Has the Euro Affected the Choice of Invoicing Currency?*

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Abstract

We present a new approach to study empirically the effect of the introduction of the euro on currency invoicing. Our approach uses a compositional multinomial logit model, in which currency choice is explained by both currency-specific and country-specific determinants. We use unique quarterly panel data of Norwegian imports from OECD countries for the 1996–2006 period. We find that eurozone countries have substantially increased their share of home currency invoicing after the introduction of the euro, whereas the home currency share of non-eurozone countries fell. In addition, the euro as a vehicle currency has overtaken the role of the US dollar in Norwegian imports. The substantial rise in producer currency invoicing by eurozone countries is primarily caused by a drop in inflation volatility and can only to a small extent be explained by an unobserved euro effect.

JEL codes: F14, F15, F31, F33, F36, E31, C25

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1 Introduction

Currency invoicing of international goods trade has interested academics and policy makers as early as the 1970s when the Bretton Woods system of fixed but adjustable exchange rates collapsed and the principle trading countries in the world moved to flexible exchange rates. The introduction of the euro in non-cash form (i.e., electronic transfers, banking, etcetera) on January 1, 1999 and in cash form on January 1, 2002[1] has given a renewed impetus to the invoicing literature.[2] The introduction of the euro is believed to have had a substantial impact on traders' choice of invoicing currency. More specifically, the euro would boost home currency invoicing by firms located in eurozone countries and euro use by non-eurozone exporters trading with eurozone countries.[3] This paper empirically investigates how a country's pattern of invoicing currency choice is affected by euro introduction.

Knowing which factors affect the pattern of invoicing is important on three accounts. The first reason is that invoicing patterns matter for how a country's trade balance responds to a change in the exchange rate. If countries' exports are fully invoiced in the exporter's currency (and thus imports are by definition invoiced in a foreign currency), a depreciation of the exporter's currency—given that trade contracts are given in the short run—would cause an initial worsening of the trade balance.[4] Second, the choice of invoicing currency affects the degree to which import prices are affected by exchange rate movements, the so-called exchange rate 'pass-through.'[5] Finally, from a microeconomic point of view, the choice of invoicing currency determines the firm's exposure to exchange risk. If a transaction is invoiced in any other currency than their own, trading firms are exposed to exchange rate uncertainty, leading to revenue uncertainty.

[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 number of European Union member states adopting the euro (the so-called eurozone) to 12 countries. Nowadays, the eurozone consists of 16 countries.

[2] The 'New Open Economy Macroeconomics' literature based on Obstfeld and Rogoff's (1995) paper also contributed to this revival. An important issue in this literature is in which currency prices are assumed to be sticky. The Redux model assumes exporters set prices in their home currency.

[3] Bacchetta and Van Wincoop (2005) present a theoretical analysis, whereas Kamps (2006) and Goldberg and Tille (2008) provide empirical evidence.

[4] See Melvin and Sultan (1990) for an empirical study on the link between invoicing currency patterns and the impact of a currency depreciation on the balance of trade.

[5] There is an extensive literature on exchange rate pass-through. Feenstra (1989) and Feenstra, Gagnon, and Knetter (1996) are early contributions.

Little is known empirically about the determinants of invoicing currency choice, let alone the effect of currency unions on invoicing patterns. The limited number of studies no doubt reflects the considerable confidentiality with which the invoicing data are treated by central banks and customs offices. Recently, a few econometric studies—using data for a single country—have studied invoicing determinants; that is, Donnenfeld and Haug (2003) for Canada, Wilander (2006) for Sweden, Donnenfeld and Haug (2008) for the United States, and Ligthart and Da Silva (2007) for the Netherlands. Wilander (2006) employs data on individual transactions, whereas the others focus on aggregate currency shares. Most of these studies show that a country's market power—measured in terms of a country's world export share—leads to increased invoicing of its home currency. We know of only two invoicing studies—i.e., Kamps (2006) and Goldberg and Tille (2008)—that empirically assess the effect of euro introduction on currency invoicing. Both studies use aggregate cross-country data for a single currency share as the dependent variable.

To investigate the effect of euro introduction on individual currencies and currency groups during the two stages of euro introduction, we use a unique invoicing dataset for Norway. The data consist of the value of Norwegian goods imports broken down by country and currency for the period 1996–2006 and are measured at a quarterly frequency. These data are used to derive bilateral currency shares for currencies of OECD countries. The econometric analysis includes 29 OECD countries, roughly capturing 85 percent of Norwegian trade. The invoicing data used in this study span the introduction of the euro, the transition period 1999–2001 (when both the euro and national legacy currencies[6] could be used in trade), and a sufficiently large post-transition period. We have chosen Norway because it is not part of the eurozone, which allows the study of the effect of the euro on partner currency use in Norwegian imports from eurozone countries and on vehicle currency invoicing in Norwegian imports from countries outside the eurozone.[7]

We employ a compositional multinomial logit approach that weights the probability of traders choosing a particular currency by the respective currency share. This approach is

[6] Legacy currencies are the currencies of the eurozone members that ceased to exist at the end of the transition period toward euro introduction.

[7] A 'vehicle currency' or 'third currency' is neither the currency of the exporter nor that of the importer in a trade transaction. We will use the terminology vehicle currency and third currency interchangeably.

appropriate because we have compositional data, that is, the currency shares lie in the closed unit interval $[0, 1]$, add up to unity for a particular country at one point in time, and are correlated. Our analysis incorporates the characteristics of 31 currencies and thus goes beyond just characterizing the determinants of the share of a single currency (e.g., the euro or US dollar). Hence, we are able to capture substitution effects between currencies due to euro introduction. We employ a euro dummy for the time period 1999Q1–2006Q4 to capture an unobserved euro effect (e.g., more trust in the common currency) during 1991Q1–2001Q4. In addition, a euro control dummy is introduced to describe legacy currency invoicing during the transition period. Finally, we employ both fixed effects and pooled models, where the former specification controls for unobserved heterogeneity across countries.

So far, the empirical invoicing literature has only used explanatory variables related to the partner countries in trade (so-called country-specific variables). This study introduces a new approach that relates covariates to the currencies, thereby introducing currency-specific variables. Because we control for currency-specific determinants, we refer to a *conditional* compositional multinomial logit model.[8] More specifically, our approach makes it possible to relate traders' invoicing motives directly to the currency attributes, that is, a euro dummy, a euro transition dummy, exchange rate volatility of the chosen currency with respect to the local currency (the Norwegian krone, NOK), exchange rate volatility of the chosen currency with respect to the partner currency, and the depth of the currency's foreign exchange market. Besides these methodological extensions, the paper also contributes to the invoicing literature more generally by considering a broader set of covariates than has been studied before. We consider new variables of interest such as inflation volatility, the depth of the foreign exchange market, and the degree of differentiation of the partner country's export package.

We find in the descriptive analysis that Norway's trading partners participating in the eurozone use their own currency more frequently than before the introduction of the euro, whereas non-eurozone partners invoice less frequently in their home currency. However, the rise in the producer currency share of eurozone countries can only be partly attributed to a substitution from eurozone vehicle currencies to the euro. We also find that the euro is

[8]The discrete choice literature usually refers to the country-specific and currency-specific regressors distinction as 'alternative-invariant' and 'alternative-varying' regressors, respectively.

chosen more often as a vehicle currency than the US dollar. The results for the fixed effects benchmark model show that above and beyond the control variables, the introduction of the euro has had a significant positive effect on the euro share. Euro introduction increases eurozone countries' share of producer currency invoicing by 2.6 percentage points.[9] If the euro is chosen as a vehicle currency by non-eurozone countries its share rises by 3 percentage points. This unobserved euro effect only materialized gradually, reflecting the three-year transition phase. We further find that the substantial rise in producer currency invoicing by eurozone countries is primarily caused by a drop in inflation volatility and can only to a small extent be explained by an unobserved euro effect. In the pooled model, invoicing in producer currencies increases if the size of the foreign exchange market is large, the degree of product differentiation is small, and the rate of inflation is low. The world trade share of a country is only significantly positive in a pooled model with country-specific variables.

This paper is organized as follows. Section 2 derives various currency shares and describes invoicing patterns in Norwegian imports using currency share data. Section 3 discusses the econometric methodology. Section 4 presents the results on the invoicing effect of the euro while controlling for other determinants of invoicing currency choice. Finally, Section 5 concludes the paper.

2 Invoicing Currency Shares

This section defines various invoicing currency shares and provides a descriptive analysis of the shares.

2.1 Currency Share Definitions

Our analysis uses quarterly data on the aggregate value of Norwegian goods imports broken down by the currency of payment and the country of the trading partner for the 1996–2006 period. We include 29 OECD countries—i.e., all OECD member countries in 2006, excluding Norway—which covers roughly 85 percent of total Norwegian imports. The data used in this study have been collected by the Norwegian customs office. The Norwegian customs law

[9] Producer currency invoicing denotes invoicing in the home currency of the exporter.

requires traders to report all goods trade transactions of a value exceeding NOK 10,000 (euro 1,127). Besides the transaction value, transaction volume, and type of commodity, traders have to report the currency of payment. A small fraction of trade is censored by the reporting threshold; it does not exceed 5 percent in imports from any partner country and amounts to less than 3 percent of the aggregate import value. Because of confidentiality concerns, we do not have access to firm-level transactions. In addition, transactions in the oil and shipping sector—in which just a few large firms are active—are excluded from the reported data. Finally, we cannot observe the currency of invoicing. In the following, we assume that the currency of payment in any period is equal to the currency of invoicing. Friberg and Wilander (2008) point out that in more than 90 percent of the cases the two coincide.

In the econometric analysis of Section 3, we make use of invoicing currency shares, which are calculated as follows. Let us define m_{jnt} to denote Norway's bilateral imports (which are measured in Norwegian krones) invoiced in currency $j = 1, ..., J$ in trade with country $n = 1, ..., N$ in quarter $t = 1, ..., T$. Dividing m_{jnt} by m_{nt}—so that we correct for scale—we arrive at the currency share for currency j in country n at time t:

$$s_{jnt} = \frac{m_{jnt}}{\sum_{j=1}^{J} m_{jnt}}, \qquad 0 \leq s_{jnt} \leq 1, \qquad \sum_{j=1}^{J} s_{jnt} = 1. \tag{1}$$

We have corrected m_{jnt} for changes in the average exchange rate of the Norwegian krone with respect to each currency in the sample (Table A.1). The J currency shares represent compositional data; that is, the shares are bounded on the $[0, 1]$ interval and add up to unity. In addition, the shares are not independent of each other because they have the same denominator; that is, $\text{Cov}(s_{jnt}, s_{knt}) \neq 0$ for any two currency shares j and k for $j \neq k$.

We distinguish a maximum of $J = 31$ currencies and compute the corresponding bilateral currency shares. We focus only on currencies of OECD countries because no other currencies outside the OECD were actually chosen. Furthermore, it would be computationally demanding to distinguish all currencies in the world. Note that the set of currencies that is effectively available for use in the OECD area falls over time, reflecting the phasing out of currencies associated with euro introduction. During the 1996–1998 period, traders could use a maximum of 31 currencies, consisting of the currencies of OECD member countries and the European

Currency Unit (ECU). For the 1999–2001 period, traders could potentially choose one of 30 currencies of the OECD member countries plus the euro. Finally, during the 2002–2006 period, 19 currencies are available; that is, all the currencies of OECD member countries, excluding the national legacy currencies and the ECU. Table A.2 shows currency shares averaged over time and countries. The Norwegian krone, the euro, and the US dollar are the most frequently used. Out of 31 currencies five currencies are never chosen (i.e., the Hungarian forint, the Mexican peso, the Slovak koruna, the South Korean won, and the Turkish lira), but these will nevertheless be included in the analysis.

To permit a graphical analysis of the currency shares, we classify the currencies in three mutually exclusive groups. The first group is local currency invoicing (LCI), which refers to invoicing in the currency of the country where the exporter's goods are sold. In our case, the local currency is the Norwegian krone. The second group is called producer currency invoicing (PCI). For all partner countries that are not part of the eurozone, there is only one producer currency. Countries that are part of the eurozone have one producer currency until 1999 (i.e., their national currency), two producer currencies between 1999 and 2002 (i.e., their national legacy currency and the euro), and one producer currency from 2002 onwards (i.e., the euro). Finally, the third group is vehicle currency invoicing (VCI), which refers to invoicing of trade transaction in a third currency. The VCI group consists of all currencies excluding the Norwegian krone and the trading partner's currency. Using this currency grouping, we can calculate the respective currency group shares for country n:

$$s_{vnt} = \frac{m_{vnt}}{\sum_v^V m_{vnt}}, \qquad m_{vnt} = \sum_{j=1}^{J_v} m_{jnt}, \qquad v \in \{\text{LCI}, \text{PCI}, \text{VCI}\}, \tag{2}$$

where m_{vnt} is the sum of country n's import values invoiced in currencies belonging to group v, J_v is the number of currencies in group v, and $J = J_{\text{LCI}} + J_{\text{PCI}} + J_{\text{VCI}}$.

The next step is to calculate the aggregate currency group shares, where we aggregate across countries. We take two approaches. The first approach corrects for trade value differences across countries. Norway's five biggest OECD trading partners make up more than 50 percent of its imports. To preclude that the invoicing of Norwegian imports from large trading partners overshadows that of smaller trading partners, we calculate equally-weighted currency group shares by averaging over the bilateral currency group shares: $s_{vt}^{E} = \frac{1}{N}\sum_{n=1}^{N} s_{vnt}$, where s_{vnt} is defined in (2) and the label E denotes equally-weighted currency group shares. The second approach calculates trade-weighted currency group shares (labeled by T) as follows: $s_{vt}^{T} = \frac{m_{vt}}{\sum_{v}^{V}\sum_{n=1}^{N} m_{vnt}}$, where $m_{vt} = \sum_{n=1}^{N} m_{vnt}$. The shares are analyzed in the next section.

2.2 Descriptive Analysis

Table 1 shows the bilateral currency shares for currency groups and the partner country's share in Norwegian imports. The share of producer currencies (PCI) varies substantially across countries, ranging from 0 to 75.3 percent. There is no clear link between the partner country's home currency share and its export share. The home currency share of Norway's most important trading partner (Sweden) amounts to 45.9 percent, whereas that of its second most important trading partner (Germany) is 73.5 percent. In addition, although Poland is ranked as Norway's 15th largest trading partner, the share of the Polish Zloty is very small. More generally, many countries that joined the OECD in the second half of the 1990s have a negligible or zero PCI share.

Norway's five biggest trading partners—equally weighted—invoice on average 30 percent of their exports to Norway in the local currency (Norwegian krone), 55 percent in the producer currency, and 15 percent in vehicle currencies. This invoicing pattern supports 'Grassman's law,' which says that trade between industrialized countries is mainly invoiced in the currency of the exporter.[10] Across all OECD countries, however, the invoicing of Norwegian imports looks quite different: 35.4 percent is invoiced in the Norwegian krone, 31.2 percent in producer currencies, and 33.3 percent in vehicle currencies.

Panel (a) of Figure 1 shows the average currency group shares of eurozone countries, whereas Panel (b) presents the trade-weighted currency group shares. The introduction of the euro as a virtual currency in 1999 is indicated by the first dotted vertical line. The second dotted vertical line depicts the date of introduction of the euro in cash transactions in 2002, at which date the national currencies of the EU member states ceased to be legal tender.

[10] Grassman (1973) found in his descriptive analysis of Swedish goods trade that two-thirds of exports to industrialized countries were invoiced in the producer's currency and a quarter are invoiced in the local currency. Because other authors in the 1980s found similar invoicing patterns, the invoicing literature refers to Grassman's law.

Panel (a) shows that the equally-weighted currency shares of eurozone countries have been affected by the introduction of the euro. Before the introduction of the euro, imports in the eurozone are mainly invoiced in the Norwegian krone. Indeed, we can see that the average PCI share of 30 percent (denoted by the dashed line) is only slightly above that of vehicle currencies, implying a failure of Grassman's law. After the introduction of the euro in cash form, however, the PCI share rises substantially—reaching nearly 60 percent in 2003Q1—and becomes dominant in 2001Q2. Hence, Grassman's law is supported after mid-2001. The rise in the PCI share comes at the expense of the LCI and VCI shares (the solid and dotted lines, respectively). Note that the euro share (not shown in the figure) increases slowly from 7 percent in 1999Q1 to 15 percent in 2000Q1 and subsequently to 25 percent in 2001Q1. During the last year of the transition period, the euro share jumps from 25 percent to 51 percent in 2001Q4 (see the start of the PCI line in Panel (a) of Figure 1).

Panel (b) depicts that the trade-weighted currency group shares are in line with Grassman's law across the entire time period. In addition, the introduction of the euro seems to have affected the currency group shares, although the effects are less pronounced as for the case of equally-weighted currency shares. At the individual country level, we find the largest rise in the PCI share after euro introduction for Greece (52 percentage points), Luxembourg (50 percentage points), Spain (37.2 percentage points), and Portugal (34.7 percentage points), which have very small shares (less than 2 percent) in trade with Norway.[11] However, the PCI share of Germany—which provides 16.4 percent of Norwegian imports from OECD countries—rises by less than 1 percentage point. Because Norway's smaller trading partners get a greater weight in the equally-weighted analysis than in the trade-weighted analysis, we find a larger euro effect for the former specification.

To investigate whether the rise in the PCI share has happened exclusively in the eurozone, we compare it to the PCI share of non-eurozone countries in our sample. Panels (c) and (d) of Figure 1 reveal that the PCI share of non-eurozone countries (the dashed line) falls slightly

[11] The figures are derived by comparing the average PCI share (expressed in percentages) during 1996–1999 period with that during the 2002–2006 period. Greece, Luxembourg, and Spain primarily switched away from vehicle currency use (VCI declined from 39.4 percent before 1999 to 7.1 percent after 2002), whereas Portugal mainly switched away from Norwegian krones (LCI dropped from 71.4 percent before 1999 to 50.6 percent after 2002).

after the introduction of the euro, whereas the PCI of eurozone countries rises substantially. One could argue that the rise in the PCI share primarily reflects a substitution from eurozone vehicle currencies to the euro. For instance, Norwegian imports from Italy that are invoiced in German marks—which counts toward VCI before euro introduction—are recorded as PCI after euro introduction. To get some idea about the potential size of this effect, we add the pre-1999 VCI share in Norwegian trade with eurozone countries to the PCI share (see the bullet pointed line). Obviously, this figure forms an upper bound on the substitution effect because the national currencies of eurozone members represent only 32 percent of total vehicle currency use. After January 1, 2002, the PCI share is still 10 percentage points higher than the bullet-pointed line, thereby providing support for a genuine euro effect.

Table 2 analyzes the composition of the trade-weighted vehicle currency share in Norwegian imports before and after euro introduction. We can see that the euro as a vehicle currency overtakes the US dollar after euro introduction. In 1996, the US dollar has the largest share (52 percent), followed by the German mark (27 percent). The share of all vehicle currencies belonging to the eurozone is 32 percent. The share of non-eurozone vehicle currencies (excluding the US dollar) accounts for 15.1 percent; it consists primarily of the currencies of Scandinavian partner countries (i.e., the Swedish krone and the Danish krone), together accounting for 12 percent. However, the share of the Pound sterling—once a major vehicle currency—is very small (2 percent). In 2006, the euro share amounts to 47.1 percent whereas the US dollar share (41.5 percent) falls below the euro share. The overall decrease of the VCI share in Norwegian imports partly reflects the introduction of the euro, which increases the PCI share in eurozone members.[12]

3 Empirical Methodology

This section sets out the empirical model used to analyze the determinants of currency invoicing. The econometric framework builds on two strands of literature: (i) the discrete-choice literature on market share data (which is developed by Berry (1994) and applied by Nevo

[12]Note that the average number of vehicle currencies used in Norwegian trade with eurozone countries dropped from 16 to 9 after euro introduction (compared to a drop from 15 to 9 in non-eurozone members).

(2001) in the field of industrial organization); and (ii) the fractional response analysis of Papke and Wooldridge (1996).

3.1 Parameter Estimation

A common starting point to model an agent's choice among alternatives is the random utility framework. In the context of invoicing, an optimizing exporter chooses the invoicing currency that gives the highest payoff in terms of utility.[13] More formally, we define the utility functional of trader $i = 1, ..., I$ located in partner country $n = 1, ..., N$ choosing currency $j \in \{1, ..., J\}$ in export to Norway in quarter $t = 1, ..., T$ as follows:

$$U_{ijnt} = \mathbf{z}'_{jnt}\boldsymbol{\alpha} + \mathbf{x}'_{nt}\boldsymbol{\beta} + \mathbf{d}_n\boldsymbol{\eta} + \xi_{ijnt}, \tag{3}$$

where $\mathbf{z}'_{jnt}$ is a $1 \times H_z$ row vector of explanatory variables related to currency $j = 1, ..., J$ in each quarter t and $\mathbf{x}'_{nt}$ is a $1 \times H_x$ row vector of explanatory variables pertaining to country n in each quarter t. Because traders are likely to choose currencies according to their attributes (e.g., size of the exchange market) and not only based on the (economic) characteristics of the currency's jurisdiction (e.g., world trade share), we include both currency-specific and country-specific covariates (Section 3.2). To model unobserved heterogeneity at the country level, we include a $1 \times N$ row vector of dummies $\mathbf{d}_n$, which are equal to one in column n and zero otherwise. Preferences of exporters differ by ξ_{ijnt}, which we take to have a known distribution. Finally, $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{\eta}$ are the coefficient vectors to be estimated.

Exporter i in country n chooses currency j at time t if and only if

$$U_{ijnt} \geq U_{iknt} \qquad \forall \;\; k \neq j \quad \text{and} \quad k = 1, ..., J. \tag{4}$$

Define the set of values of ξ_{ijnt} that leads to the choice of currency j in trade with country n at time t:

$$A_{jnt} = \{\xi_{ijnt} : U_{ijnt} \geq U_{iknt} \;\; \forall \;\; k \neq j, \;\; k = 1, ..., J\}. \tag{5}$$

[13] We are assuming that the exporter in the partner country chooses the currency. Alternatively, we could have assumed that the Norwegian importer is choosing the currency. In practice, the currency choice is the result of Nash bargaining between two trading parties. The theoretical ramifications of this setup are left for further research.

Let $\boldsymbol{\theta} \equiv [\boldsymbol{\alpha} \;\; \boldsymbol{\beta} \;\; \boldsymbol{\eta}]'$ be a row vector containing all the parameters. The currency share j of country n at time t is a function of both currency and country characteristics:

$$\mathrm{S}_{jnt}(\mathbf{z}_{jnt}, \mathbf{x}_{nt}; \boldsymbol{\theta}) = \int_{\xi_{ijnt} \in A_{jnt}} dF(\xi_{ijnt}), \tag{6}$$

where $F(\xi_{ijnt})$ is the cumulative distribution function of ξ_{ijnt}. If the ξ_{ijnt}'s are distributed identically and independently across firms, currencies, countries, and time periods with a Type I extreme-value distribution, the integral in (6) can be explicitly solved to yield the currency share function:

$$\mathrm{S}_{jnt} = \frac{\exp(\mathbf{z}'_{jnt}\boldsymbol{\alpha} + \mathbf{x}'_{nt}\boldsymbol{\beta} + \mathbf{d}_n\boldsymbol{\eta})}{\sum_j^J \exp(\mathbf{z}'_{jnt}\boldsymbol{\alpha} + \mathbf{x}'_{nt}\boldsymbol{\beta} + \mathbf{d}_n\boldsymbol{\eta})}, \qquad j \neq k. \tag{7}$$

A probability-based approach like (7) ensures that estimated currency shares for J currencies satisfy the adding-up constraint [see (1)] and are bounded on the closed interval [0,1].[14]

The country-specific coefficient vectors $\boldsymbol{\beta}$ and $\boldsymbol{\eta}$ are only identified if we normalize one currency choice to zero. We choose to set the parameters of the Norwegian krone (LCI) to zero, leaving a parameter set for $J-1$ currency shares. Accordingly, the parameters in the vectors $\boldsymbol{\beta}$ and $\boldsymbol{\eta}$ represent the difference between the respective currency choice j and the Norwegian krone. Without further restrictions, this approach would involve estimating $(N+H_x)\times(J-1)$ parameters for country-specific variables only. A more practical solution is to split the country-specific parameter vectors into the aforementioned three currency groups. We define $\boldsymbol{\beta}_v$ and $\boldsymbol{\eta}_v$ for $v \in \{\mathrm{LCI}, \mathrm{PCI}, \mathrm{VCI}\}$ and set $\boldsymbol{\beta}_{LCI} = \boldsymbol{\eta}_{LCI} = 0$. This procedure implies that the parameters in the vectors $\boldsymbol{\beta}_{VCI}$ and $\boldsymbol{\eta}_{VCI}$ are identical across all vehicle currencies. Similarly, $\boldsymbol{\eta}_{PCI}$ and $\boldsymbol{\beta}_{PCI}$ are common to the euro and the eurozone legacy currencies that are used as PCI. More important, by distinguishing $J-1$ currency shares on the left-hand side, we can meaningfully include currency-specific variables.[15] Obviously, the parameter vector $\boldsymbol{\alpha}$ remains unaffected by the splitting procedure. Note that if equation (7) had been specified without $\mathbf{z}_{jnt}$, we could have used just the three currency groups as the dependent variable. We can now define the normalized share function for the PCI and VCI

[14]We cannot use the much simpler logistic transformation because the shares might lie at the extreme values of zero or one, making the transformation impossible.

[15]For purposes of analyzing currency-specific variables, all potential currencies of OECD countries are included even though five currencies were never chosen at all.

groups:

$$\text{S}_{jnt} = \frac{\exp(\mathbf{z}'_{jnt}\boldsymbol{\alpha} + \mathbf{x}'_{nt}\boldsymbol{\beta}_v + \mathbf{d}_n\boldsymbol{\eta}_v)}{\exp(\mathbf{z}'_{LCInt}\boldsymbol{\alpha}) + \sum_j^{J-1}\exp(\mathbf{z}'_{jnt}\boldsymbol{\alpha} + \mathbf{x}'_{nt}\boldsymbol{\beta}_v + \mathbf{d}_n\boldsymbol{\eta}_v)} \quad \forall\ j \neq k \neq \text{LCI}. \tag{8}$$

Our model is a variant of the standard multinomial logit approach, which we call the *conditional* compositional multinomial logit model. To arrive at the estimated coefficient vector, we maximize the log-likelihood:

$$\ln L(\boldsymbol{\theta}|\mathbf{Z}_{nt}, \mathbf{x}_{nt}) = \sum_{n=1}^{N}\sum_{t=1}^{T}\sum_{j=1}^{J} s_{jnt} \ln \text{S}_{jnt}, \tag{9}$$

where $\boldsymbol{\theta} \equiv [\boldsymbol{\alpha}\ \boldsymbol{\beta}_{PCI}\ \boldsymbol{\beta}_{VCI}\ \boldsymbol{\eta}_{PCI}\ \boldsymbol{\eta}_{VCI}]'$ is a row vector with parameters, $\mathbf{Z}_{nt}$ is a $J \times H_z$ matrix describing all currency choices J and their characteristics $\mathbf{z}_j$, and s_{jnt} are the observed currency shares. The estimated currency share functions are then the predicted currency shares; that is, $\hat{\text{S}}_{jnt} = \hat{s}_{jnt}$, where hats denote predicted values (Appendix A.1). In the benchmark specification, we explicitly control for unobserved heterogeneity across countries. To this end, we run a country-specific fixed effects model. Because $T = 44$ is larger than $N = 29$, we do not have to deal with the well-known incidental parameter problem.[16] We formally test whether we should employ a fixed effects model or a pooled specification. Using the likelihood ratio test under the null hypothesis that the pooled model and the fixed effects model are statistically the same, we find: $-2[\ln L(a_v) - \ln L(\mathbf{d}_n\boldsymbol{\eta}_v)] = 241.97 > 39.8 = \chi^2(56)$,[17] where a_v is a common intercept per currency group. The test statistic indicates that the hypothesis of poolability across countries can be rejected. As a robustness check, we also consider a pooled model, where we replace $\mathbf{d}_n\boldsymbol{\eta}_v$ by a_v. We use robust standard errors instead of clustered standard errors, reflecting the relatively small N.[18]

3.2 Explanatory Variables

The analysis includes dummies to capture the introduction of the euro in non-cash form and the transition period after introduction, a set of trade and trade-related variables, and

[16] We do not include time-fixed effects, precisely because T is larger than N. Furthermore, we do not expect time heterogeneity across *all* countries (e.g., common business cycle shocks) to be important. With the exception of the euro introduction and transition period, the invoicing pattern is rather stable across time periods. The euro effect is being controlled for by either a country-specific dummy or a currency-specific dummy.

[17] Because $N = 29$ we have $2 \times 28 = 56$ restrictions.

[18] We have only 29 clusters, which is of insufficient size to use cluster-robust standard errors. Cameron, Gelbach, and Miller (2010) argue that at least 50 clusters are needed for accurate inference.

monetary variables. A detailed overview of the data sources is provided in Table A.1 and Table A.2 presents descriptive statistics.

3.2.1 Euro Dummies

To measure any unobserved effects on invoicing related to euro introduction (i.e., trust in the stability of the common currency), we employ a euro dummy. Changes in euro invoicing due to changes in fundamental variables (i.e., more price stability) should be captured sufficiently by the respective regressors (see Sections 3.2.2–3.2.3). As a currency-specific variable, the euro dummy (denoted by EUR_{jt}) takes on a value of unity for the legacy currencies of the eurozone countries and for the euro from January 1, 1999 onward and zero otherwise (where the legacy currencies are included up to December 31, 2001).[19] The euro as a currency-specific variable measures the overall effect of euro introduction on the euro share in Norwegian imports (including its use as a producer currency and vehicle currency). The parameter of EUR_{jt} is expected to have a positive sign, since partner countries will take advantage of the increased market power bestowed upon them by the euro and trade less in any other currency than their own.

As a country-specific variable, the euro dummy (denoted by EUR_{nt}) takes on a value of unity for all eurozone countries from January 1, 1999 onward. The country-specific euro dummy measures the effect of eurozone membership on a partner country's LCI, PCI, and VCI share. We expect a negative sign of the parameter of EUR_{nt} for LCI and VCI and a positive sign for PCI.

From January 1, 1999 to December 31, 2001, the euro has been used in non-cash trade transactions alongside the home currencies of the eurozone countries. To measure the phasing out of the eurozone home currencies during the transition period, we use a dummy variable $EuroControl_{jt}$ that takes on a value of unity if one of the legacy currencies is chosen during the transition period and zero otherwise. Based on the descriptive analysis in Section 2, we know that the euro slowly replaced the eurozone legacy currencies. Hence, we expect a

[19] Note that the official date at which the national currencies of countries participating in the eurozone ceased to be legal tender varied across member states, but lasted up to a maximum of two months after December 31, 2001. However, we do not differentiate the date by country.

negative coefficient of the $EuroControl_{jt}$ dummy.

3.2.2 Monetary Variables

Magee and Rao (1980) hypothesize that trading firms are less likely to set their prices in currencies of countries that exhibit a high rate of inflation. A high inflation rate weakens a country's currency and erodes the real value of the firm's trade receipts. We include the expected rate of inflation of the partner country (CPI_{nt}), which is calculated as the mean of the consumer price index (CPI)-based inflation rate of the last four quarters. It is expected to have a negative effect on PCI by partner countries.

Cornell (1980) and Devereux, Engel, and Storgaard (2004) argue that the expected volatility of the partner country's inflation rate $CPIVol_{nt}$ will similarly have a negative effect on the use of the producer currency, because risk-averse exporters will want to minimize the variance of their receipts. Indeed, there are no appropriate instruments to hedge inflation uncertainty. We define $CPIVol_{nt}$ as the standard deviation of a country's CPI over the last four quarters. As a currency-specific variable, $CPIVol_{jt}$ is defined as the inflation volatility of the country or country group using currency j. We expect $CPIVol_{jt}$ to be negative across currency groups.

According to Swoboda (1968), traders prefer a currency that has a thick foreign exchange market. Because of the smallness of a risk-averse trader relative to the market (atomicity), the risk of capital loss in a thick market is smaller than in a thin market.[20] We expect the size of the foreign exchange market of currency j (denoted by $SizeFX_{jt}$) to have a positive effect on currency share j. $SizeFX_{jt}$ is calculated as a 3-year moving average of the currency fractions taken from the Bank of International Settlement's triennial survey on foreign exchange market activity. As a country-specific variable, $SizeFX_{nt}$ denotes the size of the foreign exchange market of country n's currency. We expect $SizeFX_{nt}$ to have a positive effect on PCI and negative effect on VCI. Intuitively, a large foreign exchange market of the exporter's currency increases the use of his currency and reduces the need of a vehicle currency.

Baron (1976) was the first to argue that exporters will prefer to invoice in the currency whose relative price has the least volatility with a view to avoid revenue risk. Of course,

[20] Krugman (1980) and Magee and Rao (1980) elaborate formally on the role of the lower transaction costs in deep, resilient markets.

firms could use forward contracts and currency options to hedge currency risk, but these are rather expensive methods for small firms and are typically not available for long time spans.[21] The expected exchange rate volatility between the chosen currency j and the Norwegian krone $XVoltoNOK_{jt}$ is calculated as the coefficient of variation of the nominal exchange rate during the last four quarters. $XVoltoNOK_{jt}$ is expected to decrease the share of the chosen currency, irrespective of the currency group. As a country-specific variable, $XVoltoNOK_{nt}$ is the expected exchange rate volatility between country n's currency and the Norwegian krone. $XVoltoNOK_{nt}$ is expected to be negative for the LCI and PCI shares and positive for the VCI share. Intuitively, traders will shift away from LCI and PCI to a third currency with lower volatility relative to the Norwegian krone or their home currency. Similarly, we include $XVoltoPart_{jnt}$, which represents the expected exchange rate volatility between the chosen currency j and the producer's currency. This measure is also based on a four-quarter moving average of the coefficient of variation of the exchange rate. $XVoltoPart_{jnt}$ is expected to decrease the share of the chosen currency, again regardless of the currency type.[22]

3.2.3 Trade Variables

A country's market share is a key determinant of invoicing currency choice (cf. Swoboda, 1968; Bacchetta and Van Wincoop, 2005; and Ligthart and Da Silva, 2007). Bacchetta and Van Wincoop (2005) argue that a larger world trade share increases a country's market power and thus its ability to impose its currency upon the trading partner. $WorldTrade_{nt}$ denotes a country's world trade share, which is calculated as the sum of the value of goods exports and imports of country n divided by the sum of the value of world exports and imports. The effect of $WorldTrade_{nt}$ is expected to be positive for PCI relative to invoicing in the Norwegian krone (LCI). Because the need to use an international currency is reduced, the effect on VCI should be negative.

McKinnon (1979) finds that homogeneous products that are traded on organized exchanges

[21] Borsum and Odegaard (2005) survey Norwegian firms about their currency hedging practices and find that small firms use more primitive hedging methods such as invoicing in the home currency, whereas large firms use forward contracts and currency options.

[22] By construction $XVoltoNOK_{lt}$ for $l = \{n, j\}$ and $XVoltoPart_{jnt}$ are zero for LCI and PCI, respectively. $XVoltoPart_{jnt}$ is also the only variable that varies across currencies and countries.

(e.g., oil) are often priced and invoiced in leading vehicle currencies like the US dollar and the euro. In addition, firms producing differentiated goods under monopolistic competition have power to set their prices freely and invoice in their own currency. However, Krugman (1987) and Betts and Devereux (2000) point out that firms producing differentiated final goods have an incentive to 'price to market.' As a result, the share of differentiated products of partner country n, which we label $Diff_{nt}$, is expected to have a negative effect on VCI and an ambiguous effect on LCI and PCI. $Diff_{nt}$ is calculated as the sum of imported goods that are classified to be differentiated by the conservative specification of the Rauch index (cf. Rauch, 1999) divided by total value of Norwegian imports in that period.

To control for the composition of trade across countries, the partner country's share in total Norwegian trade $NorwayTrade_{nt}$ is included. In view of the gravity model (cf. Anderson, 1979), this variable captures the net effect on bilateral trade of distance (negative effect) and a country's Gross Domestic Product (positive effect). $NorwayTrade_{nt}$ is not likely to affect the preferences for either country's currency and, therefore, has an ambiguous effect on the trading partners' own currency shares (i.e., PCI and LCI). However, the effect on VCI is expected to be negative. Indeed, if goods markets of two economies are becoming more integrated there will be less need for a third currency.

4 Results

This section presents the econometric results. We start off with the benchmark model and subsequently present a robustness analysis. To allow for a proper inference of the variables' magnitudes, we derive average marginal effects.

4.1 Benchmark Specification

Table 5 reports results for the fixed effects benchmark model (labeled specification I), which includes all variables of Section 3.2. The left panel of the table presents the average marginal effects of country-specific variables for the currency groups LCI, PCI, and VCI.[23] Reported magnitudes represent the percentage point increase of currency share v with respect to a one

[23]Coefficient estimates are available upon request.

unit increase of the respective covariate. Variables showing significant marginal effects are inflation volatility ($CPIVol_{nt}$) for all three currency groups and the degree of differentiated products ($Diff_{nt}$) for LCI and VCI. The magnitudes of the inflation rate (CPI_{nt}) across currency groups are small and statistically insignificant for PCI and VCI. All three marginal effects of the $CPIVol_{nt}$ variable have their expected sign. An increase of one standard deviation in the inflation volatility of the exporter's economy reduces the share of PCI by 10.7 percentage points and increases the use of the local currency and vehicle currencies by 6.8 and 3.9 percentage points, respectively. Note that logit specification of the currency share function ensures that the sum of the marginal effects always equals zero. The effects for $Diff_{nt}$ are much smaller: A 10 percentage points increase in the share of differentiated products decreases the use of vehicle currencies by 5 percentage points and increases the use of the Norwegian krone by 5 percentage points. Hence, we find support for Krugman's (1987) pricing-to-market theory. This result may be due to the ecological inference problem (cf. King, 1997), which may occur in studies using aggregate data. Given that we do not have micro data, the large transaction sizes of large exporting firms—which are more likely to commit to large local outposts and hence are more likely to price to market—outweigh the small transaction sizes of small firms.

The right panel of Table 5 presents the average marginal effects of the currency-specific variables. Figures on the diagonal of each matrix represent the own effect and figures off the diagonal denote cross effects (i.e., with respect to the other currency groups). We find significant marginal effects for EUR_{jt} and $EuroControl_{jt}$. If the chosen currency is the euro, then its share increases by 2.6 percentage points when used as a producer currency (see the middle cell on the diagonal for the EUR_{jt} dummy), whereas if it is chosen as a vehicle currency its share increases by almost 3 percentage points (see the bottom cell on the diagonal). Interestingly, as a counterfactual exercise, if the Norwegian krone were part of the eurozone, its share would increase by 3.6 percentage points (see the first cell on the diagonal). The coefficient of $EuroControl_{jt}$ indicates the speed of transition from a the respective national legacy currency to the euro (or to any other currency). If the exporter's currency is a currency of the eurozone, then it reduces its invoicing share of the national legacy currency in any quarter between 1999 and 2001 by 2.1 percentage points and its invoicing share of vehicle currencies by 2.4 percentage points.

The pseudo R^2 of the fixed effects model is almost 0.4, which is rather high for this type of nonlinear model, and is much larger than the model with country-specific covariates only (see Section 4.2). Finally, in view of the substantial change in invoicing practices after euro introduction, we ran a structural break test with unknown change point as in Andrews (1993). We did not find evidence of a structural break, suggesting that our covariates account well enough for the change.[24]

4.2 Alternative Specifications

Table 5 considers a pooled model that estimates a common intercept across countries (which we label specification II). The model includes all variables of the benchmark model. Compared to the fixed effects model, we can see that the set of significant marginal effects expands. Within the set of country-specific marginal effects, we find that invoicing shares are affected by CPI_{nt} and $CPIVol_{nt}$ for LCI, PCI, and VCI, $Diff_{nt}$ for LCI and PCI, and $NorwayTrade_{nt}$ for PCI and VCI. The marginal effect of $CPIVol_{nt}$ for PCI is doubled compared to the fixed effects specification. Rather large is the inflation volatility effect, which also doubles. The marginal effect of CPI_{nt} has the same sign but is much smaller than that of $CPIVol_{nt}$. As expected, $NorwayTrade_{nt}$ decreases the share of vehicle currency invoicing in Norwegian imports. The marginal effects of the currency-specific variables EUR_{jt}, $EuroControl_{jt}$, and $SizeFX_{jt}$ are significant. The magnitudes for EUR_{jt} increase from 2.6 percentage points in the benchmark case to 5.8 percentage points for PCI and from 3 percentage points to 6 percentage points for VCI. A 10 percentage points increase of a currency's foreign exchange market share increases its PCI and VCI share by 2 percentage points, which is a rather small magnitude.

One could argue that exporting firms located in a country whose currency has a deep and resilient foreign exchange market prefer their own currency and choose less often a vehicle currency; that is, $SizeFX_{nt}$ is a country-specific variable rather than a currency-specific vari-

[24]Results of the structural break test are available upon request.

able. We could also test whether traders choose a currency that has the least inflation volatility. Specifying inflation volatility as a currency-specific variable ($CPIVol_{jt}$) captures inflation volatility of the producer's currency relative to any other country's inflation volatility including Norway's.[25] Specification III considers a fixed effects model in which we include $CPIVol_{jt}$ and $SizeFX_{nt}$ instead of $CPIVol_{nt}$ and $SizeFX_{jt}$ (Table 5). Significant country-specific marginal effects are $SizeFX_{nt}$ for LCI, PCI and VCI, CPI_{nt} for LCI and PCI and $Diff_{nt}$ for LCI and VCI. A 10 percentage point increase in the size of the partner currency's foreign exchange market leads to an increase of 6 percentage points of the producer currency's share, a fall of almost 2 percentage points of the local currency share, and a decrease of around 4 percentage points of vehicle currencies. In addition, we see that the marginal effects of the currency-specific variables EUR_{jt}, $EuroControl_{jt}$, and $CPIVol_{jt}$ are significant. The magnitude of $CPIVol_{jt}$ as a currency-specific variable is much lower than that as a country-specific variable. An increase of Norway's inflation volatility by one standard deviation reduces the invoicing share of the Norwegian krone by less than one percentage point. The same increase of inflation volatility of the exporter's currency reduces the invoicing share of the exporting firm by less than half of a percentage point.

Specification IV in Table 5 presents results for the pooled model, in which we assume that all explanatory variables are country specific. Interestingly, almost all the marginal effects of the variables are significant and bear the expected sign. The magnitude of the average marginal effect of the euro dummy is much larger than in the benchmark model: A country's membership of the eurozone increases PCI by 19 percentage points. Intuitively, there is much more cross-sectional variation in the country-specific EUR_nt dummy than in the currency-specific EUR_jt dummy. In addition, the presence of unobserved country-specific fixed effects that are correlated with the euro dummy may overstate the euro effect. The unobserved euro effect reduces VCI by almost 20 percentage points, suggesting that eurozone countries have been substituting away from vehicle currency use. However, this is only part of the story given that the drop in inflation volatility boosted the PCI shares of eurozone countries. The marginal effects of inflation and inflation volatility have similar magnitudes

[25] Devereux, Engel, and Storgaard (2004) argue that a country's inflation volatility only matters with respect to its trading partner's inflation volatility.

and signs as in specifications I and II. In addition to the already identified variables, we find $WorldTrade_{nt}$ and $XVoltoNOK_{nt}$ for LCI and VCI to be significant. A one percentage point increase of $WorldTrade_{nt}$ increases PCI by 8 percentage points, whereas LCI decreases by almost 13 percentage points. In line with expectations, $XVoltoNOK_{nt}$ reduces LCI and PCI and increases vehicle currency use. Compared to the benchmark specification, the pseudo R^2 is of the model is rather low.

Specification V in Table 5 also considers country-specific variables only, but focuses on the fixed-effects model. We find roughly the same set of significant variables as in specification III. Compared to the pooled model, the magnitudes of the marginal effects are greatly reduced. A country's membership of the eurozone now increases PCI by only 10.7 percentage points, suggesting that time-invariant country-specific factors contribute substantially to explaining the size of the PCI share. The model's pseudo R^2 is with 0.22 larger than its pooled counterpart, but still considerably lower than the benchmark specification.

4.3 Euro Effects on PCI for Individual Countries

Our results of the previous section suggest that the PCI share increases as a country's inflation volatility decreases or if the exporter's currency joins the euro. The fall in inflation volatility can be viewed as an observed indirect effect of euro introduction. Do our results imply that all eurozone countries that introduced the euro will have experienced an increase in PCI from doing so? What would have been the increase in the PCI share of a non-eurozone country if it were to adopt the euro? To answer these questions, this section uses the estimated fixed effects model to derive country-specific predictions as to the effect of euro introduction. We study the effect of euro introduction on the PCI shares of two very different eurozone countries, that is, Germany and Italy. The latter country is representative of a group of eurozone countries (i.e., Portugal, Ireland, Italy, Greece, and Spain, also known as PIIGS), which experienced higher inflation volatilities and lower PCI shares than their eurozone partner countries (like Germany) before the introduction of the euro.

Just before the introduction of the euro (during 1996Q1–1998Q4), Germany had a comparatively low average inflation volatility of 0.25 and a PCI share of 75 percent. On the other hand, Italy had twice the inflation volatility of Germany (0.5 on average) and a lower PCI share of 39 percent. We calculate Germany's marginal PCI effect with respect to inflation volatility in 1998 and find that an increase of 0.25 standard deviations—taking Germany's *CPIVol* to Italy's level—will decrease PCI by 4 percentage points. In addition, if Germany had introduced the euro in 1998, its PCI share would have increased by 4.1 percentage points, which exceeds the marginal effect of 2.6 percent found for all countries. Italy's marginal PCI effect shows that a reduction of its inflation volatility to Germany's level of 0.25 increases its PCI share by 4.3 percentage points. If Italy had the euro as a home currency in 1998, its PCI share would have increased by 4.3 percentage points, suggesting that Italy and Germany experienced almost the same unobserved euro effect. In 2006, Germany maintained its low inflation volatility at 0.25 and also kept its PCI share at around 77 percent. However, Italy reduced its inflation volatility to 0.25 and increased its PCI share to 73 percent. The other PIIGS reduced their inflation volatilities and increase their PCI shares to the levels of the rest of the eurozone.

There is a set of non-eurozone countries that exhibit very high average inflation volatilities: Turkey (6.23), Mexico (2.19), Czech Republic (1.14), Korea (0.81), Hungary (1.24), Poland (1.44), and the Slovak Republic (1.52). Interestingly, all of these countries have a zero or negligible PCI share. We can simulate what happens to the PCI share of those countries if they were to reduce their inflation volatilities or to adopt the euro as their home currency. If Poland had replaced the Polish zloty by the euro in 1998, its PCI share would have increased by 0.11 percentage points. Poland's average inflation volatility during 1996Q1–1998Q4 in that same year amounted to 2.0. If Poland had cut its average inflation volatility to the level of Italy in 1998, its PCI share would have increased by 0.66 percentage points.[26] However, not all non-eurozone countries are alike. The United Kingdom experienced a much lower average inflation volatility (0.37) during 1996Q1–1998Q4. Cutting the United Kingdom's inflation volatility to the level of Germany, increases its PCI share by 2.1 percentage points. If the United Kingdom had joined the eurozone in 1998, its PCI share would have risen by 4.3

[26]Countries with very small PCI shares have much smaller marginal effects of euro introduction, reflecting that: (i) the predicted probabilities lie within the $[0, 1]$ range; and (ii) the distribution function is sigmoid curved.

percentage points.

5 Conclusions

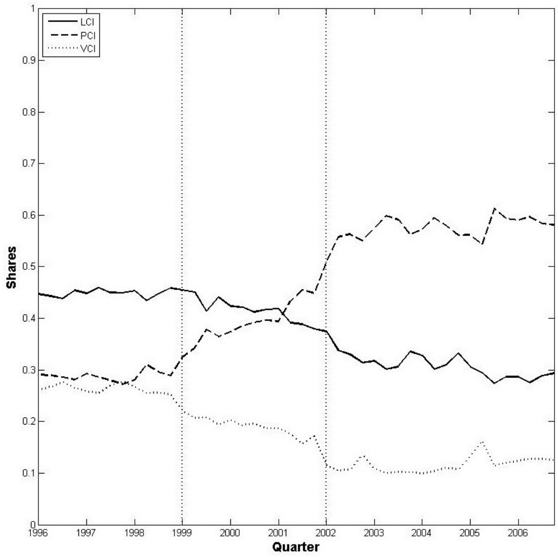
The paper analyzes the effect of euro introduction on the pattern of invoicing currency choice in international goods trade. To this end, we use quarterly data on the currency composition of Norwegian imports from OECD countries covering the period 1996–2006. We distinguish 31 currencies and calculate the corresponding bilateral currency shares rather than focusing on a single currency share or currency groups. This approach allows to capture substitution effects between currencies owing to euro introduction. Currency shares are explained by currency-specific variables as well as by country-specific variables while controlling for unobserved country heterogeneity.

The descriptive analysis shows that euro introduction increased the home currency share of eurozone exporters (so-called producer currency invoicing) at the expense of the Norwegian krone and vehicle currencies. In contrast, non-eurozone exporters experienced a slight fall in their producer currency share. However, the rise in the producer currency share of eurozone countries can only be partly attributed to a substitution from eurozone vehicle currencies to the euro. We also find that the euro has replaced the US dollar as the dominant currency in the group of vehicle currencies. The results for the fixed effects benchmark model reveal that the substantial rise in the share of producer currency invoicing by eurozone countries is primarily caused by a drop in inflation volatility and can only to a small extent be explained by an unobserved euro effect. The introduction of the euro increases the share of producer currency invoicing by eurozone countries by only 2.6 percentage points. If the euro is chosen as a vehicle currency by non-eurozone countries its share rises by 3 percentage points. This unobserved euro effect only materialized gradually, reflecting the three-year transition phase. In the pooled model, invoicing in producer currencies increases if the size of the foreign exchange market is large, the degree of product differentiation is small, and the rate of inflation is low. The world trade share of a country is only significantly positive in a pooled model with country-specific variables.

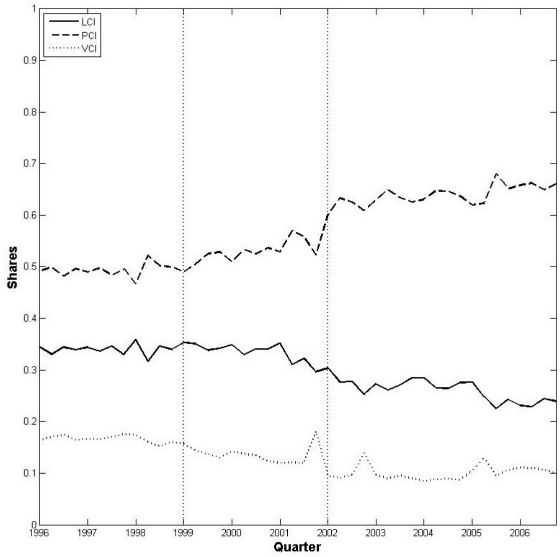
Future research could focus on invoicing transactions at the firm level, potentially via a survey of eurozone firms. Such a micro-based approach has the advantage that information on firm size and transaction volumes can be used in the analysis. Second, to check the robustness of the findings, invoicing data for other countries than Norway could be analyzed.

Figure 1: Currency Group Shares in Norwegian Imports

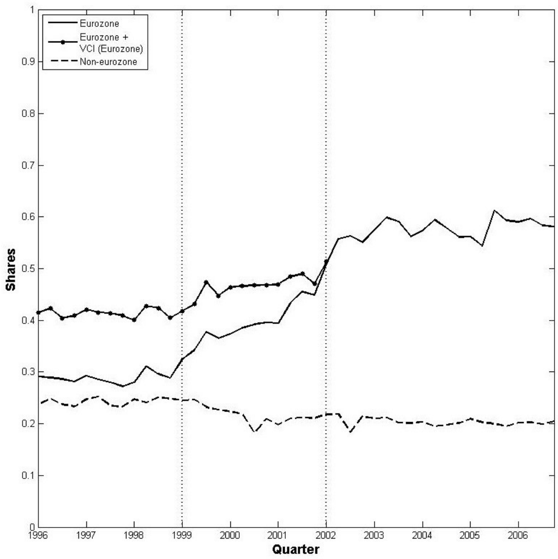
(a) Eurozone countries (equally weighted)



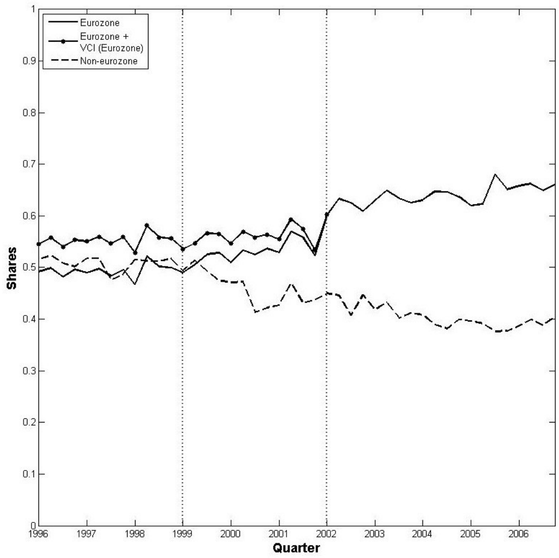
(b) Eurozone countries (trade weighted)



(c) Euro and non-euro (equally weighted)



(d) Euro and non-euro (trade weighted)



Notes: The data in Panels (a) and (b) pertain to all countries in the eurozone. The thick solid line represents the share of local currency invoicing (LCI), the dashed line denotes the share of producer currency invoicing (PCI), the dotted line depicts the share of vehicle currency invoicing (VCI). The data in Panels (c) and (d) cover all OECD countries excluding Norway, where a distinction is made between eurozone and non-eurozone countries. The thick solid line represents the share of PCI of countries in the eurozone and the dashed line denotes PCI of non-eurozone countries. The bullet pointed line denotes the sum of PCI and eurozone VCI. The first vertical line indicates the introduction of the euro in non-cash form and the second vertical line represents the introduction of the euro in cash transactions.

Table 1: Currency Group Shares by OECD Country, Averages for 1996–2006 (in Percent)

Country	Import Share	Currency Shares		
		LCI	PCI	VCI
Sweden	15.619	43.239	45.880	10.881
Germany*	13.842	19.677	73.516	6.807
United Kingdom	8.074	27.694	43.359	28.947
Denmark	7.367	37.217	45.492	17.291
United States	6.400	16.121	71.487	12.392
Netherlands*	4.522	27.144	53.956	18.900
France*	4.479	31.630	55.079	13.291
Italy*	3.771	31.586	55.709	12.705
Finland*	3.480	61.422	33.262	5.316
Japan	3.415	38.116	21.798	40.085
Canada	2.378	4.378	75.311	20.311
Belgium*	2.290	36.963	42.542	20.495
Spain*	1.618	34.442	49.668	15.891
Ireland*	1.457	33.957	16.198	49.845
Poland	1.234	38.228	1.673	60.099
Switzerland	1.229	25.808	45.922	28.271
Austria*	0.912	28.854	60.444	10.702
Korea	0.713	24.273	0	75.727
Czech Republic	0.580	57.197	0.880	41.923
Portugal*	0.575	55.399	30.513	14.089
Turkey	0.517	37.776	0	62.224
Hungary	0.408	49.612	0	50.388
Iceland	0.249	56.708	1.707	41.585
Australia	0.216	9.470	9.244	81.286
Mexico	0.129	29.698	0	70.302
Greece*	0.127	42.195	34.570	23.235
Slovak Republic	0.117	44.067	0	55.933
Luxembourg*	0.075	49.308	29.625	21.066
New Zealand	0.043	35.562	7.911	56.528
Average (equally weighted)	2.960	35.439	31.233	33.328

Notes: The first column with figures denotes the partner country's share in imports from all countries. To conserve on space, columns (2)–(4) report the currency shares for three aggregate currency groups using equation (2): LCI, PCI, and VCI refers to the invoicing share of the local currency (Norwegian krone), currencies of partner countries (i.e., the producer currencies), and vehicle currencies, respectively. An asterisk indicates that the country is a member of the eurozone on January 1, 2002. All currency fractions are averaged across 1996–2006 and expressed in percentages.

Table 2: Vehicle Currency Shares, 1996 and 2006 (in Percent)

Year	Currencies	Share of All Currencies	Share of All Vehicle Currencies
1996	Total	37.4666	100.0000
	US dollar	19.7697	52.7662
	Eurozone	12.0287	32.1052
	German mark	10.1230	27.0186
	Dutch guilder	0.6693	1.7864
	Belgian franc	0.4894	1.3062
	ECU	0.3444	0.9192
	Austrian schilling	0.1645	0.4392
	French franc	0.1381	0.3685
	Finnish mark	0.0529	0.1411
	Italian lira	0.0258	0.0689
	Irish pound	0.0113	0.0302
	Spanish peseta	0.0072	0.0193
	Portuguese escudo	0.0028	0.0075
	Non-eurozone	5.6682	15.1286
	Swedish krona	3.4730	9.2697
	Danish krone	1.1570	3.0881
	Pound sterling	0.7503	2.0026
	Swiss franc	0.2421	0.6463
	Japanese yen	0.0389	0.1037
	Canadian dollar	0.0060	0.0160
	Australian dollar	0.0007	0.0018
	Iceland krona	0.0001	0.0003
2006	Total	30.9928	100.0000
	Euro	14.6061	47.1274
	US dollar	12.8751	41.5424
	Swedish krona	2.1265	6.8612
	Danish krone	0.9188	2.9644
	Pound sterling	0.3650	1.1777
	Swiss franc	0.0533	0.1721
	Japanese yen	0.0237	0.0763
	Canadian dollar	0.0175	0.0566
	Czech koruna	0.0027	0.0087
	Polish zloty	0.0025	0.0080
	Australian dollar	0.0015	0.0047
	New Zealand dollar	0.0001	0.0003
	Iceland krona	0.0000	0.0001

Notes: The first column with data presents the average trade-weighted currency shares with respect to all currencies, whereas the second column shows the currency shares with respect to all vehicle currencies. All currency fractions are expressed in percentages.

Table 3: Average Marginal Effects for the Benchmark Model (Specification I)

Country Specific

LCI	
CPI	0.0061*
	(0.0032)
CPIVol	0.0678***
	(0.0127)
WorldTrade	-0.0002
	(0.0316)
NorwayTrade	-0.0002
	(0.0089)
Diff	0.0051**
	(0.0024)
PCI	
CPI	-0.0066
	(0.0048)
CPIVol	-0.1068***
	(0.0200)
WorldTrade	0.0006
	(0.0270)
NorwayTrade	0.0025
	(0.0090)
Diff	0.0002
	(0.0012)
VCI	
CPI	0.0005
	(0.0020)
CPIVol	0.0388***
	(0.0124)
WorldTrade	-0.0004
	(0.0334)
NorwayTrade	-0.0023
	(0.0115)
Diff	-0.0053***
	(0.0014)
Diagnostics	
Observations	1,276
Log-Likelihood	-2,493.17
Pseudo R^2	0.39

Currency Specific

	LCI	**PCI**	**VCI**
EUR			
LCI	0.0361***	-0.0164***	-0.0197*
	(0.0046)	(0.0022)	(0.0114)
PCI		0.0263***	-0.0098***
		(0.0035)	(0.0029)
VCI			0.0296***
			(0.0050)
EuroControl†			
LCI	-0.029***	0.0131***	0.0158
	(0.0059)	(0.0027)	(0.0097)
PCI		-0.0211***	0.0079***
		(0.0044)	(0.0027)
VCI			-0.0238***
			(0.0053)
SizeFX			
LCI	0.0002	-0.0001	-0.0001
	(0.0002)	(0.0001)	(0.0002)
PCI		0.0001	-0.0001
		(0.0002)	(0.0001)
VCI			0.0002
			(0.0002)
XVoltoNOK			
LCI	0.1052	-0.0476	-0.0574
	(0.0761)	(0.0346)	(0.0549)
PCI		0.0764	-0.0287
		(0.0556)	(0.0237)
VCI			0.0862
			(0.0651)
XVoltoPart			
LCI	-0.1342	0.0608	0.0732
	(0.0841)	(0.0384)	(0.0662)
PCI		-0.0975	0.0366
		(0.0617)	(0.0269)
VCI			-0.1100
			(0.0718)

Notes: The dependent variable denotes currency share j of country n at time t. The left-hand side gives the average marginal effects for the country-specific variables, whereas the right-hand side presents the average marginal effects for the currency-specific variables. The latter panel presents on the diagonal the elasticities with respect to the own currency group and reports off-diagonal the elasticities with respect to the other currency group (i.e., PCI, LCI, and VCI). ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. Robust standard errors are reported in parentheses below the estimated average marginal effects. A † indicates that we have averaged the *EuroControl* dummy across all n countries and $t = 1999Q1, ..., 2001Q4$ (i.e., the transition period).

Table 4: Average Marginal Effects for Specification II

Country Specific		Currency Specific			
LCI		*EUR*			
			LCI	**PCI**	**VCI**
CPI	0.0211***	**LCI**	0.0737***	-0.0355***	-0.0375*
	(0.0027)		(0.0051)	(0.0027)	(0.0213)
CPIVol	0.1225***	**PCI**		0.0576***	-0.0218**
	(0.0181)			(0.0042)	(0.0100)
WorldTrade	-0.0022	**VCI**			0.0600***
	(0.0078)				(0.0145)
NorwayTrade	-0.0021				
	(0.0046)	*EuroControl*†			
Diff	0.0019***		**LCI**	**PCI**	**VCI**
	(0.0005)	**LCI**	-0.0444***	0.0214***	0.0226*
			(0.0066)	(0.0033)	(0.0136)
PCI		**PCI**		-0.0347***	0.0131**
				(0.0052)	(0.0066)
CPI	-0.0352***	**VCI**			-0.0361***
	(0.0044)				(0.0105)
CPIVol	-0.2060***				
	(0.0289)	*SizeFX*			
WorldTrade	0.0057		**LCI**	**PCI**	**VCI**
	(0.0077)	**LCI**	0.0025***	-0.0012***	-0.0013*
NorwayTrade	0.0242***		(0.0002)	(0.0001)	(0.0008)
	(0.0028)	**PCI**		0.0020***	-0.0007**
Diff	-0.0021***			(0.0001)	(0.0004)
	(0.0005)	**VCI**			0.0021***
					(0.0005)
VCI					
		XVoltoNOK			
CPI	0.0139**		**LCI**	**PCI**	**VCI**
	(0.0060)	**LCI**	-0.1760*	0.0847*	0.0896
CPIVol	0.0823**		(0.1036)	(0.0493)	(0.0582)
	(0.0362)	**PCI**		-0.1377*	0.0521*
WorldTrade	-0.0035			(0.0804)	(0.0306)
	(0.0055)	**VCI**			-0.1432*
NorwayTrade	-0.0221***				(0.0785)
	(0.0060)				
Diff	0.0002	*XVoltoPart*			
	(0.0004)		**LCI**	**PCI**	**VCI**
		LCI	0.0340	-0.0164	-0.0173
Diagnostics			(0.1017)	(0.0488)	(0.0488)
		PCI		0.0266	-0.0101
Observations	1,276			(0.0794)	(0.0285)
Log-Likelihood	-2,614.15	**VCI**			0.0277
Pseudo R^2	0.36				(0.0804)

Notes: The dependent variable denotes currency share j of country n at time t. The left-hand side gives the average marginal effects for the country-specific variables, whereas the right-hand side presents the average marginal effects for the currency-specific variables. The latter panel presents on the diagonal the elasticities with respect to the own currency group and reports off-diagonal the elasticities with respect to the other currency group (i.e., PCI, LCI, and VCI). ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. Robust standard errors are reported in parentheses below the estimated average marginal effects. A † indicates that we have averaged the *EuroControl* dummy across all n countries and $t = 1999Q1, ..., 2001Q4$ (i.e., the transition period).

Table 5: Average Marginal Effects for Specification III

Country Specific	
LCI	
CPI	0.0108***
	(0.0028)
SizeFX	-0.0019**
	(0.0009)
WorldTrade	-0.0002
	(0.0324)
NorwayTrade	-0.0001
	(0.0089)
Diff	0.0054***
	(0.0020)
PCI	
CPI	-0.0137***
	(0.0043)
SizeFX	0.0061***
	(0.0007)
WorldTrade	0.0005
	(0.0286)
NorwayTrade	0.0021
	(0.0089)
Diff	-0.0004
	(0.0011)
VCI	
CPI	0.0028
	(0.0020)
SizeFX	-0.0042***
	(0.0009)
WorldTrade	-0.0003
	(0.0336)
NorwayTrade	-0.0020
	(0.0118)
Diff	-0.0050***
	(0.0013)
Diagnostics	
Observations	1,276
Log-Likelihood	-2,252.63
Pseudo R^2	0.39

Currency Specific			
EUR			
	LCI	**PCI**	**VCI**
LCI	0.0194***	-0.0087***	-0.0107*
	(0.0044)	(0.0020)	(0.0055)
PCI		0.0139***	-0.0052***
		(0.0032)	(0.0017)
VCI			0.0159***
			(0.0040)
EuroControl†			
	LCI	**PCI**	**VCI**
LCI	-0.0382***	0.0171***	0.0211***
	(0.0050)	(0.0022)	(0.0082)
PCI		-0.0274***	0.0102***
		(0.0036)	(0.0023)
VCI			-0.0314***
			(0.0055)
CPIVol			
	LCI	**PCI**	**VCI**
LCI	-0.0060***	0.0027***	0.0033**
	(0.0012)	(0.0006)	(0.0016)
PCI		-0.0043***	0.0016***
		(0.0009)	(0.0005)
VCI			-0.0049***
			(0.0012)
XVoltoNOK			
	LCI	**PCI**	**VCI**
LCI	0.1298	-0.0581	-0.0715
	(0.0839)	(0.0378)	(0.0612)
PCI		0.0930	-0.0347
		(0.0607)	(0.0264)
VCI			0.1064
			(0.0719)
XVoltoPart			
	LCI	**PCI**	**VCI**
LCI	-0.0348	0.0156	0.0191
	(0.0862)	(0.0387)	(0.0498)
PCI		-0.0249	0.0093
		(0.0619)	(0.0237)
VCI			-0.0285
			(0.0712)

Notes: The dependent variable denotes currency share j of country n at time t. The left-hand side gives the average marginal effects for the country-specific variables, whereas the right-hand side presents the average marginal effects for the currency-specific variables. The latter panel presents on the diagonal the elasticities with respect to the own currency group and reports off-diagonal the elasticities with respect to the other currency group (i.e., PCI, LCI, and VCI). ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. Robust standard errors are reported in parentheses below the estimated average marginal effects. A † indicates that we have averaged the *EuroControl* dummy across all n countries and $t = 1999Q1, ..., 2001Q4$ (i.e., the transition period).

Table 6: Average Marginal Effects for Specifications IV and V

	(IV)	(V)
LCI		
EUR	0.0039	0.0153
	(0.0310)	(0.0280)
CPI	0.0145***	0.0029
	(0.0021)	(0.0025)
CPIVol	0.0632***	0.0366***
	(0.0141)	(0.0095)
SizeFX	0.0017	-0.0033**
	(0.0018)	(0.0016)
XVoltoNOK	-0.7791***	-0.2333
	(0.2788)	(0.1476)
WorldTrade	-0.1275***	-0.0022
	(0.0103)	(0.0192)
NorwayTrade	0.0110***	-0.0033
	(0.0011)	(0.0074)
Diff	0.0009***	0.0006
	(0.0002)	(0.0007)
PCI		
EUR	0.1902***	0.1067***
	(0.0319)	(0.0272)
CPI	-0.0238***	-0.0057
	(0.0035)	(0.0039)
CPIVol	-0.1078***	-0.0570***
	(0.0229)	(0.0148)
SizeFX	0.0007	0.0033**
	(0.0019)	(0.0016)
XVoltoNOK	-0.1796	0.2522
	(0.3654)	(0.2001)
WorldTrade	0.0793***	0.0051
	(0.0143)	(0.0207)
NorwayTrade	0.0182***	0.0088
	(0.0013)	(0.0072)
Diff	-0.0013***	0.0004
	(0.0003)	(0.0008)
VCI		
EUR	-0.1941***	-0.1220***
	(0.0299)	(0.0190)
CPI	0.0094***	0.0028
	(0.0014)	(0.0015)
CPIVol	0.0446***	0.0204***
	(0.0102)	(0.0060)
SizeFX	-0.0024	0.0000
	(0.0018)	(0.0011)
XVoltoNOK	0.9587***	-0.0189
	(0.2452)	(0.1230)
WorldTrade	0.0483***	-0.0029
	(0.0118)	(0.0223)
NorwayTrade	-0.0291***	-0.0055
	(0.0015)	(0.0101)
Diff	0.0005***	-0.0010
	(0.0002)	(0.0006)
Diagnostics		
Observations	1,276	1,276
Log-Likelihood	-1,189.94	-1,088.97
Pseudo R^2	0.15	0.22

Notes: The dependent variable denotes currency share j of country n at time t. The columns present the average marginal effects for country-specific variables only. ***, **, * denote significance at the 1, 5 or 10 percent level, respectively. Robust standard errors are reported in parentheses below the estimated average marginal effects.

Appendix

A.1 Currency Shares

We know from maximum likelihood theory that the expected value of the score at the true parameter value $\boldsymbol{\theta}$ is zero:[27]

$$\mathrm{E}_0[\mathbf{g}_{nt}(\boldsymbol{\theta})] = \mathbf{0}, \tag{A.1}$$

where the scores are given by:

$$\mathbf{g}_{nt}(\boldsymbol{\theta}) = \frac{\partial \ln \mathrm{S}_{nt}(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}}, \tag{A.2}$$

and $\boldsymbol{\theta}$ is the parameter vector. The observation's score with respect to the currency-specific vector $\boldsymbol{\alpha}$ is:

$$\frac{\partial \sum_{j=1}^{J} s_{jnt} \ln \hat{\mathrm{S}}_{jnt}}{\partial \boldsymbol{\alpha}} = \mathbf{Z}'_{nt}(\boldsymbol{s}_{nt} - \hat{\mathrm{S}}_{nt}), \tag{A.3}$$

where both vectors $\boldsymbol{s}_{nt}$ and $\hat{\mathrm{S}}_{nt}$ have dimension $J \times 1$. The observation's score with respect to the country-specific vector $\boldsymbol{\beta}_v$ is:

$$\frac{\partial \sum_{j=1}^{J} s_{jnt} \ln \hat{\mathrm{S}}_{jnt}}{\partial \boldsymbol{\beta}_v} = \mathbf{x}_{nt} \sum_{j=1}^{J_v} (s_{jnt} - \hat{\mathrm{S}}_{jnt}), \tag{A.4}$$

where J_v is the number of currencies in currency group v. Since $\mathbf{Z}_{nt}$ and $\mathbf{x}_{jnt}$ are non-zero, equality (A.1) only holds true when $s_{jnt} = \hat{\mathrm{S}}_{jnt}$ for all j. Note that the scores used by Papke and Wooldridge (1996) are a special case of equation (A.4) with $J = 2$ and no currency groups; that is, $\mathbf{x}_{jnt}(s_{jnt} - \hat{\mathrm{S}}_{jnt})$.

A.2 Average Marginal Effects

In nonlinear models like ours, the marginal effect measures the effect of a change in the regressor on the conditional probability that a currency is chosen with unit probability. There are different ways to measure marginal effects because they vary with the point of evaluation. The most common form is the marginal effect at the sample mean of the regressors,[28] which is a rough measure of the sign of the coefficient, but its magnitude is hardly interpretable.

[27] The Matlab program code is available upon request.

[28] This marginal effect can be computed in Stata by using the command *mfx*.

Alternatively, for policy analysis, using the *average* marginal effect is more meaningful. The average marginal effects for the explanatory variables inform us directly about the average increase in the currency share, since the estimated probabilities are the predicted currency shares.

For currency-specific variables, the average marginal effect for currency group v is calculated by averaging over the change in the predicted probability across countries and time periods:

$$\frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}\frac{\partial \hat{\mathrm{S}}_{vnt}}{\partial z_{knrt}}, \tag{A.5}$$

where

$$\hat{\mathrm{S}}_{vnt}=\sum_{j=1}^{J_v}\hat{\mathrm{S}}_{jnt}, \tag{A.6}$$

is the predicted group share summed across the predicted currency shares in group v with J_v currencies. Equation (A.5) shows the change in the share function of choosing currency group v when the rth currency-specific explanatory variable increases by one unit for currency group k but does not change for the other currency groups. For country-specific variables, we find

$$\frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}\frac{\partial \hat{\mathrm{S}}_{vnt}}{\partial x_{nrt}}, \tag{A.7}$$

which represents the change in the predicted share of currency group v when the rth country-specific explanatory variable increases by one unit.

Because logit probabilities have closed-form solutions, the marginal effects for (A.5) can be stated explicitly as:

$$\frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}\hat{\mathrm{S}}_{vnt}(1-\hat{\mathrm{S}}_{knt})\hat{\beta}_r, \tag{A.8}$$

when $k=v$ and

$$\frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}(-\hat{\mathrm{S}}_{vnt})\hat{\mathrm{S}}_{knt}\hat{\beta}_r, \tag{A.9}$$

when $k\neq v$.

In the case of dummy variables (denoted by d) such as EUR_{jt} and $EuroControl_{jt}$ the average marginal effect for currency-specific variables is calculated as:

$$\frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}\left[\hat{\mathrm{S}}_{vnt}(\cdot|d=1)-\hat{\mathrm{S}}_{unt}(\cdot|d=0)\right], \tag{A.10}$$

when $u=v$ and

$$\frac{1}{NT}\sum_{n=1}^{N}\sum_{t=1}^{T}\left[\hat{\mathrm{S}}_{vnt}(\cdot|d=1)-\hat{\mathrm{S}}_{knt}(\cdot|d=0)\right], \tag{A.11}$$

when $k \neq v$. To arrive at the marginal effect of $EuroControl_{jt}$, we average across the transition period only.

To compute the marginal effect at a representative value of a covariate for a particular currency group, we use the choice probabilities for the respective currency group, country, and time period. The marginal effects will be as set out in (A.8)–(A.11), but without averaging across time periods and countries.

Table A.1: Data Description and Sources

Variable	Description	Primary Source
s_{jnt}	Fraction of Norwegian goods imports from partner country n that is invoiced in currency j at time t. The currency shares are calculated from aggregated bilateral import values using equation (1) of the main text. Because the bilateral import values (m_{jnt}) are reported in the Norwegian krone (NOK), we apply an exchange rate adjustment: $m^A_{jnt} = \frac{X_{jt}}{X_{j1996}} m^R_{jnt}$, where X_{jt} denotes the period average exchange rate of currency j with respect to the Norwegian krone at time t and the superscripts A and R denote adjusted and reported, respectively.	The currency shares are derived from customs data provided by Statistics Norway. The period average exchange rates are taken from the IMF's (2009) *International Financial Statistics* (IFS).
EUR_{nt}	Dummy variable taking on a value of one if the partner country n is part of the eurozone.	European Central Bank (ECB) http://www.ecb.int/
EUR_{jt}	Dummy variable taking on a value of one if the chosen currency j is part of the eurozone or is the euro itself.	ECB http://www.ecb.int/
$EuroControl_{jt}$	Dummy variable taking on a value of one if the chosen currency j is one of the legacy currencies between January 1, 1999 and December 31, 2001.	ECB http://www.ecb.int/
CPI_{nt}	Expected inflation rate of partner country n at time t (in percent). Calculated as a 4-period moving average of the consumer price index (CPI) of country n.	IMF's IFS http://www.imfstatistics.org/imf/
$CPIVol_{nt}$	Expected inflation volatility of partner country n at time t. Calculated as the standard deviation of the CPI of the four preceding quarters.	IMF's IFS http://www.imfstatistics.org/imf/
$CPIVol_{jt}$	Expected inflation volatility of partner country n or country group using currency j at time t. Calculated as the standard deviation of the CPI of the four preceding quarters.	IMF's IFS http://www.imfstatistics.org/imf/

Continued on next page

Table A.1: Data Description and Sources (Continued)

Variable	Description	Primary Source
$SizeFX_{nt}$	Depth of the foreign exchange market of the currency of country n at time t. Calculated based on the *Triennial Central Bank Survey: Foreign Exchange and Derivatives Market Activity* conducted by the Bank for International Settlements (BIS). The survey reports the currency distribution of foreign exchange market turnover during a given day. A 3-year moving average of fractions of the individual currencies is used to determine the foreign exchange market depth. Surveys relevant to our study were conducted in 1995, 1998, 2001, 2004, and 2007. Missing years were interpolated.	BIS http://www.bis.org/statistics
$SizeFX_{jt}$	Depth of the foreign exchange market of currency j at time t. See above.	BIS http://www.bis.org/statistics
$XVoltoNOK_{nt}$	Expected volatility of the exchange rate of the Norwegian krone (NOK) with respect to the currency of country n time t. Calculated as the coefficient of variation of the four preceding quarters.	IMF's IFS http://www.imfstatistics.org/imf/
$XVoltoNOK_{jt}$	Expected volatility of the exchange rate of the Norwegian krone (NOK) with respect to the chosen currency j at time t. Calculated as the coefficient of variation of the four preceding quarters.	IMF's IFS http://www.imfstatistics.org/imf/
$XVoltoPart_{jnt}$	Expected volatility of the exchange rate of the producer currency with respect to the chosen currency j at time t. Calculated as the coefficient of variation of the four preceding quarters.	IMF's IFS http://www.imfstatistics.org/imf/
$WorldTrade_{nt}$	World trade share of country n at time t (in percent). Defined as the sum of the value of goods exports and imports of country n divided by the sum of the value of world exports and imports.	OECD trade data http://www.oecd.org/statsportal/
$NorwayTrade_{nt}$	Goods trade share of country n with Norway at time t (in percent). Defined as the sum of country n's value of exports to and imports from Norway divided by the sum of Norway's goods exports and imports.	Statistics Norway http://www.ssb.no/en/
$Diff_{nt}$	Share of differentiated goods in Norwegian imports from country n in year t (in percent). Calculated as the sum of imported goods that are classified (based on SITC 4) to be differentiated by the conservative specification of the Rauch-Index (cf. Rauch, 1999) divided by total value of Norwegian imports in that period.	Statistics Norway http://www.ssb.no/en/

Table A.2: Descriptive Statistics

	Obs	Mean	St. dev	Min	Max
Currency shares					
Norwegian krone	1,276	0.3544	0.1577	0.0149	0.7995
Australian dollar	1,276	0.0033	0.0183	0	0.2016
Canadian dollar	1,276	0.0261	0.1387	0	0.8704
Czech koruna	1,276	0.0003	0.0018	0	0.0204
Danish krone	1,276	0.0280	0.0822	0	0.5354
Hungarian forint	1,276	0	0	0	0
Iceland krona	1,276	0.0006	0.0040	0	0.0650
Japanese yen	1,276	0.0078	0.0423	0	0.4854
Mexican peso	1,276	0	0	0	0
New Zealand dollar	1,276	0.0027	0.0169	0	0.2421
Polish zloty	1,276	0.0006	0.0051	0	0.0768
Pound sterling	1,276	0.0253	0.0826	0	0.5633
Slovak koruna	1,276	0	0	0	0
South Korean won	1,276	0	0	0	0
Swedish krona	1,276	0.0401	0.0823	0	0.5091
Swiss franc	1,276	0.0174	0.0878	0	0.6890
Turkish lira	1,276	0	0	0	0
US dollar	1,276	0.1680	0.1982	0	0.8949
Euro	928	0.2090	0.2317	0	0.9260
Austrian schilling	725	0.0084	0.0556	0	0.5914
Belgian franc	725	0.0062	0.0326	0	0.2851
Dutch guilder	725	0.0110	0.0533	0	0.4871
Finnish mark	725	0.0032	0.0230	0	0.2577
French franc	725	0.0086	0.0573	0	0.5321
German mark	725	0.0616	0.1159	0	0.7612
Greek drachma	725	0.0011	0.0112	0	0.1685
Irish pound	725	0.0011	0.0087	0	0.1568
Italian lira	725	0.0072	0.0498	0	0.4651
Luxembourg franc	725	0.0008	0.0082	0	0.1530
Portuguese escudo	725	0.0011	0.0079	0	0.0879
Spanish peseta	725	0.0049	0.0356	0	0.3293
ECU	348	0.0011	0.0048	0	0.0643
Explanatory variables					
EUR_{nt}	1,276	0.2955	0.4564	0	1.0000
EUR_{jt}	1,276	0.1585	0.3652	0	1.0000
$EuroControl_{jt}$	1,276	0.1303	0.3366	0	1.0000
CPI_{nt}	1,276	5.1098	11.2552	-1.0076	93.7205
CPI_{jt}	1,276	5.4667	11.8765	-1.0076	93.7205
$CPIVol_{nt}$	1,276	0.7962	1.6186	0.0331	21.5883
$SizeFX_{nt}$	1,276	8.3405	10.4873	0.0100	45.1500
$SizeFX_{jt}$	1,276	3.6759	8.9979	0	45.1500
$XVoltoNOK_{nt}$	1,276	0.0304	0.0297	0.0015	0.3326
$XVoltoNOK_{jt}$	1,276	0.0300	0.0317	0	0.3326
$XVoltoProd_{jnt}$	1,276	0.0367	0.0408	0	0.3684
$WorldTrade_{nt}$	1,276	0.7273	0.8840	0.0082	4.4337
$NorwayTrade_{nt}$	1,276	2.9284	3.6811	0.0293	15.5398
$Diff_{nt}$	1,276	74.1243	20.7023	11.7460	99.0010

Notes: The variables are described in Table A.1.

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