) the degree of development of the partner country's banking sector; (ii) the share in world trade of the partner country; (iii) a fall in demand in the foreign market; and (iv) a depreciation of the Dutch guilder. A higher expected rate of inflation in the partner country, however, raises Dutch guilder invoicing. We finally show that foreign market power has (in absolute terms) a larger effect on Dutch guilder invoicing on the export side than on the import side, suggesting that Dutch importers (all else equal) have a better bargaining position than Dutch exporters.

The remainder of the paper is structured as follows. Section 2 provides the theoretical background and presents the main hypotheses to be tested. Section 3 describes the Dutch invoicing data. Section 4 sets out the empirical methodology and discusses the data used in the regression analysis. Section 5 presents the estimation results and carries out a robustness analysis. Section 6 concludes.

2 The Choice of Invoicing Currency

A trader selling goods abroad can invoice its merchandize in the home currency, the partner's currency or a third currency. Early theoretical contributions on invoicing—pioneered by Rao and Magee (1980)—stress the pure randomness of a trader's choice of invoicing currency. More recent work rebuts this "irrelevance result." Before turning to several empirical regularities and the hypothesis formation, we will first set out the economic relevance of the invoicing currency choice.

2.1 Economic Relevance of Invoicing

Understanding what determines the choice of invoicing currency is of importance both from a microeconomic and macroeconomic point of view. At the firm level, invoicing of goods exports in a foreign currency gives rise to profit uncertainty. Specifically, an unanticipated depreciation of the home currency—after trade contracts have been concluded—depresses a firm's profits whenever there is foreign currency invoicing. Here it assumed that the firm's inputs are priced in domestic currency and its foreign currency exposure is not hedged. On the other hand, invoicing goods exports in the home currency gives rise to demand uncertainty, implying that the exporter is faced with a trade-off between securing its profits per unit of output (when choosing LCP) and protecting its foreign demand at a given profit rate (when opting for PCP).

At the macroeconomic level, the currency composition of trade determines the initial trade-balance effect of an unanticipated exchange rate change. A key assumption underlying the so-called J-curve effect—describing a country's current account worsening immediately after a weakening of its currency—is that exports are predominantly invoiced in the home currency and imports in foreign currencies. Furthermore, the degree of exchange rate pass-through to import prices is determined by currency invoicing; theoretically, it is complete under PCP and zero under LCP.[9] A low degree of pass-through means that nominal exchange rate fluctuations may imply lower expenditure-switching effects of domestic monetary policy.

2.2 Empirical Regularities

Grassman (1973, 1976) is one of the first authors to examine informally currency invoicing employing Swedish trade data for 1968. He finds a "fundamental symmetry" in trade payments, showing a dominant role for the exporter's currency. Simply put, the currency of the domestic exporter is primarily used in Swedish exports and that of the foreign exporter is

[9]Exchange rate pass-through is defined as the extent to which the home currency price of imports rises in response to a one percent depreciation of the home currency.

dominant in Swedish imports. In the literature, this result has been dubbed "Grassman's law" (Stylized Fact 1). Magee (1973) explains this pattern by pointing to the larger bargaining power of exporters in contract negotiations, reflecting that countries are generally more specialized in their exports than in imports (see Section 2.3). Empirical research by Page (1977, 1981) for six Western European countries,[10] Carse, Williamson, and Wood (1979) for the United Kingdom, and Van Nieuwkerk (1979) for the Netherlands identifies a similar pattern. Ligthart's (1991) analysis, however, reveals that Grassman's law fails in Dutch trade using data for 1990; the Dutch guilder is the dominant currency on both the export and import side of the trade account.[11]

Stylized Fact 1 (Grassman's law) *Goods trade between industrialized countries is predominantly invoiced in the exporter's currency. The importer's currency ranks second in choice, whereas third currencies play only a marginal role in invoicing.*

Grassman (1973) and Page (1977, 1981) find that trade between industrialized countries and developing countries is predominantly invoiced in either the currency of the industrialized country or a third currency (Stylized Fact 2). The US dollar, the German mark, and recently the euro are often used as third currencies, which Magee and Rao (1980) define as "vehicle currencies." Hartmann's (1998) analysis reveals that the US dollar and the German mark are the main vehicle currencies used in EU trade before the introduction of the euro.[12]

Stylized Fact 2 *Trade between industrialized countries and developing countries is primarily invoiced in either the currency of an industrialized country or in a third currency.*

Empirical evidence by Grassman (1973) and Page (1981) shows that invoicing practices differ by type of product (Stylized Fact 3). McKinnon (1979) distinguishes between differentiated tradable products and homogeneous tradable products. On the one hand, traders of differentiated goods are matched through a costly search process typically conditioned on proximity and preexisting trade ties. Such products are predominantly invoiced in the exporter's currency. If products become more differentiated, exporters enjoy greater market power. Consequently, they can set prices and enforce payment in their home currency (cf. Viaene and De Vries, 1992; and Bacchetta and Van Wincoop, 2005). This market power lends

[10] Page (1977, 1981) studies Belgium, France, the Netherlands, Sweden, United Kingdom, and West Germany.

[11] Interestingly, Ligthart (1991) shows that Grassman's law fails for the Belgian-Luxembourg Exchange Union (BLEU) too, but for reasons different from the Dutch case. In case of the BLEU, the partner currency is dominant on both the import and export side.

[12] The German mark together with the national currencies of the countries that participate in the euro area are nowadays referred to as legacy currencies. Because the European legacy currencies feature prominently in our empirical analysis, we will occasionally refer to them in the hypothesis formation.

support to the assumption of PCP in NOEM models, in which the goods market is characterized by monopolistic competition. On the other hand, homogeneous commodities (such as gold, grain, oil, and sugar) traded on organized exchanges are generally invoiced in US dollars, buttressing the US dollar's vehicle currency role. Intuitively, New York and Chicago host the world's largest commodity exchanges for grains, livestock, and metals. Because it is easier to transmit price quotations in one currency than in many, pricing in a vehicle currency contributes to efficiency in the communication of price quotations. This being the case, whenever a country trades more of those commodities, it will reflect itself in increased use of third currencies.

Stylized Fact 3 (McKinnon, 1979) *Trade in homogeneous commodities is mainly invoiced in US dollars or other vehicle currencies. Differentiated goods are generally invoiced in the exporter's home currency.*

2.3 Hypotheses

Rao and Magee (1980) argue that the choice of invoicing currency does not matter as long as both traders have the same degree of risk aversion. Since there cannot be an equilibrium where each party uses its (preferred) home currency, a price adjustment (in the form of a premium accruing to the party bearing the exchange rate risk) occurs, making traders indifferent between the two currencies. Using invoicing data for 10 OECD countries, Rao and Magee (1980) demonstrate that the proportion of trade invoiced in the exporter's currency is not significantly different from 50 percent. Rao and Magee's study, however, is a notable exception to the invoicing literature; all other studies reject the irrelevance result.

At the macroeconomic level, Swoboda (1968), Page (1977, 1981), Melvin and Sultan (1990), and Ligthart (1991) informally argue that countries with a large share in world trade are better able to invoice in their home currency (Hypothesis 1). In a similar vein, Bacchetta and Van Wincoop (2005) show more formally—using both a partial and general equilibrium NOEM model—that the larger an exporting country's market share in a foreign industry, the more likely it is that its traders invoice in their home currency. Intuitively, a larger market share increases exporters' bargaining power in trade-contract negotiations. At the microeconomic level, building on the insights of Magee (1973), Viaene and De Vries (1992) note that exporting firms have more bargaining power than importing firms. Because for most goods there are many more importing firms than exporting firms, importers are hit harder once a trade deal is off. Consequently, exporters are better at securing PCP than importers are at enforcing LCP, particularly if the exporter is able to make the first offer.[13]

[13]In view of the above, it is likely that firm size will matter too in determining the invoicing currency choice.

Hypothesis 1b provides support of Stylized Fact 1.

Hypothesis 1 *(a) The larger a country's share in world trade, the greater is its currency share in trade invoicing; and (b) Exporters have more bargaining power in currency negotiations than importers.*

The Bilson-Magee hypothesis—coined as such by Magee and Rao (1980)—focuses on the effect of the *level of inflation* on a trader's payments or receipts in real terms. Traders are assumed to care about real magnitudes and cannot eliminate risk by contracting in their home currency. The hypothesis says that all traders (including importers) in high-inflation countries prefer to invoice in currencies (either third or partner) of low-inflation countries (Hypothesis 2a.i), partly providing an underpinning of Stylized Fact 2. Cornell (1980), in turn, analyzes the relationship between relative *inflation variability* and currency invoicing. If inflation variability differs across countries, then the currency of the country with the less variable inflation rate is preferred, reflecting the risk-averse exporter's (importer's) incentive to minimize the variance of its receipts (payments) in real terms (Hypothesis 2a.ii). If the inflation rates of two countries are moderately variable and approximately equal, however, indeterminacy results. Trade between two countries with highly variable inflation rates is likely to be invoiced in a third, more stable, currency. Because the height of inflation is in most cases (strongly) correlated with its variability, Bilson and Magee's result (in terms of invoicing effects) does not differ qualitatively from Cornell's (1980).

Importantly, the Bilson-Magee hypothesis and Cornell's (1980) proposition assume that purchasing power parity (PPP) holds, implying that a country with a relatively low rate of inflation has a strong (or an appreciating) currency. Conversely, a country with a rate of inflation exceeding that of its trading partner experiences a depreciating currency. If PPP fails, as is the case in the short run, the real exchange rate changes in response to inflation shocks. In this case, inflation and nominal exchange rate changes have differing qualitative and quantitative effects on invoicing and, therefore, need to be disentangled in the analysis.[14]

Various authors—Magee (1973), Magee and Rao (1980), and Devereux, Engel, and Storgaard (2004)—investigate the effects of nominal exchange rate changes on currency invoicing. Their work builds on the insight that international trade typically involves lags between the time the goods are ordered by the buyer (referred to as "importer") and the time at which the goods are delivered and paid by the importer, who will be exposed to risk of a changing

Large firms may have a greater capacity to absorb adverse exchange rate shocks, which gives them more bargaining power than small firms. Because our macroeconomic data set does not measure firm size, it will not be captured in the empirical model of Section 4.

[14]PPP fails in the short run, owing to factors including transactions costs in international trade, menu costs in price adjustment, and nontradable cost components. See Rogoff (1996) for a detailed analysis.

exchange rate during this so-called currency-contract period. Magee (1973) demonstrates that by invoicing in a currency that appreciates during the contract period, exporters enjoy a capital gain, whereas importers experience a capital loss. Consequently, exporters are inclined to invoice in the foreign currency and importers will prefer their home currency (Hypothesis 2b.i). In contrast, Magee and Rao (1980), argue that both traders prefer to invoice in strong currencies, which follows from the Bilson-Magee hypothesis. A number of studies focus on nominal exchange rate volatility. Devereux, Engel, and Storgaard (2004)—employing a partial equilibrium NOEM model, featuring a monopolistically competitive firm—find that exchange rate volatility increases the attractiveness of PCP (Hypothesis 2b.ii). Intuitively, under PCP the firm's profit function is convex in the exchange rate, whereas under LCP it is linear in the exchange rate. Then, a higher variance of the exchange rate increases expected profits under PCP relative to LCP. All this is summarized in Hypothesis 2.

Hypothesis 2 *Part (a) on the effects of the expected rate of inflation. Traders prefer to invoice in currencies of countries with: (i) a relatively low rate of inflation; and (ii) a relatively low rate of inflation variability. Part (b) on the effects of the nominal exchange rate. Exporters (importers) prefer to invoice in currencies that: (i) are expected to appreciate (depreciate); and (ii) are more (less) volatile.*

According to Swoboda (1968) and Magee and Rao (1980), currencies with deep (or "thick") markets are preferred for invoicing if investors are risk averse. Owing to traders' smallness relative to the size of the market the risk of capital loss in case of an adverse exchange rate shock is smaller than in a thin market (Hypothesis 3a). Of course, it is well known that currency exchange costs depend inversely on the size of the market. Transactions costs can explain why vehicle currencies are used in invoicing. For example, the US dollar is used as a vehicle currency if it is cheaper to exchange *indirectly* German marks into US dollar and US dollars into Dutch guilders than to go *directly* from German marks to Dutch guilders.[15]

A well-developed domestic banking market promotes invoicing of trade in the home currency (Baron, 1976). Banks can provide export-related services, such as financing of export credit, and give advice on the terms of the trade contract. In contrast, a broader and lower-priced package of currency-risk hedging instruments—which is typically offered in countries with a well-developed banking sector—may reduce firms' incentives to invoice in their home currency. Note that currency risk of short-term trade-contracts can generally be hedged on

[15]Krugman (1980) sharpens the transactions costs insight by demonstrating that the US dollar can still be a vehicle currency even if indirect exchange is more costly than direct exchange. The necessary conditions are that: (i) the US dollar has lower bilateral transactions costs than any other currency pair; and (ii) traders are offered a slightly better exchange rate on the indirect transaction.

the forward exchange market but less or no instruments are available for long-term periods. Both their costs and limited coverage makes hedging instruments imperfect substitutes for home currency invoicing (Hypothesis 3b).[16]

Hypothesis 3 *Countries are more likely to have more trade denominated in their home currencies if: (a) their currencies have deep foreign exchange markets; and (b) their banking systems are well developed.*

Ligthart (1991) and Viaene and De Vries (1992) argue that the business cycle may affect the trader's invoicing decision. A business cycle downturn in the foreign sales market weakens Dutch exporters' bargaining position because it becomes more difficult to sell their products in that market. Accordingly, Dutch exporters will be more willing to invoice in the currency of the foreign importer as part of their marketing strategy (Hypothesis 4). Similarly, Dutch importers have more bargaining power in currency negotiations if foreign exporters face a fall in demand for their products supplied to the Dutch market, increasing the share of contracts invoiced in Dutch guilders.

Hypothesis 4 *Exporters are more willing to invoice in the foreign importer's currency if they experience weak demand conditions in the destination market.*

Matsuyama, Kiyotaki, and Matsui (1993) show—using a random matching game of monetary exchanges—that a currency develops as an international medium of exchange as countries become more integrated economically. The high degree of economic integration of the European Union (it being a customs union, which faces a common extern tariff and no tariffs among member states) benefits invoicing in the union's currencies (Hypothesis 5). In addition, the institutional and macroeconomic changes that took place among the 12 euro-area countries during the run up to monetary integration may have been conducive to invoicing in euro-area currencies too.

Hypothesis 5 *Countries participating in an economic union—potentially also involving some form of (less than perfect) monetary integration—are more likely to invoice their trade in the currencies of the union.*

3 Descriptive Analysis

This section describes the invoicing data. Sections 4-5 analyze the determinants of invoicing currency choice in a more formal manner.

[16]The length of the currency-contract period may play a role in the invoicing decision too. We do not have data on the length of currency contracts, however.

3.1 Dutch Invoicing Data

The data we use in this study are based on reports of cross-border payments and receipts related to Dutch goods trade, which are collected by the Dutch Central Bank for balance of payments purposes.[17] The data (in aggregate format) identify for each month the value of exports or imports (in Dutch guilders), from which country the payment is received or to which country the payment is made, and in which currency the payment is settled. In contrast to micro-based studies, we neither have information on invoicing of individual transactions nor know the characteristics of the trading firms and types of products traded. This no doubt reflects the considerable confidentiality with which invoicing data are treated by central banks. We assume that the currency used for payment in any period is equal to the currency of invoicing, given that we cannot observe the latter. In practice, however, more than 90 percent of the cases the two coincide (San Paolo Bank and European Commission, 1990). We aggregate monthly data to obtain quarterly figures. The data—based on the IMF's *International Financial Statistics* (IFS) country classification—contain 163 countries during the 1987–1998 period.[18] Because we cannot correctly define the partner currency for euro-area trading partners of the Netherlands after the introduction of the euro, we choose the pre-1999 time period in our analysis.

A cursory inspection of the data reveals that the number of currencies used in Dutch trade with industrialized (developing) countries is larger (smaller) than the number of trading partners. In the 1996–1998 period, 11 euro-area countries employ on average 28 different currencies in their trade with the Netherlands. More generally, 22 industrialized countries invoice in 30 currencies. In contrast, 141 developing countries use merely 44 different currencies. At the world level, 163 Dutch trading partners—covering 99.3 percent of Dutch trade—invoice in 46 currencies, mistakenly suggesting a large role for third currencies. A more meaningful analysis, however, is based on currency shares, which take account of trade-weighted currency use. Given that our macroeconomic data set provides information on the countries, currencies, and trade values involved in Dutch bilateral trade, we are able to calculate the share of the home currency, the partner currency, and third currencies.

3.2 Invoicing Patterns

Third Currencies Table 1 shows countries' (average) trade and currency shares in Dutch goods trade ranked according to their trade share. In keeping with expectations, the distribution of trade by country is highly concentrated. Roughly 30 of 163 countries cover 95

[17] See Appendix A.1 for a more detailed data description.

[18] The econometric analysis of Section 5 will use a subset of industrialized countries for which quarterly data on the explanatory variables is available. The full data set includes 272 countries (see Appendix A.1).

percent of Dutch goods trade on the export side (Panel (a)) and import side (Panel (b)). Not more than nine countries generate approximately 80 percent of Dutch goods trade. A strong degree of regional integration is clearly visible. On the export side, seven of the nine countries are part of the European Union, whereas six EU countries can be identified on the import side. The distribution of foreign currencies use in Dutch trade also appears to be highly concentrated among a selected group of currencies. Roughly 4-5 currencies account for 90 percent of foreign currency use.

If all countries in Table 1 were to use their home currency and the Dutch guilder in equal proportions for all trade, then a country's home currency share would correspond to half its export share. Evidently, if the currency share of a country is more than half of its trade share, then that currency must have been used as a vehicle currency by third countries. The US dollar and German mark appear to have a substantial vehicle currency role in Dutch goods trade. Indeed, the US dollar is the only currency whose share of invoicing in Dutch exports exceeds by a factor three the United States' share in Dutch exports and by a factor two the United States' share in Dutch imports. The German mark is used as a vehicle currency to a lesser extent, but has a prominent role in EU trade. Such a vehicle role does not seem to hold for the pound sterling. In the past, however, the pound sterling was an important vehicle currency. Finally, countries listed on the right-hand side of Table 1 feature small trade shares and in many cases zero currency shares; they resort to third currencies or Dutch guilders in invoicing their trade.

Grassman's Law Figure 1 presents the invoicing of Dutch goods trade with industrialized countries for the 1987–1998 period. Generally, the three currency shares are rather stable over time, reflecting a substantial degree of hysteresis in invoicing practices. We can, however, observe a rising share of third currency use, which is more pronounced on the import side than on the export side. Can we find evidence to support Stylized Fact 1? For trade with industrialized countries, the share of the Dutch guilder on the export side is dominant throughout the entire period, which is in line with the empirical regularity that industrialized countries tend to have their exports primarily invoiced in their home currency. On the import side, however, the Dutch guilder share is the largest from 1990 onwards only, implying that Grassman's law fails for the 1990–1998 period. Early studies by Van Nieuwkerk (1979) and Van der Toorn (1986) find an invoicing pattern in keeping with Grassman's law, confirming our results for the pre-1990 period.[19]

[19]Van Nieuwkerk's (1979) findings are based on aggregate invoicing data for the 1970s. Because he does not distinguish between the three currency types, his evidence in favor of Grassman's law should be interpreted with care. Van der Toorn (1986), in turn, employs a survey of 72 Dutch firms (for the year 1983), which covers

The failure of Grassman's law for the post-1990 time span remains valid when we consider the currency composition of *total* Dutch trade. On the export side, on average, 44 percent of trade is paid in Dutch guilders, 36.2 percent in the partner currency, and 19.8 percent in third currencies. On the import side, the share of the Dutch guilder (40 percent) also exceeds the share of the partner currency (38.3 percent) but not by much. Similar results are obtained if the United States and the United Kingdom—whose currencies have (in case of the US dollar) or used to have (in case of the pound sterling) a key vehicle role and may therefore be over-represented—are eliminated from the data set. Foreshadowing the formal analysis in Section 5, possible explanations for the failure of Grassman's law in case of the Netherlands are: (i) its well-developed banking sector; (ii) its relatively large world trade share and high degree of integration with other EU countries; and (iii) its low rate of inflation.[20]

Cross-Country Invoicing Patterns The overall invoicing pattern hides substantial regional disparities (Table 2). First, Dutch trade with developing countries is primarily invoiced in third currencies or Dutch guilders, supporting Stylized Fact 2. Thus, home currency shares of developing countries (denoted as partner currencies in the table) are small or negligible, which is not surprising given that in many cases the foreign exchange markets of developing countries' currencies are thin. Interestingly, this pattern is also apparent for former Central and Eastern European countries that have accessed the European Union in May 2004; the Dutch guilder share for this country group is the highest of all country groups. Second, the invoicing patterns of Japan and the United States stand out. Japan, although an industrialized country, relies predominantly on third currencies (i.e., the US dollar) in its exports to the Netherlands. Dutch exports to Japan also feature an above average share of third currencies. Not surprisingly, the world's leading economy, the United States, mainly invoices in its own currency.[21] Last but not least, the US dollar share in Dutch trade with the Middle East is quite large, reflecting the export of oil, which is priced and paid in US dollars (thus supporting Stylized Fact 3). Dutch trade with the Middle East is small, however.

Figure 2 presents the currency composition of Dutch trade with nine of its most important trading partners, which are ranked by their economic size (as measured by nominal GDP per capita). It is shown that there is a positive correlation between the degree to which the partner currency is used in invoicing Dutch exports and the partner country's economic size. This pattern is also present on the import side but is less apparent. In light of results by Rey (2001) and Bacchetta and Van Wincoop (2005), we have reasons to doubt that it is economic

only a small fraction (4 percent) of Dutch trade.

[20] In 1998, in terms of openness, the Netherlands ranks fifth among the EU15 and, in terms of world trade share, it is listed as the number eight country in the world.

[21] Besides being a key invoicing currency, the US dollar is also the world's reserve currency.

size *per se* that matters; it is more likely that we are picking up the positive effect of GDP per capita on a country's world trade share. Indeed, GDP per capita is just one of many variables affecting world trade, which makes it less precise a measure of market power.

4 Empirical Model

This section sets out the empirical model used to analyze the determinants of invoicing, which is constructed based on the hypotheses discussed previously.

4.1 Model Specification

Our dependent variables are the invoicing-currency shares, that is, the proportion of exports from (imports into) the Netherlands invoiced in the three types of currencies. More formally, s^m_{kit} stands for the invoicing share of currency $k = \{H, P, V\}$ (where H, P, and V denote the home, partner, and third currency) of trade flow $m = \{E, I\}$ (where E denotes exports and I are imports) with trading partner $i = 1, ..., N$ in quarter $t = 1, ..., T$. Both exports and imports can be described by a system of equations, featuring a common set of explanatory variables. Because the general model structure is identical for each trade flow (although the parameters may differ, see below), we can drop the superscript m to arrive at:

$$\begin{aligned} s_{Hit} &= \alpha_{Hi} + \lambda_{Ht} + X'_{it}\beta_H + \mu_H D + \varepsilon_{Hit}, \\ s_{Pit} &= \alpha_{Pi} + \lambda_{Pt} + X'_{it}\beta_P + \mu_P D + \varepsilon_{Pit}, \\ s_{Vit} &= \alpha_{Vi} + \lambda_{Vt} + X'_{it}\beta_V + \mu_V D + \varepsilon_{Vit}, \end{aligned} \tag{1}$$

and the "adding-up" restriction on currency shares

$$\sum_k s_{kit} = 1, \qquad \forall \qquad i = 1, ..., N, \qquad t = 1, ..., T, \tag{2}$$

where α_{ki} is an intercept (which is potentially country specific), λ_{kt} is a time-fixed effect, β_k is a $L \times 1$ vector of slope coefficients, X'_{it} is the ith observation on L continuous explanatory variables, D is a dummy variable (with coefficient μ_k), and ε_{kit} is an independently and identically distributed error term. The adding-up restriction on the dependent variable (2) imposes conditions on the intercept and slope parameters to be estimated:

$$\sum_k \alpha_{ki} = 1, \qquad \forall \qquad i = 1, ..., N, \tag{3}$$

$$\sum_k \beta_{kl} = 0, \qquad \forall \qquad l = 1, ..., L, \tag{4}$$

where the latter follows from $\Delta s_H + \Delta s_P + \Delta s_V = \Delta X_l(\beta_{Hl} + \beta_{Pl} + \beta_{Vl}) = 0$ and a Δ represents an absolute change. In addition, the disturbances across equations sum to zero so that $\sum_k \varepsilon_{ki} = 0$.

Generally, our explanatory variables can be classified in three broad categories: macroeconomic, product type, and institutional. The first category consists of eight macroeconomic variables: the partner country's share in world trade (X_1, Hypothesis 1a), the strength of the trading partner's currency (i.e., inflation and inflation volatility (X_2 and X_3, Hypothesis 2a) and the change in the nominal exchange rate and nominal exchange rate volatility (X_4 and X_5, Hypothesis 2b)), the depth of the foreign exchange market of a currency (X_6, Hypothesis 3a), the degree of development of the banking sector of the partner country (X_7, Hypothesis 3b), and demand conditions in the export market (X_8, Hypothesis 4), which is represented by the unemployment rate in the partner country.

The second kind of explanatory variable describes the type of product traded, that is, the share of homogeneous products in trade (X_9, Stylized Fact 3). This variable also controls for the change in the composition of Dutch goods trade.

Last but not least, we introduce a dummy to account for the potential special invoicing treatment of currencies of the old EU member states (denoted by EU15), arising from the high degree of economic integration (and the associated greater familiarity of Dutch traders with these currencies, see Hypothesis 5). The EU dummy—which is one if the trading partner is a member of the EU15 and zero elsewhere—is also likely to pick up some distance effects; countries in an economic union are often physically located closely to one another. Based on the stylized facts and hypotheses of Section 2, we expect the signs of the coefficients set out in Table 3.

4.2 Measurement of Explanatory Variables

Because of data availability constraints with respect to the explanatory variables, not all trading partners of the Netherlands could be incorporated into the regression analysis. We restrict the econometric analysis to 30 OECD countries (the total of members inclusive of the Netherlands), for which quarterly data are more readily available than for developing countries. The data cover the 1987–1998 period so that $T = 48 > N$. The average share in total Dutch trade accounted for by OECD countries amounts to 91.4 percent, whereas the remaining 8.6 percent corresponds to 242 (primarily developing) countries and jurisdictions. Our panel data set is unbalanced in both the benchmark scenario and the alternative specifications.[22] The measurement of the explanatory variables is reviewed below. Appendix Table 1 sets out the data sources.

A country's share in world trade—defined as the sum of its exports and imports as share of world exports and imports—is used as a proxy for its economic power. Alternatively, GDP

[22] We have incomplete series on quarterly unemployment rates and banking sector development, yielding less observations than the maximum number. We should therefore write T_i instead of T.

per capita could have been employed—allowing us to test for a potential difference in effect size between GDP per capita and the world trade share—but quarterly GDP series for all countries concerned are not available for our sample period.

The strength of the partner country's currency is proxied by two variables: (i) expectations of inflation in the partner country; and (ii) the change in the nominal exchange rate of the Dutch guilder with respect to the partner's currency. We distinguish between the measures for two reasons. First, PPP fails in practice, implying that a positive inflation differential of the Netherlands with the partner country does not necessarily result in a proportional depreciation of the Dutch guilder.[23] Second, traders can hedge (if any instruments are available) against adverse exchange rate movements. On inflation expectations, we assume that agents' expectations at time $t-1$ about the inflation rate at time t are based solely on past observations. More specifically, it is an uncentered moving average (MA) process that uses the previous four quarters of observations on the rate of change of the consumer price index. To analyze the sensitivity of the inflation coefficient to alternative lag structures, we use lags of two years (8-period MA process) and four years (16-period MA process). In a similar fashion, we derive expectations about the (period-average) nominal exchange rate, which is the price of a foreign currency measured in terms of Dutch guilders. We construct a variable that captures the percentage change in the (period-average) exchange rate with respect to a 4-period MA process of the spot exchange rate. In addition, we study inflation rate volatility, which is captured by the coefficient of variation of the rate of inflation (i.e., the standard deviation of inflation divided by expected inflation) and nominal exchange rate volatility (also defined by the coefficient of variation).

We measure transactions costs related to the depth of the foreign exchange market of a currency using bid-ask spreads of spot exchange rates expressed as a percentage of the bid rate. Following Beck, Levine, and Loayza (2000), we define the development of the banking sector by the ratio of domestic private credit to GDP.[24]

The quarterly unemployment rate of the partner country is used to proxy demand conditions in the foreign export market relative to those in the Dutch market. A rise in the unemployment rate of the partner country signals that it is on the declining segment of its business cycle, featuring falling product demand.[25]

[23]Indeed, the correlation between expected inflation and the change in the exchange rate is less than -0.50 for all cases discussed below.

[24]Because of the unavailability of quarterly GDP data for some countries, we have used equally divided annual GDP data as a proxy.

[25]A high unemployment rate may also be induced by structural rigidities in a country's labor market (e.g., rigid wages), which may be associated with rigidities in other markets and institutions (e.g., slow customs clearance). The latter may also make it harder for firms to enter the foreign market.

Since our data set does not allow us to observe invoicing by type of product, we construct a raw materials variable, capturing the share of homogeneous commodities in Dutch trade with various countries.[26] We use both a narrow and a broad definition of raw materials. The *narrow definition* covers sections 3, 67–68, and 97 of the Standard International Trade Classification (SITC), whereas the *broad definition* includes sections 0–4, 67–68, and 97 (see Appendix A.1). The chosen SITC categories in the broad definition, which is used in the benchmark regression, closely correspond to those used by Carse and Wood (1979).

4.3 Econometric Issues

Before turning to the estimation results, we will briefly discuss various econometric issues that we encountered in selecting an appropriate model. Because the three currency shares for each type of trade flow (exports or imports) add up to unity—creating linear dependency between equations—each set of equations is likely to feature contemporaneous cross-equation error correlation. The Breusch-Pagan (1980) Lagrange multiplier test of independence of errors across equations indicates that on the export side, all three (different) combinations of two equations are dependent (Table 4). On the import side, two of three combinations of equations are related.

Disturbance correlations across equations does not necessarily require advanced estimation techniques. It is a well-known result that for unconstrained systems of equations featuring identical regressors, SURE estimation yields results identical (in terms of coefficients and standard errors) to an equation-by-equation ordinary least squares (OLS) estimation. If restrictions apply across equations then matters are less obvious. Gains in efficiency may be achieved by estimating the equations as a constrained SURE model, using Zellner's (1962) feasible Generalized Least Squares (GLS) technique.[27] In this context, there are $k+1$ equations—k regression equations and one adding-up restriction on dependent variables—and k dependent variables, yielding a singular equation system if it were estimated in this form. To address the singularity issue, the system can be estimated by deleting one of the regression equations, leaving $k-1$ linearly independent *regression* equations. As Barten (1969) shows, the parameter estimates of the constrained system are invariant to which equation is deleted as long as the residuals are spherical. Note that the parameters of the omitted equation are estimated indirectly by the other dependent variables and the *implied* adding-up restrictions (see (3)-(4)).

The left panel of Tables 5a-b provides the SURE results for the case of a restricted depen-

[26] The share of raw materials in Dutch trade is computed from annual data rather than quarterly data.

[27] The estimator is "feasible" because it uses an estimate of the variance-covariance matrix, which is obtained by using the OLS residuals. Asymptotically, the feasible GLS estimator is equivalent to the GLS estimator.

dent variable. We include time-fixed effects, in the form of 11 annual dummies, to capture any unobserved determinants common to all countries. Note that we also experimented with quarterly time dummies to pick up seasonal effects, but none of them turned out significant. SURE parameter estimates are shown to be equivalent to those from OLS applied to each equation separately, implying that OLS estimates are consistent. The standard errors of the systems approach are slightly smaller than those obtained by OLS; it does not change the set of significant variables, however. Interestingly, the implied parameter conditions (3)-(4) are automatically satisfied in the OLS model. This is an example of the *adding-up property*, which is mathematically proved by Worswick and Champernowne (1954–1955), but has not received much attention in the econometrics literature.

Using the equation-by-equation OLS residuals, we test for the presence of cross-panel heteroscedasticity and within-panel autocorrelation.[28] The results are presented at the bottom of the left panel of Tables 5a-b. The Breusch-Pagan (1979) heteroscedasticity test indicates that five of six equations suffer from heteroscedasticity; only column (g) of Table 5b has homoscedastic errors. In addition, the Wooldridge test—which checks for autocorrelation in panels—yields autocorrelation in equations (b) and (c) on the export side and in all equations on the import side, potentially reflecting hysteresis in invoicing practices.

To deal with nonspherical disturbances, we employ a generalized regression model and apply feasible GLS.[29] Although we have identical explanatory variables across equations, GLS on the system of equations is not equivalent to GLS on each equation separately. First, the estimated parameters (and standard errors) differ. Second, the adding-up constraints on the parameters (see (3)-(4)) are no longer automatically satisfied if equation-by-equation GLS is applied. Avery (1977) shows that if errors within and between equations are correlated, parameter estimates can be improved by joint GLS estimation of the equations. Therefore, we estimate a GLS model in a systems context. For this purpose, we have pooled the data and estimate a single equation in which we explicitly impose adding-up constraints on the cross-equation parameters. We correct for country-specific autocorrelation, using a first-order autoregressive (AR) process. In addition, we use White's procedure—taking into account the panel structure of the errors—to address heteroscedasticity in the panels. Appendix A.2 provides a description of the estimation procedure.

[28] In our analysis we make use of Stata 9.2. Stata's *sureg* procedure—which we employ to estimate our constrained SURE system—does not correct for heteroscedasticity and autocorrelation.

[29] We also estimated a random-effects (RE) GLS model, the results of which are not reported. On an equation-by-equation basis, the RE-GLS model is generally rejected, except for the third currency share.

5 Empirical Results

This section first discusses the benchmark specification before turning to alternative specifications, which analyze the sensitivity of our results.

5.1 Benchmark Model

The left panel of Tables 5a-b shows the constrained SURE estimation results—which apply constraint (2) without adjustments for autocorrelation and heteroscedasticity—whereas the right panel of Tables 5a-b reports the results of the constrained GLS systems approach (where implied constraints (3)-(4) are imposed). We note that the SURE results (in the left panel) yield a slightly different set of determinants than those in the right panel, but we will not discuss the former in detail given that this model is ill-specified. Annual dummies (i.e., $(T/4)-1 = 11$, where $T = 48$) are included in all regression equations but have been omitted from the tables. Because we have pooled the data to perform a systems estimation, we do not have equation-by-equation test statistics in the right panel. Furthermore, R^2 is not well defined in GLS regressions; purely for descriptive purposes we calculate a *pseudo* R^2, which equals the percent of variance in the invoicing shares explained by the predictors. Based on this measure, the fit is quite reasonable; it is slightly better on the import side than on the export side.

The partner country's share in world trade is significant in all equations at the 1 percent level, which verifies Hypothesis 1a. Foreign market power has (in absolute terms) a larger effect on Dutch guilder invoicing on the export side than on the import side, suggesting that Dutch importers (all else equal) have a better bargaining position in currency negotiations than Dutch exporters. A one percentage point rise in the world trade share of the partner country reduces Dutch guilder invoicing by 2.60 percentage points on the export side compared with a reduction of 2.05 percentage points on the import side. Hypothesis 1b is thus not supported, which is not surprising given the failure of Grassman's law. As expected, the share of third currency invoicing in both Dutch exports and imports falls by less than the Dutch guilder share if the partner country has more bargaining power in world trade.

On the export side, expected inflation is significant with the correct sign; it increases the share of Dutch guilder invoicing at the expense of the partner currency (see columns (d) and (e)). Expected inflation does not influence third currency invoicing. On the import side, expected inflation increases the share of imports invoiced in Dutch guilders, whereas it decreases third currency invoicing, but does not significantly affect the partner currency share. Expected inflation plays a larger role in determining the Dutch guilder share on the import side than on the export side; the inflation coefficients are 0.75 and 0.28, respectively. A depre-

ciation of the Dutch guilder (i.e., a rise in the nominal exchange rate) significantly depresses Dutch guilder invoicing in exports and imports, contradicting Hypothesis 2b.i. Rather, it seems to support Magee and Rao's (1980) thesis, saying that exporters and importers prefer to be invoiced in currencies that are expected to appreciate. It may very well be that we are picking up some valuation effects of exchange rate changes on the currency shares. We do not find support for invoicing currency shares being affected by inflation volatility. Similarly, exchange rate volatility is insignificant in all equations. Consequently, parts (a.ii) and (b.ii) of Hypothesis 2 are not verified.

The depth of the foreign exchange is not significant in the equations for both the Dutch guilder and partner currency share. Currencies of countries with a deep foreign exchange market do seem to play a vehicle currency role in Dutch exports, but not in Dutch imports. Hypothesis 3a is thus only partially supported. As for the second financial variable, a better developed banking sector in the partner country decreases Dutch guilder invoicing and increases partner currency invoicing in exports and imports. Consequently, Hypothesis 3b is fully supported. Quantitatively, banking sector development is the most important invoicing determinant.

The unemployment rate is significant in equations (d)-(e) and (j)-(l) and has the correct sign. Firms exporting to a foreign market characterized by a fall in demand pursue LCP as a way to promote sales. Hypothesis 4 is thus fully verified. The business cycle plays a bigger role on the import side than on the export side.[30] Somewhat surprisingly, an economic downturn abroad induces Dutch importers to invoice more often in third currencies. In keeping with our expectations, the unemployment rate does not affect third currency invoicing on the export side. It could very well be that the unemployment rate is also picking up some cross-country variation, reflecting structural rigidities in (labor) markets.

Stylized Fact 3 holds up only partially (i.e., on the import side). Contrary to expectations, Dutch exports of raw materials are primarily invoiced in Dutch guilders. A rise in exports of raw materials comes at the expense of partner currency invoicing. On the import side, raw materials negatively affect the Dutch guilder share and positively affect the share of the partner currency, which is in line with our expectations. The equation for third currencies features an incorrect sign for raw materials, however. It is likely that the apparent connection (at the aggregate level) between raw materials and third currency invoicing observed in descriptive studies is not so much a consequence of the characteristics of the commodities

[30] We have also experimented with the standardized unemployment rate of the OECD—giving rise to a larger number of observations because it has a wider country coverage than the IMF's unemployment rate—which yielded (in absolute value terms) a bigger estimated coefficient of the unemployment variable in the equation for the Dutch guilder share.

themselves, but more of the countries that export them. These countries may feature above EU-average inflation rates and less stable currencies. Of course, in a macro-based study it is hard to control for each specific commodity for which a special invoicing treatment may exist.

The EU dummy is significantly positive in equations (d)-(e) and (j)-(k), indicating that Dutch trade with EU countries is invoiced to a greater extent in EU currencies. Not surprisingly, the EU dummy is significantly negative in the equations for third currencies, supporting Hypothesis 5 and Grassman's claim on the marginal role of third currencies in EU trade (see Stylized Fact 1). The results for the EU dummy also seem to suggest that physical distance between countries—although not explicitly modeled—could matter too.

5.2 Alternative Specifications

Tables 6a-b present results of various robustness checks on the determinants of invoicing for exports and imports. To save on space, we only report the equations for the Dutch guilder share although the equation is estimated as part of a constrained system of equations, except for equations (b) and (h). The results below show that the qualitative results found in the benchmark model are fairly robust to changes in definitions.

Column (b) of Table 6a presents the single-equation (or unconstrained) GLS estimation results for the export side with a view to compare them with those for the constrained model (column (a)). Similarly, for the import side, columns (g) and (h) of Table 6b show results for the constrained and unconstrained specification. The unconstrained GLS model yields a set of determinants of invoicing roughly similar to that found in the constrained model, except for the change in the exchange rate. On the export side, a depreciation of the Dutch guilder is significant at the 1 percent level in the constrained GLS model, whereas it is insignificant in the unconstrained GLS model. The converse result is obtained for the import side. Qualitatively, the parameters of the set of significant variables common to both approaches do not differ. Quantitatively, however, the parameters do vary across specifications. For example, the effect of the unemployment rate on the export side is (in absolute terms) much smaller in the constrained model. On the import side, the opposite is the case.

The benchmark equation system includes 11 annual dummies (which are not reported) to capture trends common to all countries. Annual dummies are negatively significant (at least at the 5 percent level) during 1993–1997 on both the export and import side, suggesting that Dutch guilder invoicing is on a declining trend (see also the discussion in Section 3.2). Dropping the annual dummies (column (c)) affects the set of significant variables on the export side; inflation volatility becomes significant (with the correct sign) at the 10 percent level, whereas the EU dummy loses significance. It does not, however, affect the signs of the coefficients of the other variables that were found significant in the benchmark case, but only

changes their value. For example, on the export side, the coefficient of expected inflation drops in value by 0.075 percentage points. On the import side, the set of significant variables does not change. The size of the coefficient of expected inflation falls, whereas the unemployment effect is (in absolute terms) much smaller. Compared with a system including the annual dummies, the log-likelihood of the equations deteriorates, showing that common effects have to be controlled for.

We now study whether results are sensitive to alternative specifications of the lag structure on expected inflation and inflation volatility with a view to capture a more sluggish price adjustment in the goods market as compared to the financial sector. Specifically, we use an 8-period MA and a 16-period MA process of inflation (columns (d)-(e) of Table 6a and columns (j)-(k) of Table 6b) to model hysteresis in expectations formation. Compared with the benchmark, the 8-period MA process on the export side increases the coefficient on expected inflation by around 0.03 percentage points, whereas the coefficient on the unemployment rate rises (in absolute terms) by 0.30 percentage points. The raw materials variable loses significance and inflation volatility becomes significant at the 10 percent level, but features an incorrect sign. Allowing for more hysteresis in expectations formation does not change the results on the import side much. The 16-period MA process (column (k)) generates notable changes on the import side. Compared with the benchmark, it yields a larger coefficient for expected inflation. Furthermore, exchange rate volatility is significant with an incorrect positive sign, which Donnenfeld and Haug (2003) also find.

It is also of interest to investigate whether our results are robust to changes in the definition of raw materials. We saw that the broad definition of the share of raw materials in trade did not perform according to our expectations. Columns (f) and (l) show that the results for raw materials are even worse using the narrow definition. The estimated coefficient now has the wrong sign on both the import and export side. It does not affect the signs of the other variables that were found to be significant. Employing a narrow definition of raw materials, however, increases the size of the coefficient on expected inflation and reduces the importance of the partner country's banking sector development in exports and imports.

6 Conclusions

The paper studies the determinants of currency invoicing in goods trade, employing a unique panel data set on payment currencies used in Dutch trade. Both a detailed descriptive and an econometric analysis are conducted. The analysis throws light on regional invoicing practices as well as on the economic and institutional factors determining currency invoicing.

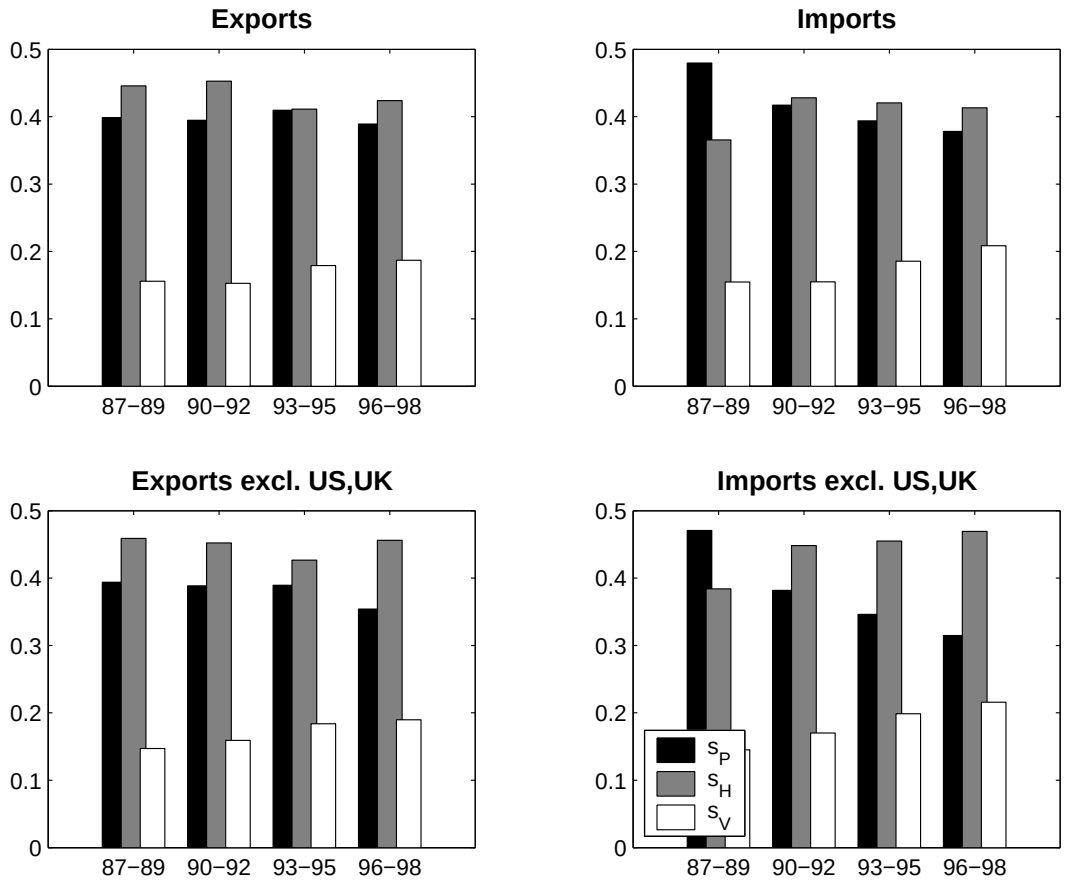
One of the key findings of the econometric analysis is that a country's share of producer

currency pricing falls if demand is weak in the foreign export market. We identified three other factors that negatively affect Dutch guilder invoicing, which (in order of importance) are: (i) the degree of development of the partner country's banking sector; (ii) the share in world trade of the partner country; and (iii) an expected depreciation of the Dutch guilder. A higher expected rate of inflation in the partner country, however, raises Dutch guilder invoicing. Expected inflation seems to matter more on the import side than on the export side, reflecting the low Dutch inflation rate. In contrast to expectations, the share of raw materials in Dutch goods exports induces more Dutch guilder invoicing, but its sign is as hypothesized on the import side. Another key finding is that third currency invoicing (on the export side) increases with the depth of the foreign exchange market of a currency, whereas it decreases with the world trade share of the partner country. Furthermore, a country being part of the European Union depresses third currency use. Generally, it is much harder to explain third currency use. Habit formation and network effects are likely to play an important role, which are both picked up by a country's world trade share.

The descriptive analysis shows that Grassman's law—describing an empirical pattern in which producing currency pricing is dominant—fails for the Netherlands during the post-1990 period, reflecting the prevalence of Dutch guilder invoicing on the import side. Based on the determinants found in the econometric analysis, the failure of Grassman's law in the Netherlands can be explained by the well-developed Dutch banking sector, the relatively large openness of the Dutch economy, and the relatively low rate of Dutch inflation.

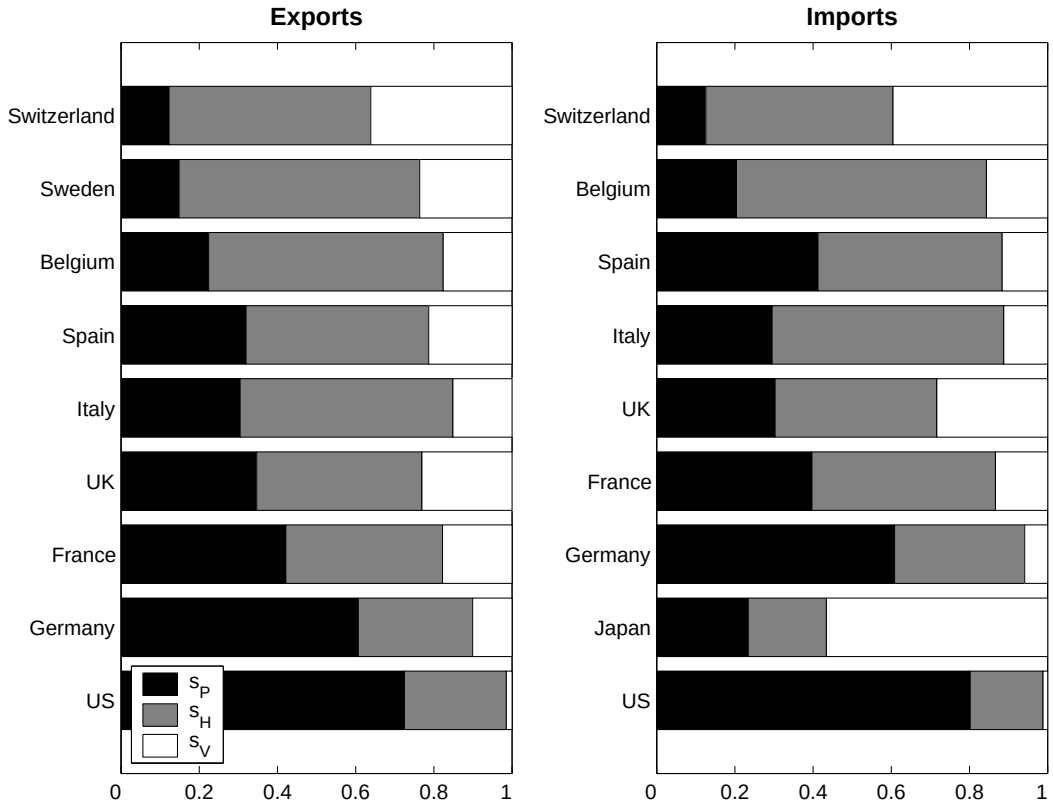
In future work, we intend to expand the set of countries covered by the analysis, particularly including developing countries. Because of constraints on the availability of quarterly data for developing countries, the data frequency needs to be reduced to an annual basis. The extended data set allows us to test for differences in invoicing practices between industrialized and less developed countries. Once data series on euro invoicing are of sufficient length, the analysis can also be applied to euro invoicing in the euro area.

Figure 1: Invoicing in Dutch Goods Trade with Industrialized Countries, 1987–1998



Notes: Currency shares are measured on the vertical axis, whereas time periods are reported on the horizontal axis. s_H, s_P, and s_V denote the currency shares of the home, partner, and third country. The data on industrialized countries cover 89.4 percent of Dutch total trade. The IMF's IFS classification is used to identify the set of industrialized countries. The bottom panel of the figure excludes Dutch trade with the United Kingdom and the United States.

Figure 2: Invoicing Shares Ranked by GDP per Capita, 1987–1998



Notes: s_H, s_P, and s_V (measured on the horizontal axis) denote the currency shares of the home, partner, and third country. Note that we have ranked countries (on the vertical axis) in increasing order of their GDP per capita. Because we focus on the nine most important trading partners of the Netherlands on the export side (left panel) and import side (right panel) separately, the country listing differs across panels.

Table 1: Trade and Currency Shares in Dutch Goods Trade, 1987–1998

Panel (a): Exports

Rank 1/	Country	Exports		Currency share 2/	Rank	Country	Exports		Currency share 2/
		Share	Cumulative share				Share	Cumulative share	
(1)	Germany	24.58	24.58	18.29	(17)	Portugal	0.65	89.12	0.06
(2)	United Kingdom	13.43	38.01	5.12	(18)	Hong Kong SAR	0.64	89.76	0.04
(3)	Belgium	11.82	49.84	2.81	(19)	Taiwan	0.61	90.37	0.00
(4)	France	9.83	59.66	4.42	(20)	Poland	0.52	90.89	0.00
(5)	United States	6.10	65.77	19.44	(21)	Turkey	0.46	91.35	0.00
(6)	Italy	5.60	71.36	1.78	(22)	Australia	0.41	91.77	0.14
(7)	Switzerland	3.97	75.34	0.53	(23)	Russian Federation	0.41	92.17	0.00
(8)	Spain	2.80	78.14	0.92	(24)	Canada	0.39	92.57	0.09
(9)	Sweden	2.68	80.82	0.42	(25)	Singapore	0.38	92.94	0.02
(10)	Denmark	1.54	82.37	0.28	(26)	Saudi-Arabia	0.38	93.32	0.03
(11)	Austria	1.33	83.70	0.27	(27)	Republic of Korea	0.35	93.67	0.00
(12)	Japan	1.22	84.92	0.61	(28)	Israel	0.35	94.01	0.00
(13)	Norway	0.98	85.90	0.16	(29)	South Africa	0.26	94.27	0.00
(14)	Greece	0.95	86.85	0.01	(30)	Brazil	0.25	94.52	0.00
(15)	Finland	0.86	87.71	0.12	(31)	United Arab Emirates	0.23	94.76	0.00
(16)	Ireland	0.75	88.46	0.11	(32)	Indonesia	0.23	94.99	0.00

1/ Countries are ranked according to their share in Dutch exports.
2/ Share of the country's currency in Dutch goods exports. Note that the share of the Dutch guilder amounts to 43.72 percent.

Panel (b): Imports

Rank 1/	Country	Imports		Currency share 2/	Rank	Country	Imports		Currency share 2/
		Share	Cumulative share				Share	Cumulative share	
(1)	Germany	23.16	23.16	19.45	(17)	Norway	0.73	91.03	0.12
(2)	United Kingdom	12.79	35.95	4.26	(18)	Singapore	0.59	91.61	0.05
(3)	Belgium	11.73	47.68	2.59	(19)	Portugal	0.50	92.11	0.03
(4)	United States	10.70	58.38	24.33	(20)	Republic of Korea	0.45	92.56	0.00
(5)	France	6.79	65.17	2.99	(21)	Canada	0.44	93.00	0.11
(6)	Japan	5.69	70.86	1.52	(22)	China	0.38	93.38	0.00
(7)	Switzerland	4.95	75.81	0.65	(23)	Poland	0.37	93.75	0.00
(8)	Italy	3.61	79.42	1.15	(24)	Israel	0.35	94.10	0.00
(9)	Spain	1.96	81.38	0.84	(25)	Kuwait	0.32	94.42	0.00
(10)	Sweden	1.96	83.34	0.53	(26)	Luxembourg	0.30	94.72	0.00
(11)	Hong Kong SAR	1.61	84.94	0.32	(27)	Indonesia	0.29	95.01	0.02
(12)	Ireland	1.51	86.46	0.11	(28)	Thailand	0.29	95.30	0.00
(13)	Denmark	1.15	87.61	0.30	(29)	Turkey	0.28	95.57	0.00
(14)	Taiwan	1.12	88.73	0.00	(30)	India	0.27	95.84	0.02
(15)	Austria	0.83	89.56	0.21	(31)	Brazil	0.26	96.11	0.00
(16)	Finland	0.73	90.30	0.06	(32)	Malaysia	0.25	96.36	0.10

1/ Countries are ranked according to their share in Dutch imports.
2/ Share of the country's currency in Dutch goods imports. Note that the share of the Dutch guilder amounts to 39.86 percent.

Table 2: Regional Breakdown of Invoicing in Dutch Goods Trade, 1987–1989 and 1996–1998

Region 1/			Trade shares 2/		Currency 3/	Currency shares			
			Exports	Imports		Export		Import	
						1987-1989	1996-1998	1987-1989	1996-1998
World			100.0	100.0	Home	45.9	42.9	35.9	40.1
					Partner	36.6	34.6	44.7	33.7
					Third	17.5	22.5	19.5	26.2
	Europe		83.5	72.5	Home	46.1	44.1	40.6	46.7
					Partner	37.2	34.6	43.2	31.9
					Third	16.6	21.3	16.2	21.4
		Accession countries	1.6	1.1	Home	77.0	61.2	58.5	54.8
					Partner	0.0	0.4	0.2	1.3
					Third	23.0	38.5	41.3	43.9
		Euro-area countries	57.7	48.7	Home	43.6	43.5	38.2	48.8
					Partner	43.1	39.4	51.9	36.2
					Third	13.2	17.1	10.0	15.0
	North America		7.6	13.0	Home	29.9	25.0	12.6	20.8
					Partner	67.6	71.6	83.2	76.2
					Third	2.5	3.4	4.1	3.0
		United States	7.2	12.5	Home	27.4	23.9	12.6	20.8
					Partner	71.7	74.3	87.2	77.9
					Third	0.9	1.8	0.3	1.3
	South and Central America		1.2	1.4	Home	56.6	38.6	18.3	13.8
					Partner	0.2	0.9	0.2	3.1
					Third	43.3	60.5	81.5	83.1
	Middle East		1.5	0.8	Home	55.1	49.3	30.8	33.2
					Partner	3.2	1.8	0.9	0.9
					Third	41.7	48.9	68.3	65.8
	Other Asia		4.6	11.4	Home	48.9	45.6	22.6	24.8
					Partner	9.0	8.7	27.0	11.4
					Third	42.1	45.7	50.4	63.8
		Japan	1.3	5.4	Home	45.2	43.5	28.9	19.6
					Partner	30.3	25.7	38.9	18.5
					Third	24.5	30.8	32.2	61.9
	Africa		1.1	0.7	Home	69.7	47.3	27.0	32.2
					Partner	0.2	0.4	2.3	2.8
					Third	30.1	52.2	70.6	64.9
	Oceania		0.5	0.2	Home	65.9	41.8	12.3	18.3
					Partner	15.7	37.7	18.3	20.5
					Third	18.5	20.5	69.4	61.2

1/ Based on all recorded Dutch trade and the country classification of the Dutch Central Bank.

2/ Average export share of each country or region for the period 1987-1989.

3/ The home currency is the Dutch guilder.

Table 3: Theoretically Expected Signs

Share	β_1	β_2	β_3	$\beta_4^{(1)}$		β_5		β_6	β_7	$\beta_8^{(2)}$	β_9
				Exports	Imports	Exports	Imports				
Dutch guilder	−	+	+	−	+	+	−	−	−	−	−
Partner currency	+	−	−	+	−	−	+	+	+	+	−
Third currency	−	+	+	+	+	+	+	+	−	0	+

Notes: (1) A rise in the exchange rate implies a depreciation (appreciation) of the home (foreign) currency; and (2) A fall in demand is represented by a rise in the unemployment rate in the partner country.

Table 4: Correlation Matrix of Residuals

Currency type	Exports 1/			Imports 1/		
	Home currency	Partner currency	Third currency	Home currency	Partner currency	Third currency
Home currency 2/	--	53.32 ***	207.53 ***	--	0.67	442.21 ***
Partner currency	-0.308	--	182.40 ***	0.018	--	182.40 ***
Third currency	-0.607	-0.569	--	-0.886	-0.569	--

1/ The correlations of the equation-by-equation OLS residuals are shown below the diagonal. The Breusch-Pagan test statistics are shown above the diagonal. *** Indicates significance at the 1 percent level.
2/ Dutch guilder.

Table 5a: SURE and Constrained GLS Estimation Results for Exports

Explanatory variables 1/	CDV-SURE 2/			Constrained pooled GLS 3/		
	Home 4/ (a)	Partner (b)	Third (c)	Home 4/ (d)	Partner (e)	Third (f)
World trade share	-2.8998 ***	4.8598 ***	-1.9601 ***	-2.6302 ***	4.3553 ***	-1.7251 ***
	(0.1253)	(0.1211)	(0.1450)	(0.1414)	(0.1555)	(0.1571)
Expected inflation	0.4427 ***	-0.4833 ***	0.0406	0.2758 ***	-0.3499 ***	0.0741
	(0.0726)	(0.0701)	(0.0840)	(0.0605)	(0.0488)	(0.0659)
Inflation volatility	0.0015	-0.0058 **	0.0043	0.0012	-0.0009	-0.0003
	(0.0025)	(0.0025)	(0.0029)	(0.0009)	(0.0007)	(0.0009)
Exchange rate change	-0.0416	0.1155 *	-0.0738	-0.0979 ***	0.0704 ***	0.0275
	(0.0674)	(0.0651)	(0.0780)	(0.0336)	(0.0257)	(0.0315)
Exchange rate volatility	0.1261	-0.1020	-0.0241	-0.0107	0.0384	-0.0277
	(0.1422)	(0.1375)	(0.1646)	(0.0801)	(0.0585)	(0.0753)
Foreign exchange market depth	-6.3876 **	-19.7449 ***	26.1325 ***	-2.7525	-0.6560	3.4085 *
	(3.0558)	(2.9532)	(3.5362)	(2.1192)	(1.2290)	(2.0674)
Banking sector development	-4.2210 ***	3.5262 ***	0.6948	-4.5493 ***	3.4831 ***	1.0662
	(0.7291)	(0.7046)	(0.8437)	(0.8526)	(0.7125)	(0.8532)
Unemployment rate	-0.6801 ***	1.0271 ***	-0.2471 ***	-0.4974 ***	0.5002 ***	-0.0029
	(0.0853)	(0.0825)	(0.0987)	(0.0514)	(0.0831)	(0.0678)
Raw materials (broad definition)	0.2696 ***	-0.4518 ***	0.1822 ***	0.1060 **	-0.1551 ***	0.0491
	(0.0555)	(0.0536)	(0.0642)	(0.0467)	(0.0415)	(0.0480)
EU dummy	0.0328 ***	0.0320 ***	-0.0649 ***	0.0261 **	0.0640 ***	-0.0902 ***
	(0.0086)	(0.0083)	(0.0099)	(0.0110)	(0.0090)	(0.0105)
Constant	0.6407 ***	0.0905 ***	0.2688 ***	0.6801 ***	0.0139	0.3059 ***
	(0.0169)	(0.0163)	(0.0195)	(0.0163)	(0.0147)	(0.0156)
Number of observations	563	563	563		1689	
$Chi^2(13)$	1046.47	2867.37	494.33	-	-	-
$Prob > chi^2$	0.0000	0.0000	0.0000			
Pseudo R-squared 5/	0.65	0.84	0.47	-	0.52	-
Log-likelihood 6/	-	-	-		3428.37	
Breusch-Pagan	4.75 **	2.84 *	82.00 ***	-	-	-
Wooldridge test	1.71	51.25 ***	13.66 ***	-	-	-

1/ The standard errors are given in parentheses below each coefficient. A triple, double, single asterisk indicates significance at the 1 percent level, the 5 percent level, and the 10 percent level, respectively. The equations includes annual dummies, the results of which are not reported.
2/ CDV denotes constrained dependent variables.
3/ Results of a pooled GLS regression. We used dummies interacted with explanatory variables to estimate each equation within the pool.
4/ Dutch guilder.
5/ R-squared is not well defined when GLS is used. The pseudo R-squared is the percent of variance explained by the predictors.
6/ Loglikelihood statistics are available for the pooled outcome only.

Table 5b: SURE and Constrained GLS Estimation Results for Imports

Explanatory variables 1/	CDV-SURE 2/			Constrained pooled GLS 3/		
	Home 4/ (g)	Partner (h)	Third (i)	Home 4/ (j)	Partner (k)	Third (l)
World trade share	-2.2117 ***	4.8412 ***	-2.6295 ***	-2.0469 ***	4.0718 ***	-2.0249 ***
	(0.2033)	(0.1073)	(0.2316)	(0.2157)	(0.2041)	(0.2160)
Expected inflation	1.2024 ***	-0.0576	-1.1448 ***	0.7459 ***	-0.0870	-0.6589 ***
	(0.1420)	(0.0749)	(0.1618)	(0.1322)	(0.0606)	(0.1304)
Inflation volatility	-0.0004	-0.0022	0.0018	-0.0011	0.0008	0.0003
	(0.0045)	(0.0024)	(0.0052)	(0.0008)	(0.0008)	(0.0006)
Exchange rate change	-0.1569	0.0383	0.1186	-0.1274 ***	0.0373	0.0901
	(0.1189)	(0.0628)	(0.1355)	(0.0339)	(0.0237)	(0.0336)
Exchange rate volatility	-1.4324 ***	-0.3673 ***	1.7998 ***	0.0203	-0.0828	0.0625
	(0.2461)	(0.1299)	(0.2804)	(0.0825)	(0.0507)	(0.0816)
Foreign exchange market depth	-11.8903 **	-18.8510 ***	30.7412 ***	-1.1186	-1.4302	2.5488
	(5.5247)	(2.9158)	(6.2937)	(1.8858)	(1.0001)	(1.8644)
Banking sector development	-2.1912 *	3.0534 ***	-0.8622	-7.3195 ***	4.7403 ***	2.5792 *
	(1.2916)	(0.6817)	(1.4714)	(1.4089)	(0.7710)	(1.3780)
Unemployment rate	-0.9501 ***	0.4785 ***	0.4716 **	-0.6821 ***	0.2101 **	0.4720 ***
	(0.1642)	(0.0867)	(0.1871)	(0.1019)	(0.0850)	(0.1002)
Raw materials (broad definition)	-0.0083	0.2324 ***	-0.2241 ***	-0.1047 ***	0.2425 ***	-0.1378 ***
	(0.0333)	(0.0175)	(0.0379)	(0.0301)	(0.0162)	(0.0279)
EU dummy	0.2294 ***	0.0783 ***	-0.3077 ***	0.2792 ***	0.0742 ***	-0.3534 ***
	(0.0170)	(0.0090)	(0.0194)	(0.0166)	(0.0107)	(0.0181)
Constant	0.5431 ***	-0.0715 ***	0.5284 ***	0.5551 ***	-0.0987 ***	0.5436 ***
	(0.0351)	(0.0185)	(0.0400)	(0.0318)	(0.0137)	(0.0318)
Number of observations	563	563	563		1689	
$Chi^2(13)$	638.13	3020.97	637.06	-	-	-
$Prob > chi^2$	0.0000	0.0000	0.0000			
Pseudo R-squared 5/	0.53	0.84	0.53	-	0.62	-
Log-likelihood 6/	-	-	-		3226.67	
Breusch-Pagan	0.28	16.08 ***	16.65 ***	-	-	-
Wooldridge test	20.20 ***	8.67 ***	16.63 ***	-	-	-

1/ The standard errors are given in parentheses below each coefficient. A triple, double, single asterisk indicates significance at the 1 percent level, the 5 percent level, and the 10 percent level, respectively. The equations includes annual dummies, the results of which are not reported.
2/ CDV denotes constrained dependent variables.
3/ Results of a pooled GLS regression. We used dummies interacted with explanatory variables to estimate each equation within the pool.
4/ Dutch guilder.
5/ R-squared is not well defined when GLS is used. The pseudo R-squared is the percent of variance explained by the predictors.
6/ Loglikelihood statistics are available for the pooled outcome only.

Table 6a: Alternative Specifications of the Estimation Equation for Exports

Explanatory variables 1/	Constrained benchmark	Non-system benchmark 2/	Without year dummies	Inflation MA8	Inflation MA16	Narrow definition of raw materials
	(a)	(b)	(c)	(d)	(e)	(f)
World trade share	-2.6302 ***	-2.5284 ***	-2.5975 ***	-2.5486 ***	-2.6308 ***	-2.5671 ***
	(0.1414)	(0.1622)	(0.1601)	(0.1395)	(0.1321)	(0.1197)
Expected inflation	0.2758 ***	0.3411 **	0.2001 ***	0.3060 ***	0.2444 ***	0.3009 ***
	(0.0605)	(0.0718)	(0.0644)	(0.0573)	(0.0517)	(0.0611)
Inflation volatility	0.0012	0.0016	0.0016 *	-0.0010 *	0.0005	0.0015
	(0.0009)	(0.0012)	(0.0009)	(0.0005)	(0.0004)	(0.0009)
Exchange rate change	-0.0979 ***	-0.1186	-0.1087 ***	-0.0918 ***	-0.0841 **	-0.0889 ***
	(0.0336)	(0.0465)	(0.0314)	(0.0333)	(0.0339)	(0.0334)
Exchange rate volatility	-0.0107	0.0738	-0.4322	-0.0071	-0.0025	-0.0155
	(0.0801)	(0.1119)	(0.0009)	(0.0791)	(0.0800)	(0.0795)
Foreign exchange market depth	-2.7525	-3.8847	-1.9615	-2.3783	-3.0623	-2.1346
	(2.1192)	(3.0584)	(2.0182)	(2.1414)	(2.1611)	(1.9974)
Banking sector development	-4.5493 ***	-4.0142 ***	-4.2397 ***	-4.0962 ***	-4.0767 ***	-3.1341 ***
	(0.8526)	(1.0678)	(0.9452)	(0.8652)	(0.8598)	(0.8223)
Unemployment rate	-0.2413 ***	-0.5058 ***	-0.2650 ***	-0.5447 ***	-0.5170 ***	-0.2310 ***
	(0.0514)	(0.1222)	(0.0460)	(0.0866)	(0.0873)	(0.0835)
Raw materials	0.1060 **	0.0721 ***	0.1997 ***	0.0971	0.0817 *	0.1593 **
	(0.0467)	(0.0577)	(0.0396)	(0.0464)	(0.0469)	(0.0708)
EU dummy	0.0261 **	0.0353 ***	0.0002	0.0303 ***	0.0318 ***	0.0183 ***
	(0.0110)	(0.0123)	(0.0118)	(0.0110)	(0.0111)	(0.0109)
Constant	0.6801 ***	0.6634 ***	0.6233 ***	0.6740 ***	0.6784 ***	0.6511 ***
	(0.0163)	(0.0211)	(0.0158)	(0.0165)	(0.0162)	(0.0153)
Number of observations	1689	563	1689	1689	1689	1689
Log-likelihood	3428.37	1035.28	3423.70	3439.79	3428.09	3759.86
Pseudo R-squared 3/	0.52	0.61	0.55	0.51	0.52	0.58

1/ The standard errors are given in parentheses below each coefficient. A triple, double, single asterisk indicates significance at the 1 percent level, the 5 percent level, and the 10 percent level, respectively. All regressions include annual dummies except column (c).
2/ The equation is estimated separately from the other two equations.
3/ The percent of variance explained by the predictors.

Table 6b: Alternative Specifications of the Estimation Equation for Imports

Explanatory variables 1/	Constrained benchmark	Non-system benchmark 2/	Without year dummies	Inflation MA8	Inflation MA16	Narrow definition of raw materials
	(g)	(h)	(i)	(j)	(k)	(l)
World trade share	-2.0469 ***	-2.0841 ***	-2.2594 ***	-1.9717 ***	-2.0326 ***	-2.0411 ***
	(0.2157)	(0.2700)	(0.2066)	(0.2180)	(0.2003)	(0.1882)
Expected inflation	0.7459 ***	0.9100 ***	0.6098 ***	0.7462 ***	0.8430 ***	0.9180 ***
	(0.1322)	(0.1848)	(0.1268)	(0.1250)	(0.1110)	(0.1329)
Inflation volatility	-0.0011	-0.0010	-0.0010	-0.0003	-0.0002	-0.0011
	(0.0008)	(0.0011)	(0.0008)	(0.0003)	(0.0002)	(0.0008)
Exchange rate change	-0.1274 ***	-0.1447 ***	-0.1314 ***	-0.1140 ***	-0.0980 ***	-0.1292 ***
	(0.0339)	(0.0431)	(0.0322)	(0.0333)	(0.0335)	(0.0331)
Exchange rate volatility	0.0203	0.0160 ***	0.0123	0.0185	0.0213 ***	0.0028
	(0.0825)	(0.1080)	(0.770)	(0.0812)	(0.0812)	(0.0804)
Foreign exchange market depth	-1.1186	-0.4931	-1.1156	-0.8018	-1.1946	0.3663
	(1.8858)	(2.5941)	(1.8158)	(1.9191)	(1.8386)	(1.7714)
Banking sector development	-7.3190 ***	-6.3067 ***	-6.9301 ***	-7.0981 ***	-5.0502 **	-3.0107 **
	(1.4089)	(2.0031)	(1.3907)	(1.4226)	(1.4015)	(1.1919)
Unemployment rate	-0.6821 ***	-0.5779 ***	-0.3843 ***	-0.7057 ***	-0.7421 ***	-0.6860 ***
	(0.1019)	(0.1335)	(0.0670)	(0.1029)	(0.1028)	(0.0974)
Raw materials	-0.1047 ***	-0.1454 ***	-0.1327 ***	-0.0814 ***	-0.0678 ***	0.1678 ***
	(0.0301)	(0.0500)	(0.0318)	(0.0296)	(0.0307)	(0.0445)
EU dummy	0.2792 ***	0.2949 ***	0.2331 ***	0.2954 ***	0.2977 ***	0.2980 ***
	(0.0166)	(0.0180)	(0.0148)	(0.0155)	(0.0153)	(0.0148)
Constant	0.5551 ***	0.5109 ***	0.5615 ***	0.5317 ***	0.496 ***	0.4287 ***
	(0.0318)	(0.0411)	(0.0312)	(0.0318)	(0.0314)	(0.0263)
Number of observations	1689	563	1689	1689	1689	1689
Log-likelihood	3428.37	962.03	3212.99	3224.05	3235.17	3536.81
Pseudo R-squared 3/	0.62	0.45	0.62	0.62	0.63	0.64

1/ The standard errors are given in parentheses below each coefficient. A triple, double, single asterisk indicates significance at the 1 percent level, the 5 percent level, and the 10 percent level, respectively. Regressions include annual dummies except column (i).
2/ The equation is estimated separately from the other two equations.
3/ The percent of variance explained by the predictors.

Appendix

A.1 Data Sources

The independent variables are presented in Appendix Table 1.

Appendix Table 1. Data Sources

Variable	Underlying series	Source
X_1	Export and imports	IMF's *International Financial Statistics (IFS*
		http://ifs.apdi.net/imf
X_2 and X_3	Consumer Price Index	IMF's *IFS*
X_4 and X_5	Period-average exchange rate	IMF's *IFS*
X_6	Bid-ask spread	Datasteam
		http://product.datastream.com/navigator/
X_7	Domestic private credit	IMF's *IFS*
	Nominal GDP	IMF's *IFS*
X_8	Unemployment rate	IMF's *IFS*
X_9	Raw materials (broad)	United Nations Comtrade Web Site
	Sections 0–4, 67–68, and 97	http://unstats.un.org/unsd/comtrade
	Raw materials (narrow)	United Nations Comtrade Web Site
	Sections 3, 67–68, and 97	http://unstats.un.org/unsd/comtrade

Notes: The SITC (Revision 3) sections are: 0 (food and live animals), 1 (beverages and tobacco), 2 (crude materials), 3 (mineral fuels, lubricants, and related materials), 4 (animal and vegetable oils, fats, and waxes), 67 (iron and steel), 68 (non-ferrous metals), and 97 (gold, non-monetary, excluding gold ores and concentrates).

The dependent variable is constructed using trade payments data from the Dutch Central Bank. Resident traders (corporations and individuals) are by law required to report their cross-border payments/receipts (above a certain threshold value) to Dutch commercial banks, which in turn report this information to the Dutch Central Bank. The reporting threshold was euro 5,000 in the early 1990s and has been adjusted upward to euro 10,000 by end-1990. Our data set includes imports destined for reexports (where ownership of the goods is transferred to a Dutch resident, who exports the goods without any further industrial processing), but does not cover pure transit trade (where no change in ownership occurs, implying that it

is not recorded in the balance of payments).

We have aggregated monthly data to quarterly data and cleaned the data set by removing negative trade receipts and payments—a negligible amount, on the order of 0.7 percent of exports or imports—which were related to "repairs on goods," "good procured in ports by carriers" (e.g., ships supplied with fuel), and corrections related to reporting mistakes made in previous quarters.

To calculate the currency shares, we had to identify the official currency of each of 272 countries and jurisdictions that are present in the data set of the Dutch Central Bank (which covers all recorded Dutch trade except minor corrections). Throughout the paper (except for Table 2), the definition of country groups and/or regions is based on the IMF's *IFS*-country classification. In matching the countries in the database of the Dutch Central Bank with the IMF's country grouping, 109 small jurisdictions (with negligible trade shares, accounting for a mere 0.68 percent of Dutch trade) were left out so that we ended up with 163 countries.

A.2 Systems Estimation

No standard routines are available in Stata 9.2 to deal with autocorrelation in systems of equations in panel format. To solve this problem, we stack the data in long format and interact the explanatory variables and constant term with three dummies representing each of the three currency-share equations. For this purpose, we create a new panel identifier from the country and date identifiers. Subsequently, we apply GLS[31] to the pooled data set, incorporating corrections for autocorrelation (in the form of a panel-specific first-order AR process) and heteroscedasticity (using White's procedure for panels). Because we create a dummy to represent the constant term of each equation, we suppress the regular constant term of the regression procedure.

Stata 9.2 does not support constrained estimation in a GLS systems context, however. To impose linear constraints, we use the Stata plug-in program *linest*, which performs a two-stage estimation. In the second stage, constraints are imposed on the first-stage results of an unconstrained estimation. Note that the two-stage estimator is asymptotically equivalent to the "true" one-stage constrained estimator.

[31] Here it is justified to apply GLS given that we have more time periods than countries in our panel.

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