Invoicing Currency and Financial Hedging*

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Abstract

We use the results of a survey conducted on a sample of 3,013 exporting firms located in five euro-countries to explore the link between exporters' currency choice decisions and use of financial instruments to hedge exchange rate risks. Approximately 90% of firms in the sample invoice exports in their (producer) currency. Large firms are however more likely to use another currency. These firms are also more likely to hedge against exchange rate risk, which increases their propensity to invoice in the importer's currency. We propose a model of currency choice and hedging that rationalizes these findings. When the cost of hedging has a fixed component, large firms are more likely to hedge and to invoice in the importer's currency. This has implications for exchange rate pass-through.

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1 Introduction

Exchange rate movements have become a major source of uncertainty for firms operating in several countries. As a result, hedging instruments such as forwards, futures, swaps and options are used by 94% of the world's largest corporations and risk management ranks among the most important objectives of firms' financial executives (Nance et al. 1993, ISDA 2009).[1] Daily trading in foreign exchange markets averages $5.1 trillion as of 2016 (BIS 2016),[2] firms accounting for most of the dramatic growth in the use of hedging instruments over the past decades. This paper investigates the link between the choice of an invoicing currency and exchange-rate risk management by exporting firms.

Individual motives for and aggregate consequences of pricing exports in the currency of the exporter ("Producer Currency Pricing" or PCP), in the currency of the importing country ("Local Currency Pricing" or LCP) or in a third currency ("Vehicle Currency Pricing" or VCP) are the topic of a large literature in international macroeconomics, starting from Betts & Devereux (1996).[3] While early papers considered the choice of an invoicing currency as exogenous, the literature then studied possible determinants of this choice: the curvature of the demand function, the extent of price rigidities, the underlying exchange rate volatility, the structure of costs and their correlation with exchange rates (see Burstein & Gopinath, 2014, for a unified framework). The possibility for firms to hedge against exchange rate risk using hedging instruments has however been neglected in the literature so far.[4] The use of hedging instruments provides firms with the opportunity to price in local currency, *without having to bear the associated exchange rate*

[1] Empirical studies document significant effects of exchange rate changes on firm cash flows, sales, and competitive positions in product markets (see e.g. Hung 1992, Williamson 2001). See also Rawls & Smithson (1990) and Brealey & Myers (1981) for earlier studies.

[2] Source: Bank for International Settlements' (BIS) Triennial Central Bank Survey on Foreign exchange turnover in April 2016. The previous BIS statistics on OTC derivatives markets show that notional amounts outstanding totaled approximately $600 trillion since 2008. See `http://www.bis.org/statistics/about_derivatives_stats.htm`, and Stulz (2004) for a discussion.

[3] Whether the price of exported goods is in PCP or LCP matters if prices are rigid in the short-run and nominal exchange rates fluctuate. Assuming LCP instead of PCP has been shown to affect the extent of expenditure switching that follows exchange rate changes, with consequences for the transmission of international shocks (Corsetti & Pesenti 2009), the optimal monetary policy (Devereux & Engel 2003) or the choice of an exchange rate regime (Corsetti & Pesenti 2005). From a microeconomic perspective, the choice between PCP and LCP determines who, among the buyer and the exporting firm, bears the exchange rate risk.

[4] One exception is Friberg (1998).

risk. Firm's hedging choices against exchange rate fluctuations are therefore complementary to currency choice decisions.

We study this complementarity from both the empirical and theoretical viewpoints. Using data from a wide survey of European firms, we document that large firms are more likely to choose LCP and to use hedging instruments while small firms choose PCP and do not hedge against exchange rate risks. We interpret these facts in a simple model of currency choice where firms can use hedging instruments.

First, we use survey data collected in 2010 from 3,013 exporting firms located in five Eurozone countries to study the relationship between currency choice decisions and the use of hedging instruments. While the recent empirical literature has extensively discussed the determinants of currency choices by exporting firms, a unique feature of this survey is to document firms' currency choices *and* their use of hedging instruments. In our data, firms are questioned about their use of instruments such as derivatives or trade insurances, that often include a protection against exchange rate risk. We use this information to investigate the potential complementarity between hedging and LCP. In our data, firms mostly use PCP. Around 90% of exporters declare pricing in euros when exporting outside the EMU. This represents about 75% of the value of exports since large exporters are more likely to price in another currency. This is consistent with Goldberg & Tille (2009) who interpret the link between LCP pricing and the size of the transaction as a consequence of currency choices being influenced by the bargaining power of the consumer, an increasing function of the size of her purchases.

Probit regressions reveal that firms using financial hedging are more likely to price in foreign currency, controlling for other determinants of currency choices. Because LCP firms might choose to hedge as a consequence of their exchange rate risk exposure, this result might be driven by reverse causality, however. We therefore instrument the use of financial hedging by firms using various measures of access to risk management, and find that the relationship between LCP and hedging is even stronger once potential endogeneity is controlled for. Besides, the impact of firms' size on the probability to choose LCP becomes statistically insignificant when controlling for the instrumented hedging variable. This suggests that large firms are more prone to choose LCP because they have better access to financial hedging.[5]

Second, we model the invoicing decisions of firms when they have the

[5]The size-hedging link is consistent with Dohring (2008), whose explanation is that hedging involves a fixed cost that large firms are more prone to pay. Our theoretical framework relies on the same argument. The result is also consistent with evidence in the finance literature that large firms hedge while small firms often do not conduct active risk management (Nance et al. 1993, Geczy et al. 1997, for instance).

possibility to hedge exchange rate risk. To this purpose, we generalize the analysis of Bacchetta & van Wincoop (2005) and Burstein & Gopinath (2014) to the case where exporting firms can purchase exchange rate derivatives at a cost. In a one period ahead sticky price environment with exchange rate uncertainty, the choice between PCP and LCP depends on the curvature of the demand function, the type of returns to scale, and the sensitivity of marginal costs to the exchange rate. We depart from the usual framework by i) assuming exporters to be risk-averse[6] and ii) enabling them to use financial instruments to hedge against exchange rate risk.[7] Using financial instruments, the firm can set prices in the importer's currency without having to bear the associated exchange rate risk. The menu of pricing strategies for the exporter is the following: i) pricing in her (producer) currency and suffering a competitiveness loss if the exchange rate appreciates (PCP), ii) pricing in the importer's currency and being exposed to an exchange rate risk on foreign revenues (LCP), or iii) pricing in the importer's currency and paying the cost of financial hedging (HLCP). We study the determinants of this choice, as a function of the model's primitives. When hedging involves a fixed cost, we show that large firms are more likely to choose the HLCP strategy because the benefits of stabilizing profits, increasing in sales, more than compensates for the cost of hedging (i.e., purchasing derivatives). The model thus provides theoretical grounds for the empirical relationship between currency choices and firms' size, rationalizing the documented evidence.

Our paper contributes to the literature on the determinants of invoicing currency choices. On the empirical side, our paper relates to Goldberg & Tille (2016) and Gopinath et al. (2010) who use rich data covering the universe of Canadian and US import transactions, respectively. Goldberg & Tille (2016) find that the invoicing currency depends on (i) macro determinants such as exchange rate volatility, (ii) micro determinants such as market structure and product differentiation, and (iii) transaction determinants such as the size of the transaction. In comparison with these papers, our survey data does

[6]We thus depart from the classic Modigliani and Miller theorem which states that, under some assumptions, risk management is irrelevant to the firm. Absent any risk aversion, the exporter would never choose to hedge exchange rate risk in equilibrium. Several explanations can explain exporters' risk aversion, including an outgrowth of managers' risk aversion (Stulz 1984), convex tax schedules, expected costs of financial distress (Smith & Stulz 1985), or a reduction in firms' reliance on outside financing (Froot et al. 1993, Viswanathan & Rampini 2010). Graham & Smith (2000), Graham & Harvey (2001) and Graham & Rogers (2002) provide empirical evidence that firm managers actively manage risks.

[7]We implicitly assume that financial instruments (i.e., derivatives) constitute the best hedging device at hand. For example, buying derivatives is easier than trying to borrow in the foreign currency or to set up operational hedging.

not allow for a structural analysis of the determinants of currency choices. Nevertheless, we are able to formally link currency choices with the use of hedging instruments at the firm level. The use of survey data is common in the literature. Using a survey on Swedish exporters, Friberg & Wilander (2008) show that a bargain between the seller and the buyer determines the invoicing currency. Ito et al. (2015) use a survey of Japanese firms to document the correlation between firms' exchange rate exposure and their risk management strategy. They find that the exposure to the YEN/USD exchange rate is positively correlated with the use of hedging instruments by Japanese firms which mainly price in USD. Our contributions with respect to these papers are threefold. First, we are the first to document the invoicing currency of individual firms for a panel of Eurozone countries. As the euro is a vehicle currency, euro exporters mostly have to choose between pricing in euro or pricing in the importer's currency. Second, we highlight the link between firm size, financial hedging, and invoicing currency. Third, we show the causal impact of access to hedging on the choice of the invoicing currency.

On the theoretical side, the literature has examined the endogenous decision of an invoicing currency (see, among others, Friberg 1998, Bacchetta & van Wincoop 2005, Devereux, Engel & Storgaard 2004, Gopinath, Itskhoki & Rigobon 2010). Burstein & Gopinath (2014) propose a unified framework linking the different factors influencing the choice of an invoicing currency. We build on their framework and further allow firms to hedge against exchange rate risk at a cost (e.g. by using derivatives). Friberg (1998) also examines the choice of the price setting currency. In his setup, firms can freely access forward currency markets, returns to scale are decreasing, and marginal costs are independent of the exchange rate. In our model, we discuss firms' choice of invoicing currency when firms can hedge against exchange rate fluctuations, under different possible assumptions for the demand and cost specifications, including when marginal costs depend on the exchange rate. We assume that the use of financial instruments involves a fixed cost, which creates a link between firm's decision to use derivatives and their size.[8]

The paper also contributes to the literature on exchange rate pass-through. Differences in the choice of an invoicing currency by individual exporters relates to recent evidence on the heterogeneity in pass-through behaviors across exporters (see Berman et al. 2012, Fitzgerald & Haller 2014, Amiti et al. 2014, Auer & Schoenle 2016, Garetto 2016). These papers offer several explanations for the link between firms' size and the degree of pass-through: additive

[8]The presence of a fixed cost is consistent with Niepmann & Schmidt-Eisenlohr (2014) who find that heterogeneity in firms' use of trade finance products is explained by substantial fixed costs, the latter reflecting the fees charged by banks on those products.

trade costs, differences in the use of operational hedging (through imports), market power, and incomplete information. We point to an alternative mechanism linking firm size and pass-through, that involves the use of hedging instruments. As large firms are more likely to hedge against exchange risk and price in local currency, we expect their local prices to be little responsive to exchange rate fluctuations. Heterogeneity in invoicing currency driven by firms' decisions to hedge using financial instruments provides a complementary explanation for the heterogeneity in pass-through rates observed in the data.

The rest of the paper is organized as follows. Section 2 studies the link between currency choices and hedging using survey data on European exporters. Section 3 proposes a simple model to rationalize the evidence. Section 4 concludes.

2 Empirical evidence

2.1 Data

The data consist of a survey conducted by the European Firms in a Global Economy (EFIGE) project. A representative sample of approximately 15,000 firms of more than 10 employees from 7 countries (Austria, France, Germany, Hungary, Italy, Spain, and UK) were surveyed in 2010. More than 150 items provide information on the structure of the firm, her workforce, market environment, pricing decisions, internationalization, investment and innovation policies. Items of particular interest to us are listed in Table 1. We construct a set of firm-level control variables regarding the firm's 4-digit industry, ownership structure, turnover, the share of foreign markets in sales, the number of destination markets served, and the distribution of exports across 8 areas (EU15, rest of EU, non-EU European countries, China and India, other Asian countries, USA and Canada, rest of America, and rest of the world). We keep firms which i) declare exporting, ii) report an export share lower than 100% and iii) are located in the EMU.

We are interested in firms' risk management practices. We therefore use firms' answer to the question "How do you deal with the exchange rate risk?" to reduce our sample to firms that are exposed to exchange rate (henceforth ER) risk. As show in Figure 1, about 50 to 60% of exporters report that this question is not applicable: the geography of their sales does not in effect expose them to such risk. Large exporters are more likely to be exposed to exchange rate risk because they are more prone to exporting outside of the EMU. As a consequence, exporters that are not exposed to ER risk represent

less than 40% of aggregate sales (see the comparison of the black and grey bars in Figure 1). Once we drop firms that declare not being exposed to ER risk, our sample consists of 3,013 EMU firms exporting outside of the euro area and exposed to ER fluctuations. 99 of these firms are located in Austria, 770 in France, 630 in Germany, 844 in Italy and 670 in Spain.

The use of survey data can raise concerns about sample representativeness. To address this concern, we use available information on the absolute and relative sample weights of each firm, and a measure of the probability for each firm to be sampled. In the EFIGE survey, firms are split into categories and firm categories are split into strata, where firms' strata are defined by country, class size (10-49, 49-249, more than 249 employees), and NACE 1-digit sector. Absolute weights are computed by strata, as the ratio of the number of firms in a stratum over the number of firms in the same category in the survey. Relative weights are then computed by multiplying absolute weights by the contribution of each strata to the overall economy. In the rest of the analysis, we consider three alternative weighting schemes. First, we weight observations with absolute sample weights to build statistics on the "representative firm" in each country. Second, we rescale the absolute sample weights using data on firms' mean turnover in each strata (from Amadeus). That way, we obtain statistics that account for the relative weight of each firm in total sales. Third, we present statistics on each firm's weight in total exports using sample weights rescaled by each firm's exports. Statistics obtained for the representative firm and for size-weighted firms allow us to compare the behavior of small and large firms. In the econometric analysis, all regressions are weighted by the inverse of the sampling probability.

The core of our analysis exploits information on firms' currency choice when selling goods outside of the euro area. We use answers to the question "In which currency do you set prices in foreign countries?" to identify a PCP strategy whenever the answer is euro. Figure 2 summarizes the results for our sample of firms. Whatever their country of origin, a vast majority of firms - from 88% in Austria to 95% in France - declare choosing PCP (black bars in Figure 2). The use of PCP is thus prevalent, even though less pronounced when looking at the relative size of firms (light and medium grey bars in Figure 2). Large firms are less likely to price in PCP. In the rest of the analysis, we will consider the remaining 10% of firms who do not price in euros as LCP firms. Note that this is meant to simplify the vocabulary since these firms could also use a third (vehicle) currency.

How does this compare with previous studies of currency choices? Kamps (2006) reports that only 60% of EMU exports were invoiced in euro as of 2004. In the ECB (2011) report on the internationalization of the euro, this proportion reaches 68% for EMU exports to non-euro area countries. These

are aggregate figures. As such, one should therefore compare them with our size-weighted statistics. Once firms' size is taken into account, around 75% of exports are found to be invoiced in euro (70% for Italy, 82% for Germany).[9] In unreported results, we compare currency choices in different sub-samples of firms constructed based on the geography of their sales, their sector or the nationality of their main competitor. We found that PCP is relatively more prevalent for firms mostly exporting to the European Union and slightly less common for firms in the textile and leather industries. The nationality of the firm's main competitor does not appear to be correlated with invoicing currency choices. While the results here are not especially conclusive, we will use these variables as control in the empirical framework. Indeed, they represent the best available proxies for the determinants of currency choices identified in the existing literature.

We complement information on currency choices with variables measuring firms' risk management strategy. Our primary measure of financial hedging use answers to the question "How do you deal with the exchange rate risk?". We identify firms as using financial hedging whenever they answer that they use a foreign exchange risk protection. We also use detailed information on whether firms are covered by trade insurance products, use financial derivatives or rely on trade credit for their exports.

Figure 3 gives the proportion of firms using one of these instruments and the relative propensity of large firms using them. Hedging seems widespread in EMU countries: between 25 and 50% of firms declare hedging against exchange rate risk. Trade insurance is also used by a substantial share of firms, from 25% in Italy to 40% in Austria. The use of derivatives and trade credits is much less developed: less than 5% of firms declare using them, with notable exceptions in Spain and Italy where 20% of firms use them. Those instruments - in particular hedging and trade insurance - are used relatively more by larger exporters.

Our hypothesis in this section is that currency choices and hedging strategies are complementary from the exporter's point of view. Figure 4 shows statistics consistent with this view. The propensity of firms to use various hedging instruments is measured in the sub-sample of PCP firms ("PCP" bars) and in the sub-sample of LCP firms ("LCP" bars). It visually appears that PCP firms tend to rely less on hedging instruments. In the next sub-section, we investigate the statistical significance of this result and ask whether it can be interpreted in a causal way.

[9]It is worth noting that the weighting procedure is based on firms' size and total exports, while ECB figures are based on exports to non-Eurozone countries. Since large firms probably export relatively more to non euro-countries, the weight on those firms should be *relatively* larger for our results to be comparable with the ECB statistics.

2.2 Determinants of currency choice

Heterogeneity in currency choices is a key feature of the stylized facts presented in section 2.1. In particular, large firms adopt LCP more often than smaller ones. Moreover, currency choice decisions seem to be correlated with an active risk management strategy. In this section, we use probit regressions to study the statistical significance of these patterns. The benchmark regression takes the following form:

$$\mathbb{P}(PCP_f = 1|X_f) = \mathbb{P}(PCP_f^* > 0|X_f) = \Phi(X_f'\beta)$$

where $\mathbb{P}(PCP_f = 1|X_f)$ is the probability that firm f set prices in euros, PCP_f^* is the unobserved latent variable, and X_f is a vector of explanatory variables. We control for potential determinants of invoicing strategies identified in the existing literature: various measures of the firm's size, the share of exports in sales and the geographic composition of exports. All regressions also control for the firm's country of origin and her 4-digit sector of activity. Finally, we depart from the existing literature and also include proxies for the firm's hedging strategy.

We first study the correlation between firms' size and currency choices. To this aim, we control for different measures of size as explanatory variables using firm's turnover or sales. Results are summarized in Figure 5, where we report the coefficients estimated on each size interval, taking firms in the first interval as a benchmark.[10] As expected, results show that the probability of choosing a PCP strategy is decreasing in firms' size. Moreover, the difference is significant for firms above a threshold, namely for firms with more than €15 million sales or 50 employees. This result is consistent with previous evidence that firms of heterogeneous size make different currency choices. Based on these non-parametric results, we systematically control for firms' size in the rest of the analysis. To limit the number of estimated coefficients, we account for firm size with a dummy variable equal to one for firms with a turnover above €50 million.

Table 2 presents a set of benchmark regressions that test standard determinants of currency choices. We control for firm size and various measures of exposure to exchange rate risk, the share of exports in sales, the number of destination markets served and the share of different destinations in export sales.[11] Finally, firms were asked how they decide on their price for their do-

[10]The corresponding regressions also control for the exporter's country of origin and the sector of activity.

[11]The number of destination markets is a proxy for whether the composition of the firm's export sales offers a natural diversification mechanism against exchange rate risks. In the previous literature, it has been shown that the use of LCP is systematically larger

mestic market. One possible answer is that the price is fixed by the market, i.e. the firm does not have any market power. We construct a dummy variable that identifies firms without market power, based on the idea that lack of market power is likely to push firms to choose LCP to stick to the market price. We use this dummy to control for firms' market power in column (4).

Results are broadly in line with expectations. The probability that a firm chooses LCP is increasing in the firm's export share. Firms selling more in Asia and America are also less likely to adopt PCP strategies than firms mostly exposed to European and African markets. Finally, having no pricing power is also a significant predictor of the firm's propensity to set prices in the importer's currency. Overall, these results are consistent with the view that currency choices depend on the firm's exposure to exchange rate risk and bargaining power in export markets.

In Table 3, we investigate the correlation between hedging and currency choices. We start from the benchmark regression displayed in column (4) of Table 2 and add each of the four measures of firms' risk management available in the survey. Firms declaring that they hedge against exchange rate risk are less likely to choose PCP (column (1)). This is also true for firms reporting that they use derivatives (column (2)). On the other hand, neither the dummy for firms using trade credit nor the subscription of trade insurances have an impact on currency choices (columns (3) and (4)). These results continue to hold when all four measures are introduced simultaneously in column (5).

The correlation between hedging strategies and currency choices in Table 3 is difficult to interpret in a causal way due to potential reverse causality. Indeed, the firm's decision to price in local currency de facto creates exposure to exchange rate risks, inducing a need for financial hedging. Because the endogenous variable is binary, one cannot use a standard IV strategy. To treat the reverse causality problem, we thus estimate a bivariate probit model (see Wooldridge 2001, section 15.7.3, p. 477). Formally, we estimate

$$\mathbb{P}(PCP_f = 1|\delta_1, HEDG_f) = \mathbb{P}[z_1\delta_1 + \alpha HEDG_f + \epsilon_1 > 0] = \mathbb{P}(z_1\delta_1 + \alpha HEDG_f)$$
$$\mathbb{P}(HEDG_f = 1|\delta_1, \delta_2) = \mathbb{P}[z_1\delta_1 + z_2\delta_2 + \epsilon_2 > 0] = \mathbb{P}(z_1\delta_1 + z_2\delta_2)$$

where $HEDG_f$ is a binary variable equal to one if the firm chooses to use a hedging strategy, z_1 is a vector of variables affecting both the decision to hedge and the invoicing currency choice and z_2 is a vector of variables affecting the decision to hedge which is orthogonal to the invoicing currency choice. In our baseline specification, we assume that the correlation between

towards some destinations, notably the United States.

ϵ_1 and ϵ_2 is nil. If the correlation is not nil, then hedging is an endogenous variable in the currency equation. To have a consistent estimate of α, we have to find a set of variables correlated with the hedging decision but uncorrelated with ϵ_1.

Table 4 reports the results. Columns (2)-(3) report estimation results when hedging is instrumented by a dummy equal to one if the firm has subscribed a trade insurance, and a dummy equal to one if the firm reports to be lacking organizational or managerial resources for further growth. The use of the trade insurance dummy as instrument for hedging is justified on the ground of external evidence for France showing that firms subscribing trade insurance are often proposed hedging instruments against ER risk in the same package.[12] We use our second instrument based on the assumption that firms with management issues probably have less resources to perform active risk management. As shown in column (1), none of the variables directly impact currency choices. This is consistent with the required assumption that $corr(\epsilon_1, z_2) = 0$. They however affect hedging decisions (column (3)), which suggests that our instruments are not weak. As expected, the use of hedging instruments is more prevalent among firms covered by trade insurance but less common in firms with organizational issues. Importantly, the impact of hedging remains significant and negative in the second stage regression (column (2)) when hedging is instrumented by these two variables. These results suggest that hedging decisions cause the choice of LCP. In comparison with the probit regression, the marginal impact of hedging on invoicing choice is higher. On the contrary, the impact of firms' size is reduced and no more significant at 10%. This is consistent with the view that part of the reason why large firms are more likely to adopt LCP strategies is that they have better access to financial hedging, which allows them to reduce their exposure to exchange rate fluctuations under LCP.

We estimate a second bivariate probit regression in which we augment the hedging regression with two additional instruments: a dummy for firms covered by trade credits and the log of the number of destinations served. The results are presented in columns (4)-(5) of Table 4. Consistent with Froot et al. (1993), results show that firms financing part of their exports using a trade credit (i.e., financially constrained firms) are more likely to hedge their exchange rate risk. Moreover, hedging is positively correlated with the number of destinations served, a result consistent with Allayannis et al. (2001). Once again we find a negative and significant causal impact of hedging on the decision to choose PCP, once endogeneity is taken into account. Note that in these regressions, we can use the correlation between

[12] See www.coface.fr.

the error terms ($corr(\epsilon_1, \epsilon_2)$) to test for the endogeneity of a variable (this is equivalent to an Hausman endogeneity test as shown by Knapp & Seaks 1998). Such correlation is .37 in the estimation results reported in columns (2) and (3) and .48 in the results reported in columns (4) and (5). A correlation of zero means that hedging is exogenous. A Wald test rejects the null-hypothesis at 24% in the first system and 11% in the second system. This suggests that endogeneity is a moderate issue here.

These results point out that, controlling for size, firms with better access to hedging instruments are less likely to choose PCP. Since large firms are also more likely to hedge against exchange rate risk, this relationship may be at the origin of the link between a firm's size and her invoicing strategy. It is indeed the case that, once hedging is taken into account, the coefficient on the firm's size decreases in absolute value (compare Tables 2 and 3). The size-invoicing relationship is therefore explained by large firms having better access to financial hedging. The opportunity to hedge against exchange rate risk enables firms to invoice in local currency without facing a risk on their marginal revenue. This explains why their propensity to choose LCP is larger.

Having established the robustness of the relationship between invoicing strategies and hedging decisions, we now discuss the theoretical mechanisms which might explain the evidence.

3 A model of currency choice and hedging

We model the invoicing currency choice of an exporting firm facing the possibility to hedge exchange rate risk. We build on Burstein & Gopinath (2014) using a one period ahead sticky price environment and consider the invoicing currency choice in partial equilibrium. In this set-up, the optimal invoicing strategy depends on the curvature of the profit function with respect to exchange rates at the pre-set optimal price. We show how it is affected by the demand function, the type of returns to scale and the sensitivity of marginal costs to exchange rate variations. We then generalize the analysis to the case where the exporting firm can purchase derivatives to hedge against exchange rate risk. The augmented setup allows us to discuss and theoretically rationalize the evidence in Section 2.

3.1 Optimal invoicing strategy

Consider an exporting firm that chooses an invoicing strategy. We assume that the exchange rate is the only source of uncertainty in the economy, and that markets are perfectly segmented so that firms can adopt a different strat-

egy in each destination. Therefore, the optimal invoicing choice depends on the uncertainty about the firm's destination-specific profits under alternative invoicing strategies.

The exporting firm faces a demand function $D(p^*)$ in each destination, where p^* is the price faced by the importer, and a cost function $C(q, w(S))$ which depends on the level q of output and the vector of input prices $w(S)$. Input prices potentially depend on the exchange rate S, e.g. if the firm imports part of her inputs from the foreign country.[13] To simplify the analysis, we restrict the cost function to be linear in S. In the following, we denote $mc \equiv \frac{\partial C(q,w(S))}{\partial q}$ the firm's marginal cost of production, $\alpha \equiv \frac{\partial \ln mc}{\partial \ln S}$ and $mc_q \equiv \frac{\partial \ln mc}{\partial \ln q}$ the partial elasticities of her marginal cost with respect to the exchange rate and the quantity produced, respectively. Finally, $\eta \equiv -\frac{d \ln D(p^*)}{d \ln p^*}$ denotes the price elasticity of demand.

Before the realization of the exchange rate, the exporter chooses whether to set her price in domestic currency ("Producer Currency Pricing", PCP) or in the importing country's currency ("Local Currency Pricing", LCP). The difference between LCP and PCP profits is the following. Under LCP, an exchange rate change creates uncertainty about the unit revenue denominated in the exporter's currency Sp^{LCP} but no demand uncertainty. In contrast, under PCP there is only uncertainty about demand, and thereby costs. Under PCP the firm sets a price p^{PCP}, which implies a local price p^{PCP}/S in the destination country. Exchange rate fluctuations affect the local currency price, and thereby the level of demand and costs. The choice between PCP and LCP is made by the firm's manager so as to maximize her expected utility:

$$\max_{PCP,LCP} \left\{ \mathbb{E}\left[u\left(\pi^{PCP}(S)\right)\right], \mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right] \right\}$$

where $\mathbb{E}[.]$ is the expectation operator, $u(.)$ is the manager's utility function, which we assume increasing in profits ($du(\pi^i)/\pi^i > 0$) and $\pi^i(S)$ is the profit under strategy $i = \{PCP, LCP\}$, as a function of the exchange rate:

$$\pi^{PCP}(S) = p^{PCP} D\left(\frac{p^{PCP}}{S}\right) - C\left[D\left(\frac{p^{PCP}}{S}\right), w(S)\right]$$
$$\pi^{LCP}(S) = Sp^{LCP} D\left(p^{LCP}\right) - C\left[D\left(p^{LCP}\right), w(S)\right]$$

Note that these profit functions are evaluated at the equilibrium, i.e. for optimal values of p^{PCP} and p^{LCP}. Following the literature, we assume that $\pi^{PCP}(\mathbb{E}[S]) = \pi^{LCP}(\mathbb{E}[S])$, i.e. the invoicing strategy becomes irrelevant at

[13] We define bilateral exchange rates such that one unit of foreign currency is worth S units of domestic currency. The marginal cost is therefore increasing in the exchange rate.

the expected exchange rate.[14] Lemma 3.1 recalls a well-known finding in the literature.

Lemma 3.1. *LCP (resp. PCP) is preferred when $\pi^{PCP}(S)$ is a concave (resp. convex) function of S.*

Proof. LCP is preferred whenever $\mathbb{E}\left[u\left(\pi^{PCP}(S)\right)\right] < \mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right]$, i.e. $\mathbb{E}\left[\pi^{PCP}(S)\right] < \mathbb{E}\left[\pi^{LCP}(S)\right]$. Note that

$$\mathbb{E}\left[\pi^{LCP}(S)\right]) = \pi^{LCP}(\mathbb{E}\left[S\right]) = \pi^{PCP}(\mathbb{E}\left[S\right]).$$

It follows that LCP is the optimal strategy whenever $\mathbb{E}\left[\pi^{PCP}(S)\right] < \pi^{PCP}(\mathbb{E}\left[S\right])$ which holds true if $\pi^{PCP}(S)$ is a concave function of S. Conversely, PCP is the optimal strategy if $\pi^{PCP}(S)$ is a convex function of S. □

As shown in Bacchetta & van Wincoop (2005), lemma 3.1 holds true whatever the manager's risk attitude. The only condition is that her utility is increasing in profits. Indeed, for the above profit functions $\pi^{PCP}(S)$ and $\pi^{LCP}(S)$, firms set their prices optimally therefore the derivative of profits with respect to the exchange rate is the same regardless of the invoicing strategy, and the rate of risk aversion does not matter.

The intuition for lemma 3.1 is the following. Given that the effect of the exchange rate on both profit functions is identical if prices are immediately adjusted to the exchange rate, a change in the exchange rate affects both profit functions identically even for preset prices. However, changes in the variance of the exchange rate will yield higher expected utility under the pricing system with the largest convexity of profits (captured by the second order derivative). With a larger convexity, exchange rate depreciations increase profits more than exchange rate appreciations decrease profits, which increases expected profits. The choice between LCP and PCP then depends on the relative convexity of these two profit functions with respect to the exchange rate.

[14] Intuitively, this means that if prices could be immediately adjusted to the exchange rate, both price setting currencies would yield the same profit. Burstein & Gopinath (2014) also assume that flexible price profits are the same regardless of the invoicing currency, and Bacchetta & van Wincoop (2005) and Friberg & Wilander (2008) make similar assumptions. Even absent this assumption, the intuitions of lemma 3.1 that profits under LCP and PCP vary differently in the exchange rate would hold true, as long as the difference between $\pi^{PCP}(\mathbb{E}[S])$ and $\pi^{LCP}(\mathbb{E}[S])$ does not exactly offset the differences in profits under every possible realization of the exchange rate S. We argue that neither a deviation from our assumption nor this latter possibility seems reasonable.

Consider the exporting firm's profits under LCP. For a given level of exchange rate uncertainty, expected profits vary linearly in the exchange rate, i.e. exchange rate depreciations and appreciations increase and decrease profits (respectively) to the same extent.[15] Now, consider the firm's profits under PCP. In this case, an exchange rate depreciation increases firm's profits more than an exchange rate appreciation decrease profits if PCP profits are convex in the exchange rate. In contrast, if PCP profits are concave in the exchange rate, an exchange rate depreciation increases profits less than an exchange rate appreciation decreases them. Given that profits under LCP vary linearly in the exchange rate, the curvature of PCP profits directly determines which price setting strategy yields the highest expected profits.

How does exchange rate volatility affect an exporting firm's choice between LCP and PCP? Figure 6 illustrates lemma 3.1, plotting $\pi^{PCP}([S])$ as a concave function of S, and $\mathbb{E}\left[\pi^{PCP}(S)\right]$ when S is uniformly distributed around $\mathbb{E}[S]$. The curvature of $\pi^{PCP}(S)$ determines the gap between both lines, representing the benefits from LCP over PCP when $\pi^{PCP}(S)$ is concave in S. The difference between $\pi^{PCP}(\mathbb{E}[S])$ and $\mathbb{E}\left[\pi^{PCP}(S)\right]$, i.e. the relative advantage of LCP over PCP, is stronger the more uncertain the exchange rate. This illustrates that invoicing strategies are more of an issue when exchange rates are more volatile.

Given lemma 3.1 and the assumptions regarding the form of profits, it is now possible to derive the condition under which LCP is the optimal strategy. Proposition 3.2 summarizes the results.

Proposition 3.2. *Applying lemma 3.1, the exporting firm chooses to price under local currency pricing whenever the following inequality is met:*

$$\eta - 1 - \frac{d\ln\eta}{d\ln\frac{p^{PCP}}{S}} < \frac{mc\,(\eta mc_q + \alpha)}{p^{PCP} - mc} \tag{1}$$

Proof. See appendix A.1. □

The convexity of PCP profits in the exchange rate is crucial in that in tells us whether the increase in PCP profits following an exchange rate depreciation outweigh the decrease in PCP profits following exchange rate appreciation of the same magnitude. Proposition 3.2 gives the conditions under which it is the case, i.e. the conditions for LCP to be chosen.

As an example, let us consider the benchmark case satisfying three assumptions: a CES demand function ($\frac{d\ln\eta}{d\ln p^{PCP}/S} = 0$), a cost function with

[15] Recall that an exchange rate depreciation in our model corresponds to an increase in S.

constant returns to scale ($mc_q = 0$) and a marginal cost which is independent of the exchange rate ($\alpha = 0$). In that case, the concavity of PCP profits is only determined by the price elasticity of demand. Optimally, the exporter chooses to price in her own currency for $\eta > 1$, i.e. when the price elasticity of demand is high enough so that PCP profits increase more when the exchange rate depreciates than they decrease when the exchange rate appreciates. In practice, $\eta > 1$ is necessary for firms to obtain positive markups. As a result, firms always choose PCP in this benchmark case. For LCP to be an optimal strategy, one has to relax one of the three assumptions and deviate from the benchmark case.

In the previous example, three channels driving the convexity of PCP profits are muted: the price elasticity of demand, the type of returns to scale and the sensitivity of marginal costs to the exchange rate. We now discuss in turn these channels and how they may lead firms to choose to price in the local currency. Again, one needs to compare PCP profits following a depreciation with PCP profits following an appreciation of the same magnitude. To gain intuition on whether any channel amplifies or dampens gains after depreciation relative to losses after an appreciation, it is worth emphasizing that differences in PCP profits come either from differences in terms of demand, or total costs.

First, LCP is more likely to be chosen if $\frac{d \ln \eta}{d \ln p^{PCP}/S}$ is positive and large. In such a case, demand increases at a slow rate when the exchange rate depreciates and therefore PCP profit gains following a depreciation are smaller than losses following a depreciation. Conversely, in the extreme case where the elasticity of demand is decreasing in the price ($\frac{d \ln \eta}{d \ln p^{PCP}/S} < 0$), gains in PCP profits following a depreciation outweigh the losses following an appreciation. Inequality 1 is then less likely to hold and firms are more likely to price in the producer currency.

Second, the increase in production scale following an exchange rate depreciation might impact the convexity of PCP profits through total costs. If firms use a decreasing returns to scale technology ($mc_q > 0$), the increase in total costs following an exchange rate depreciation is higher than the decrease in costs following an appreciation. This makes depreciation-driven profit gains smaller than the losses following a depreciation, and explains why LCP is more likely under decreasing returns to scale. Conversely, if firms use an increasing returns to scale technology ($mc_q < 0$), total costs increase less following a depreciation than they decrease following an appreciation. In such a case, the potential gains outweigh the potential losses which makes PCP more likely.

Third, the sensitivity of marginal costs to the exchange rate ($\alpha > 0$) favors LCP strategies for similar reasons. Again, assume that the exchange rate

depreciates. When some inputs are imported and paid in foreign currency, an exchange rate depreciation raises the price of imported inputs, thereby dampening the gains in PCP profits following the depreciation. When $\alpha > 0$, this operational hedging effect increases total costs following a depreciation more than it decreases costs following an appreciation. This explains why LCP is more likely for firms engaged in operational hedging.

The result in Proposition 3.2 encompasses previous findings of the literature, summarized in Burstein & Gopinath (2014). Bacchetta & van Wincoop (2005) detail the intuition for why optimal invoicing strategies depend on the curvature of the profit function, which is ultimately determined by assumptions on the demand and cost functions that we explicitly derive. In particular, they underline the role of decreasing returns to scale as a driver of LCP. The convexity of the demand function is also a well-known factor of LCP/incomplete exchange rate pass-through as already emphasized in Krugman (1987) and, more recently, in Berman et al. (2012).

While the results summarized in Proposition 3.2 are standard, they typically neglect another dimension of the problem, namely the possibility for firms to hedge against exchange rate risk. In this setting, exporters have no choice but to incur the exchange rate risk, either through an uncertainty on the demand addressed by the foreign market (under PCP) or through the variability of unit revenues (under LCP). We now consider the possibility for the firm to use financial derivatives to hedge against exchange rate risk.

3.2 Optimal hedging strategy

Suppose now that the firm can hedge against the transaction risk induced by exchange rate fluctuations. Namely, a LCP firm can buy derivatives to insure a given amount in her own currency for the future export revenue she will receive in foreign currency. The exporting firm's choice between PCP and LCP now entails a third option: whether or not to hedge when LCP is chosen. The optimal hedging choice of the firm depends on the comparison between her expected utility under LCP when the exchange rate risk is hedged and when it is not. We denote by the superscript HLCP the choice variables under *hedged* local currency pricing. The exporting firm using LCP makes her hedging choice by comparing expected profits under LCP and HLCP, respectively $\mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right]$ versus $\mathbb{E}\left[u\left(\pi^{HLCP}(S)\right)\right]$, where the exporter's profit under HLCP writes:

$$\pi^{HLCP}(S) = Sp^{HLCP}D\left(p^{HLCP}\right) - C\left[D\left(p^{HLCP}\right), w(S)\right] - h\left(S - f\right) - HC\left[h, f\right]$$

$h \in \left[0, p^{HLCP} D\left(p^{HLCP}\right)\right]$ is the transaction amount hedged against exchange rate changes. f denotes the forward exchange rate so that $(f - S)$ is the ex-post benefit of hedging on each unit of export revenue. In equilibrium, $f = \mathbb{E}(S)$ so that the benefit of hedging is zero in expectation. Hedging stabilizes export profits around their expected value. Finally, $HC[h, f]$ is the hedging cost. Because the use of derivatives necessitates some form of knowledge (see e.g. Brealey & Myers (1981)), we assume that hedging costs entail a fixed component F that represents investment in the knowhow necessary to design and buy the proper set of derivative instruments well suited for a given firm's exchange rate exposure. For simplicity we do not assume any variable component in the hedging cost, i.e. $HC[h, f] = F$.[16]

Due to the linearity of HLCP profits in the amount hedged, we obtain the following lemma concerning the optimal hedging choice of the exporting firm.

Lemma 3.3. *Conditional on hedging, the exporting firm fully hedges:*

$$\max_h \mathbb{E}\left[u\left(\pi^{HLCP}(S)\right)\right] \rightarrow h^* = p^{HLCP} D\left(p^{HLCP}\right)$$

Proof. The choice of the quantity of hedging $h \in \left[0, p^{HLCP} D\left(p^{HLCP}\right)\right]$ boils down to a standard minimization of average total costs of hedging when the returns from hedging $h(f - S)$ is linear. The exporting firm chooses the amount of hedging that minimizes the average total cost of hedging. Conditionally on hedging being profitable, the firm chooses to hedge the maximum quantity $p^{HLCP} D\left(p^{HLCP}\right)$ as the average fixed cost always declines as output rises. The fixed hedging cost is indeed spread over a larger number of units of output hedged. □

All findings in Section 3.1 hold true even when firms are risk neutral. In contrast, the benefit of hedging hinges on the firm valuing the stabi-

[16] Appendix A.3 extends the results to the case where hedging costs also entail a variable component. Although in reality derivatives dealers such as banks often propose fees that are decreasing in the amount of derivative purchased (essentially making variable costs decreasing in the amount hedged), decreasing variable costs of hedging would only strengthen our results. Therefore we only discuss the possibility of variable costs that are increasing in the amount hedged. One could further argue that the variable component represents the change in value of the derivative instrument when the price of the underlying asset - the forward exchange rate between the domestic and foreign currency in our case - is modified. In such a case the variable-cost component would not be increasing in the amount hedged but rather in the distance between the spot and the forward exchange rates (i.e. HC would depend on f). Because this would not change the prediction of the model regarding the link between hedging strategies and the firm's size, we neglect this possibility in the rest of the analysis.

lization of export revenues that hedging provides. In line with the aforementioned finance literature on hedging, this further requires to assume the exporting firm's manager to be risk averse:[17] $\frac{d^2u(\pi^i)}{d\,\pi^{i\,2}} < 0$ where $i = \{PCP, LCP, HLCP\}$. We maintain this assumption in the rest of the analysis.

As opposed to a risk-neutral exporter who would never find it profitable to pay the cost of hedging, a risk-averse exporter trades off the benefit of stabilizing her export revenues, conditional on pricing in LCP, and saving on the hedging cost. Proposition 3.4 summarizes the condition under which the risk-averse exporter optimally chooses to hedge:

Proposition 3.4. *A risk-averse exporting firm chooses to hedge against exchange rate risk whenever the following inequality is satisfied:*

$$\mathbb{E}\left[u\left(\pi^{HLCP}(S)\right)\right] - \mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right] > 0$$

which rewrites as

$$u\left(\pi^{LCP}\left(\mathbb{E}\left[S\right]\right)\right) - \mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right] > \frac{du(\pi^{LCP}(S))}{d\pi^{LCP}(S)}F \tag{2}$$

Proof. See appendix A.2. □

Equation (2) underlines the trade-off that an exporting firm using LCP faces when choosing whether or not to hedge against exchange rate risk. The left-hand side of equation (2) represents the benefit of removing the uncertainty linked to exchange-rate risk. It is positive whenever the manager is risk-averse, and all the more so the more negative $d^2u(\pi^i)/d\,\pi^{i\,2}$. The hedging benefit is also increasing in $\pi^{LCP}(S)$ due to $du(\pi^i)/d\pi^i > 0$. The right-hand side of equation (2) represents the (utility) cost of hedging. It is decreasing in the size of profits.

A firm will choose to hedge against exchange rate risk whenever the benefit is larger than the cost. High-profit firms enjoy a higher benefit and a lower cost compared to low-profit firms, therefore larger firms are more likely to hedge. Intuitively, the fixed component of hedging cost implies that larger firms can spread the hedging cost over more units, while the benefit applies to each unit of revenue hedged. As shown in Appendix A.3, the intuition

[17] A strand of the finance literature provides explanations for firms' risk-averse decision making. This can be due to managers' risk aversion (Stulz 1984), convex tax schedules that require to smooth revenue over time, exogenous costs of financial distress (Smith & Stulz (1985)), or firms behaving as risk-averse in the amount of internal funds they have due to their reliance on outside financing (Froot et al. (1993) and Viswanathan & Rampini (2010)).

goes through for more sophisticated hedging cost functions, as long as the variable component of the hedging cost is not too convex in the quantity hedged. This set-up thus offers a rationale for the empirical evidence underlined in Section 2.2, namely that large firms are more likely to buy hedging instruments to cover against exchange rate risks.

3.3 Discussion of empirical findings

An exporting firm jointly chooses to invoice her products in the currency of the exporting country (PCP), in the currency of the importing country (LCP), and whether or not she hedges against exchange rate fluctuations under LCP (HLCP).

In our model, under the assumption that demand is not too convex, returns to scale are not increasing and marginal costs are no too sensitive to the exchange rate, we have that LCP is more likely to be observed (i) for low markup firms (i.e. firms with low prices compared to marginal costs); and (ii) for high markup firms. Firms with intermediate markups are more likely to choose PCP.[18] This suggests that there exists a non-linear relationship between currency choice and firms' market power. In the data we find that large Eurozone firms are less likely to price in euros, but we do not find a non-linear effect between firms' size and currency choice.[19] There are two potential explanations to reconcile these findings with our theory: i) markups and size are not strongly correlated, or ii) markups and sales are correlated but because our sample is restricted to firms with more than ten employees, we do not observe the small low-markup firms pricing in the importer's currency.

Given these conditions for LCP to be chosen, a risk-neutral exporter would never find it profitable to pay the hedging cost. A risk-averse exporter, however, trades off the benefit of stabilizing her export revenues and the cost of hedging. We show that for the same level of risk aversion, large firms enjoy higher benefit from hedging and lower unitary costs compared to small firms when hedging costs entail a fixed component. Firms' size therefore plays a crucial role in determining which of those firms choosing LCP will choose HLCP. These results help rationalize the empirical findings discussed in Section 2.2 that large Eurozone firms are more likely to use financial

[18] When $\frac{d \ln \eta}{d \ln p^{PCP}/S} > 0$, $mc_q > 0$ and $\alpha < p^{PCP}/mc$, condition (1) writes as the condition for a polynomial of order two in $(p^{PCP} - mc)$ to be positive, such that the condition is met for values of $(p^{PCP} - mc)$ below and above the (positive) roots of the polynomial. Under those assumptions, the condition for firms to choose LCP is therefore more likely to be met for lower and higher values of $(p^{PCP} - mc)$.

[19] Unfortunately, we do not have information on markups in our data.

hedging instruments. If firms' manager are risk-averse, they have an incentive to hedge against the risks associated with local currency pricing. If hedging costs entail a fixed component, larger Eurozone firms are more likely to hedge this risk.

4 Conclusion

The paper offers three new empirical results. First, large firms in euro-area countries are less likely to use the euro than smaller ones. Second, large firms and firms that price their goods in the currency of the importer (choosing LCP) are more likely to hedge against exchange rate risk. Third, hedging opportunities increase the propensity for firms to choose LCP. These results have three main implications.

First, the results suggest that the development of new technologies that facilitate the hedging of exchange rate risk for individual exporters should lead to an increasing use of local currency pricing strategies. This in turn should have end-effect on the international transmission of shocks.

Second, the results on financial hedging also have important implications for the costs of exchange rate fluctuations. As large firms tend to hedge against exchange rate fluctuations, it seems that exchange rate risk is not born solely by one of the two parties involved in export transactions, as usually assumed in the literature. Instead, it seems that this risk is somewhat diversified through financial markets.

Finally, we show that within countries and sectors, firms have different strategies regarding the invoicing currency of their exports. Such heterogeneity has direct implication for exchange rate pass-through. Indeed, firms pricing in the importers' currency do not pass exchange rate fluctuations through import prices. Differences in invoicing currency may thus partly explain the heterogeneity in the degree of exchange rate pass-through documented in the literature. We show that such heterogeneity is related to firms' access to financial hedging; a dimension which has not yet been explored in the literature on exchange rate pass-through.

A Details on the model

A.1 Proof of proposition 3.2

Recall that

$$\pi^{PCP}(S) = p^{PCP} D\left(\frac{p^{PCP}}{S}\right) - C\left[D\left(\frac{p^{PCP}}{S}\right), w(S)\right]$$

The first derivative of $\pi^{PCP}(S)$ with respect to S writes

$$\frac{d\pi^{PCP}(S)}{dS} = \eta D\left(\frac{p^{PCP}}{S}\right)\frac{p^{PCP} - mc}{S} - \frac{\partial C(.)}{\partial S}$$

where $\eta \equiv -\frac{d\ln D(p^*)}{d\ln p^*}$, $mc \equiv \frac{\partial C(.)}{\partial D(.)}$ and we have used $\frac{dp^{PCP}}{dS} = 0$ in a one period ahead sticky price setting. As in Burstein & Gopinath (2014), we now assume that the marginal cost of production depends on the quantity produced as well as on the exchange rate: $mc = mc\left(D\left(\frac{p^{PCP}}{S}\right), S\right)$, where the exchange rate modifies the marginal cost of production insofar as some variable costs of production incurred by the exporting firm are local to the importing country. The analysis is further simplified by assuming $\frac{\partial^2 C(.)}{\partial S^2} = 0$, i.e. the cost function is linear in S. Under this assumption, the second derivative of $\pi^{PCP}(S)$ with respect to S then writes

$$\begin{aligned}\frac{d^2\pi^{PCP}(S)}{dS^2} =& \frac{d\eta}{dS} D(.)\frac{p^{PCP} - mc}{S} \\ &+ \eta\frac{dD(.)}{dp^{PCP}/S}\frac{dp^{PCP}/S}{dS}\frac{p^{PCP} - mc}{S} \\ &- \eta D(.)\frac{p^{PCP} - mc}{S^2} \\ &- \eta D(.)\frac{1}{S}\frac{dmc}{dS}\end{aligned}$$

and

$$\begin{aligned}\frac{dmc}{dS} =& \frac{\partial mc}{\partial D(.)}\frac{dD(.)}{dS} + \frac{\partial mc}{\partial S} \\ =& \frac{mc}{S}\left(\eta mc_q + \alpha\right)\end{aligned}$$

where $mc_q \equiv \frac{\partial \ln mc}{\partial \ln D(.)}$ is the partial elasticity of the marginal cost with respect to output and $\alpha \equiv \frac{\partial \ln mc}{\partial \ln S}$ is the partial elasticity of the marginal cost to the

exchange rate. We therefore obtain

$$\frac{d^2\pi^{PCP}}{dS^2} = \eta D(.)\frac{p^{PCP}-mc}{S^2}\left[-\frac{d\ln\eta}{d\ln p^{PCP}/S}+\eta-1-\frac{mc}{p^{PCP}-mc}\left(\eta mc_q+\alpha\right)\right]$$

and the concavity (convexity) of π^{PCP} with respect to the exchange rate S depends on the term within the brackets as given in (1). QED.

A.2 Proof of proposition 3.4

From the firm's program, we have that the firm chooses the hedging strategy that maximizes expected utility:

$$\max_{HLCP,LCP}\left\{\mathbb{E}\left[u\left(\pi^{HLCP}(S)\right)\right],\mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right]\right\}$$

i.e. the firm chooses HLCP whenever

$$\mathbb{E}\left[u\left(\pi^{HLCP}(S)\right)\right]-\mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right]>0$$

From lemma 3.3, we know that when using HLCP the firm fully hedges. Therefore profits under HLCP are certain ex-ante:

$$\mathbb{E}\left[u\left(\pi^{HLCP}\right)\right]=u\left(\pi^{HLCP}\right).$$

Using the fact that $f=\mathbb{E}(S)$ in equilibrium, we have

$$u\left(\pi^{HLCP}\right)=u\left(\pi^{LCP}\left(\mathbb{E}[S]\right)-F\right).$$

Remark that $u\left(\pi^{LCP}\left(\mathbb{E}(S)\right)-F\right)\approx u\left(\pi^{LCP}\left(\mathbb{E}(S)\right)\right)-\frac{du(\pi^{LCP})}{d\pi^{LCP}}F$. Inequality (2) obtains. QED.

A.3 Extension to a more general hedging cost

On top of the fixed cost assumed in Section 3.2, we could assume that hedging costs entail a variable component. Although in reality it is likely that variable costs of hedging are decreasing in the amount hedged, we discuss in this appendix the robustness of our results to variable costs that are increasing in the amount hedged. We now explain why the qualitative results in proposition 3.4 are not modified when adding a hedging cost component that increases in the quantity hedged h.

Assume

$$HC\left[h\right]=c(h)+F$$

where $c(h)$ is the variable cost component. With a variable cost component that is increasing in h (i.e., when $c'(h)>0$), the optimal strategy no longer necessarily involves full hedging. Instead, the firm chooses h so as to minimize the average total cost, which itself depends on the shape of the variable cost component. In optimum:

$$h^{*}c'(h^{*})-\left[c(h^{*})+F\right]=0$$

If we take a linear variable cost $c(h)=\beta h$, lemma 3.3 still holds true and condition (2) rewrites

$$u\left(\pi^{LCP}\mathbb{E}\left(S\right)\right)-\mathbb{E}\left(u\left(\pi^{LCP}(S)\right)\right)>\frac{du(\pi^{LCP})}{d\pi^{LCP}}\left[\beta p^{HLCP}D\left(p^{HLCP}\right)+F\right]$$

If we take a convex variable cost, say $c(h)=\beta\frac{h^{2}}{2}$, lemma 3.3 does not necessarily hold true anymore (it now depends on the convexity of the variable cost).[20] Provided that the variable cost is not too convex in h, lemma 3.3 still holds true and condition (2) rewrites as above when the variable cost is linear.[21]

In all cases, adding a variable cost component makes condition (2) more stringent: When the variable cost is linear or when it is convex and the firm fully hedges, this adds a term on the right-hand side of (2). All in all, it is the fixed-cost component of the hedging cost that makes the cost of hedging decreasing in the size of profits in equation (2). Our main result - i.e. that larger firms are more likely to hedge - therefore holds true except for extreme cases where the variable cost is very convex in the quantity hedged.

The more risk averse the exporting firm's manager, the more likely the benefits from hedging to outweigh the costs. When hedging costs entail a variable cost component, this latter should not be too convex for exporters to hedge.

[20] Whether or not lemma 3.3 still holds true depends on whether the bottom of the U-shaped average total cost function - which determines the optimal quantity hedged h^{*} - occurs below or above the maximum hedged value $p^{HLCP}D\left(p^{HLCP}\right)$.

[21] If the variable cost is highly convex and the firm does not fully hedge (lemma 3.3 does not hold), an extra term has to be subtracted from the left-hand side of condition (2), so as to reduce the utility benefit of hedging compared to the full-hedge case (when lemma 3.3 holds). This extra term reduces the utility benefit from removing the uncertainty because not all uncertainty is hedged when variable costs are highly convex. Note that this extra term is higher for large firms.

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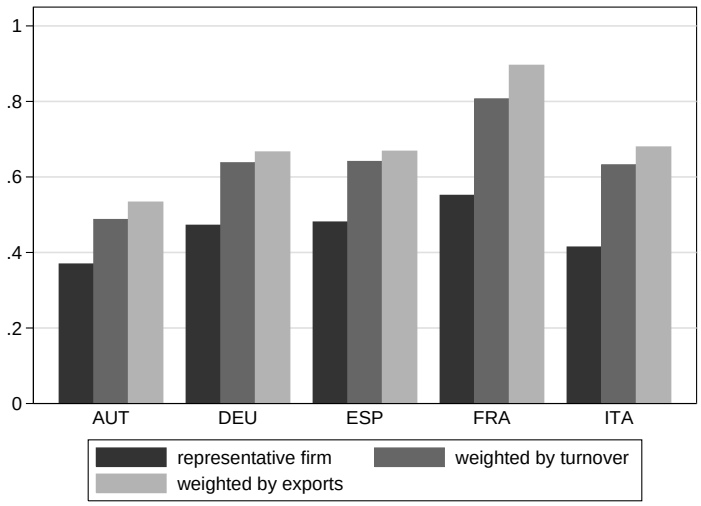
Figure 1 – Share of exporters facing exchange rate risks



Notes: This graph displays the share of firms from each country which declare being exposed to exchange rate risks when selling their product abroad. The black bars correspond to the answer of the representative firm, obtained by weighting individual answers using the absolute sample weights. The light grey bars weight individual firms by their size, as measured by their sales. The medium grey bars weight firms by the value of their exports.

Table 1 – Description of variables

Question	Answer	Variable
How do you deal with the exchange rate risk? Which of the following statements is similar to what your firm does?	1- I use a foreign exchange risk protection 2- I do not normally hedge against exchange rate risk 3- The question is not applicable, as I only sell to countries with the same currency of my domestic market	**Dummy exporter faces ER risk:** 1 if answer = 1 or 2 **Dummy hedging**: 1 if answer = 1

Continued on next page

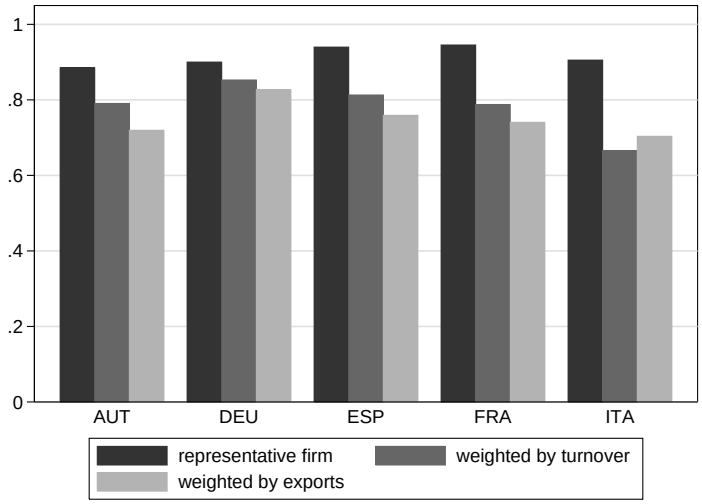
Question	Answer	Variable
In which currency do you set your prices in foreign countries?	1- Euro 2 - Domestic (for UK and Hungarian firms) 3- Other	**Dummy PCP**: 1 if answer = 1
In which of the following ranges falls the annual turnover in 2008 of your firm?	1- less than 1 million euro 2- 1-2 million euro 3- 2-10 million euro 4- 10-15 million euro 5- 15-50 million euro 6- 50-250 million euro 7- + 250 million euro	**One dummy for each interval** **Dummy Sales +50M:** 1 if answer = 6 or 7
Please indicate the total number of employees of your firm in your home country? Include all the employers, temporary staff, but exclude free lancers and occasional workers.	1- 10-19 employees 2- 20-49 employees 3- 50-249 employees 4- 250 employees and more	**1 dummy for each interval**
Which percentage of your 2008 annual turnover did the export activities represent?	Percentage: 1 to 100	**Export share**
Indicate to how many countries in total the firm exported its products in 2008?	Quantity: 1 to 200	**# dest.**
If we assume that the total export activities equal to 100 which percentage goes to destinations in the EU(15)? Same question for: Other EU cties, Other European not EU, China-India, Other Asian cties, USA-Canada, Central-South America, Other cties	Percentage: 0 to 100	**Share destination**

Continued on next page

Question	Answer	Variable
Has your firm benefited/purchased a trade/export insurance coverage?	1- Yes 2- No	**Dummy Trade Insurance**: 1 if answer = 1
During the last year did your firm use any kind of derivatives products (e.g. forward operations, futures, swaps) for external financing needs or treasury management or foreign exchange risk protection?	1- Yes 2- No	**Dummy Derivatives**: 1 if answer = 1
Has a significant share of your exports been financed by export credit?	1- Yes 2- No	**Dummy Trade Credit**: 1 if answer = 1
Factors preventing growth - Lack of management and/or organizational resources	1- Yes 2- No	**Dummy management**: 1 if answer = 1
How do you mainly set your prices in your domestic market?	1- margin o/ total costs 2- margin o/ variable costs 3- fixed by the market 4- regulated 5- Other	**Dummy Market:** 1 if answer = 3

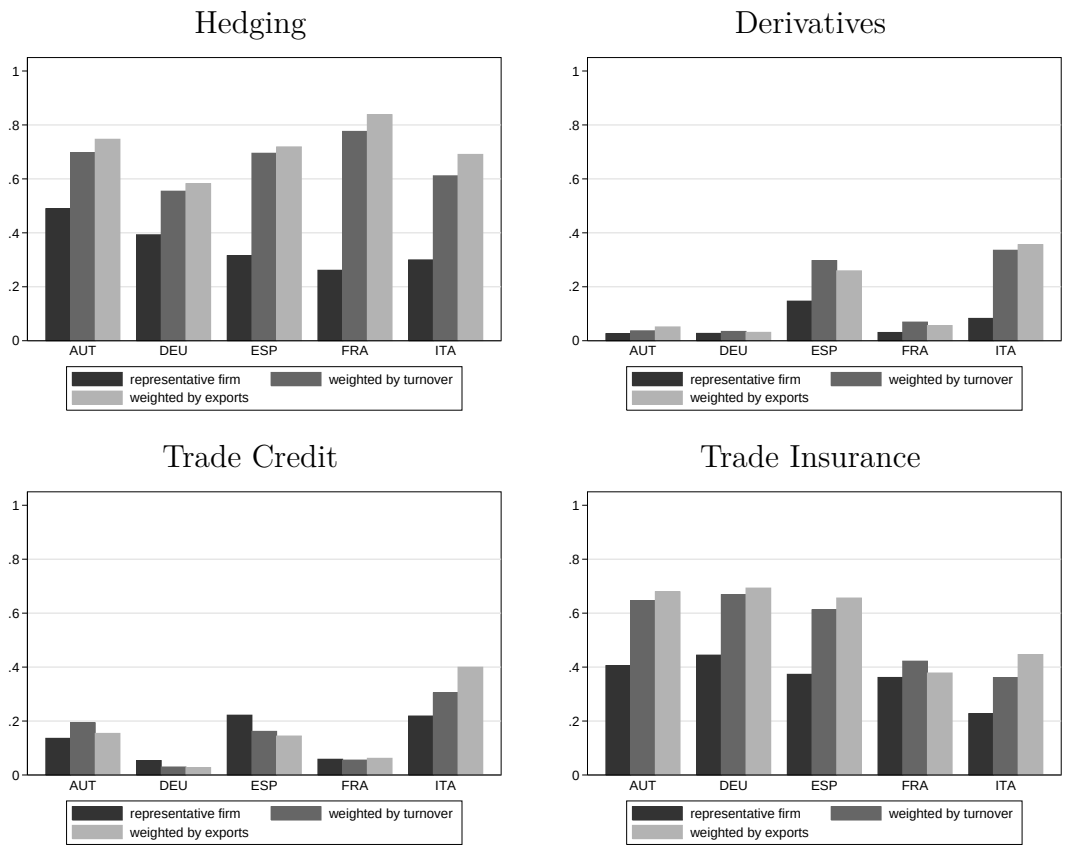
Notes: This table reproduces the questions exploited in our empirical analysis, the possible answers proposed in the survey, and the corresponding variables as used in the regressions.

Figure 2 – Share of firms pricing in euros



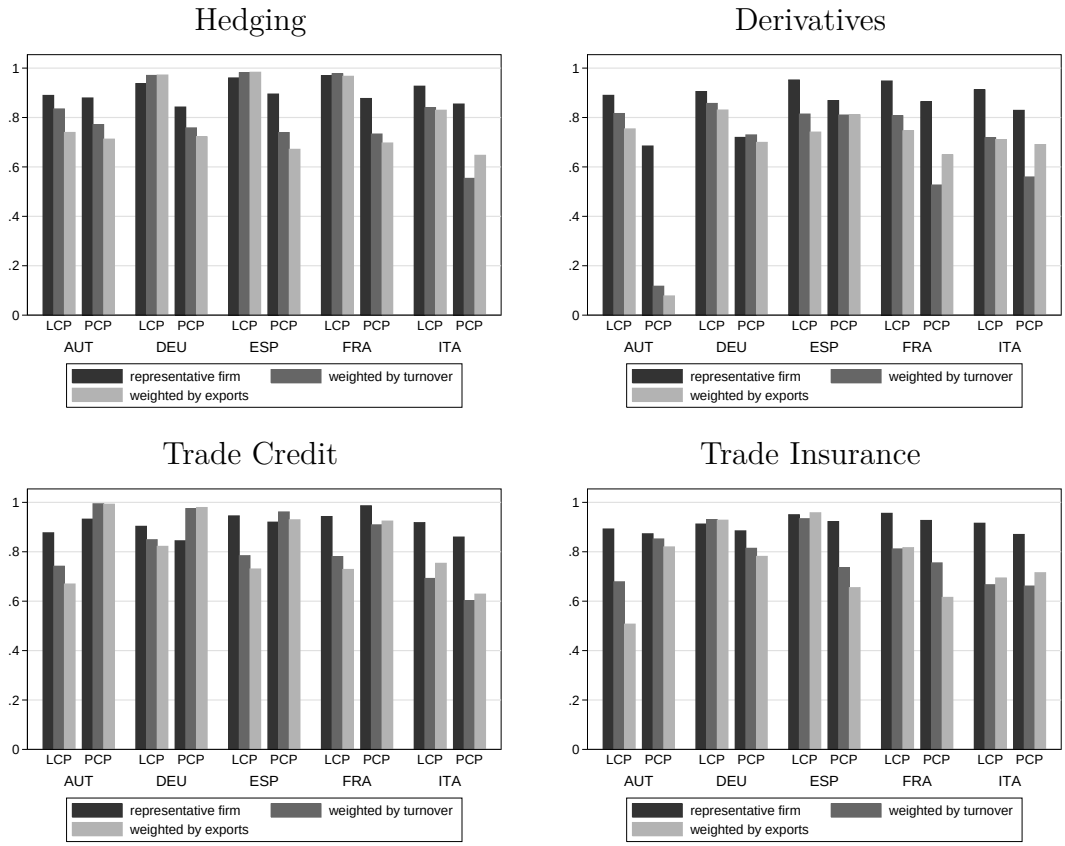
Notes: This graph displays the share of firms from each country which declare setting their price in euros. The black bars correspond to the answer of the representative firm, obtained by weighting individual answers using the absolute sample weights. The light grey bars weight individual firms by their size, as measured by their sales. The medium grey bars weight firms by the value of their exports.

Figure 3 – Use of Hedging, Derivatives, or Trade Finance



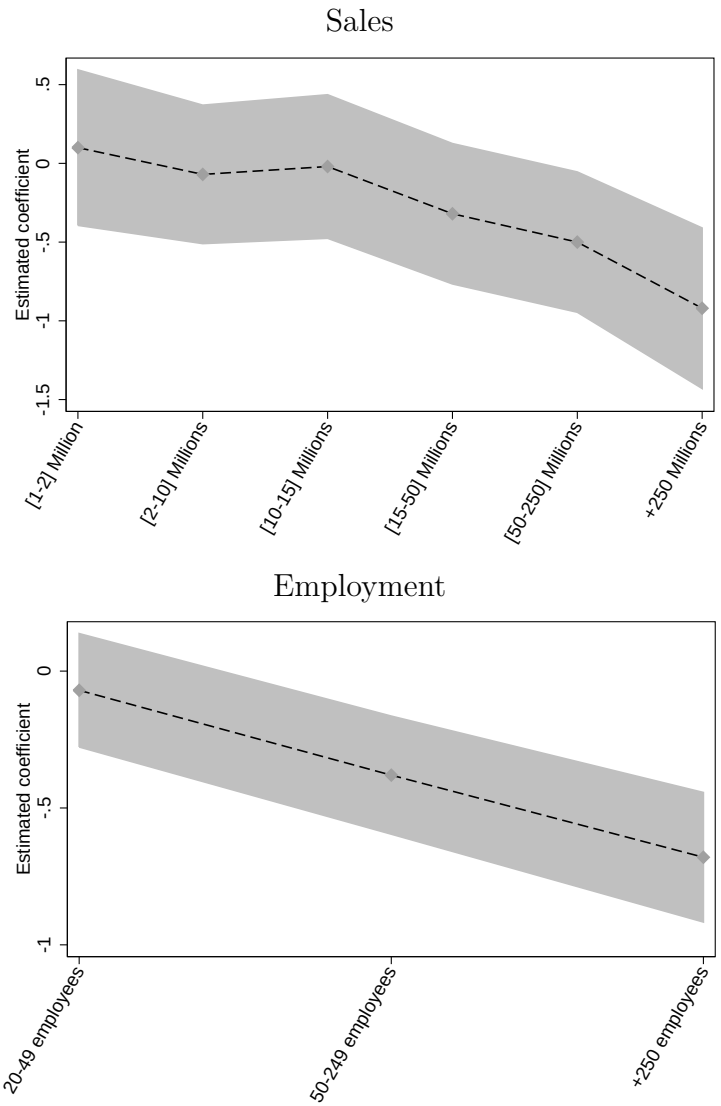
Notes: These graphs display the share of firms from each country which declare using financial hedging for dealing with their exchange rate exposure ("Hedging"), using financial derivatives ("Derivatives"), financing their export activity using a trade credit ("Trade Credit") and being covered by a trade insurance ("Trade Insurance"). The black bars correspond to the answer of the representative firm, obtained by weighting individual answers using the absolute sample weights. The light grey bars weight individual firms by their size, as measured by their sales. The medium grey bars weight firms by the value of their exports.

Figure 4 – Correlation between hedging and currency choices



Notes: These graphs display the share of firms from each country which declare using financial hedging for dealing with their exchange rate exposure ("Hedging"), using financial derivatives ("Derivatives"), financing their export activity using a trade credit ("Trade Credit") and being covered by a trade insurance ("Trade Insurance"). The statistics are depicted separately for firms pricing in euros ("PCP" bars) and for firms pricing in the importer's currency ("LCP" bars). The black bars correspond to the answer of the representative firm, obtained by weighting individual answers using the absolute sample weights. The light grey bars weight individual firms by their size, as measured by their sales. The medium grey bars weight firms by the value of their exports.

Figure 5 – PCP probability as a function of the firm's size



Notes: Estimated coefficients of the probit model explaining the probability that the firm prices in euros, as a function of her size. The firm's size is measured by her turnover, in million euros (top panel) or her employment (bottom panel). In both cases, the reference group corresponds to the smallest firms. All regressions also control for a full set of fixed effects for the firm's country of origin and sector of activity. The grey area is the 95% confidence interval.

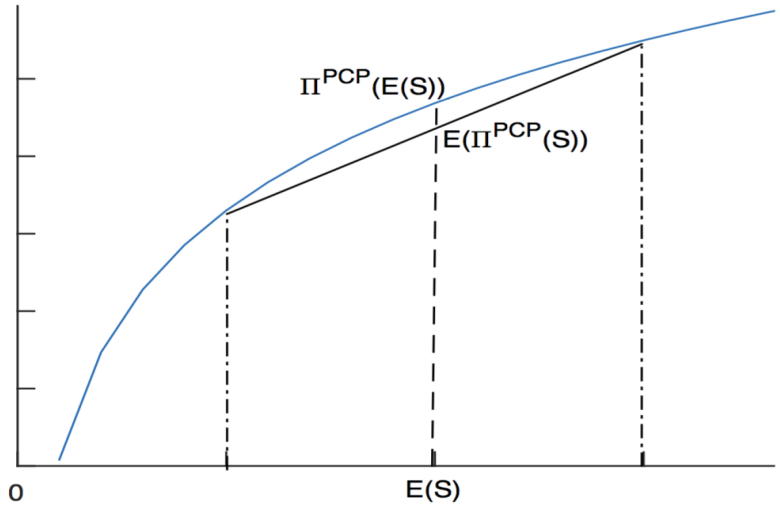


Figure 6 – Illustration of lemma 3.1 when S is uniformly distributed

Table 2 – Determinants of currency choices: Baseline results

	Dep.Var: Probability(PCP)			
	(1)	(2)	(3)	(4)
Sales above 50 millions	-0.48***	-0.54***	-0.55***	-0.52***
	(-5.346)	(-5.784)	(-5.783)	(-5.527)
Share of exports	-0.71***	-0.56***	-0.58***	-0.56***
	(-5.427)	(-4.031)	(-3.723)	(-4.040)
Sh. Oth. EU		0.00	0.00	0.00
		(0.685)	(0.668)	(0.675)
Sh. Other Eur.		-0.00	-0.00	-0.00
		(-0.918)	(-0.904)	(-1.063)
Sh. Chn-Ind		-0.01***	-0.01***	-0.01***
		(-3.114)	(-3.115)	(-3.079)
Sh. Other Asia		-0.01**	-0.01**	-0.01**
		(-2.398)	(-2.405)	(-2.531)
Sh. North Am.		-0.01***	-0.01***	-0.01***
		(-6.134)	(-6.079)	(-6.299)
Sh. South Am.		-0.01***	-0.02***	-0.01***
		(-6.048)	(-6.075)	(-5.982)
Sh. Row		-0.00	-0.00	-0.00*
		(-1.503)	(-1.520)	(-1.721)
# destinations			0.01	
			(0.329)	
No pricing power				-0.21**
				(-2.563)
Origin country FE	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes
# Observations	3,011	3,011	3,011	3,011

Notes: This table presents the estimated coefficients of a probit model. The explained variable is the probability that the firm set prices in euros (PCP strategy). The explanatory variables are a dummy equal to one if the firm's turnover is above 50 million euros ("Sales above 50 millions"), the share of exports in total sales ("Share of exports"), the share of exports sold in the EU15 ("Sh. Oth. EU"), in the rest of Europe ("Sh. Other Eur"), in China or India ("Sh. Chn-Ind"), in the rest of Asia ("Sh. Other Asia"), in North America ("Sh. North Am."), in South America ("Sh. South Am.") and in the rest of the world ("Sh. Row), the log of the number of destinations ("# destinations") and a dummy equal to one if the firm declares herself not having any pricing power ("No pricing power"). Regressions control for sector and country of origin fixed effects. T-statistics computed from robust standard errors are reported under parenthesis. ***, ** and * respectively indicate significance at the 1, 5 and 10% level.

Table 3 – Determinants of currency choices: The role of financial hedging

	Dep.Var: Probability(PCP)				
	(1)	(2)	(3)	(4)	(5)
Sales > 50 millions	-0.41***	-0.47***	-0.50***	-0.52***	-0.38***
	(-4.334)	(-4.956)	(-5.274)	(-5.545)	(-3.963)
Share of exports	-0.46***	-0.53***	-0.54***	-0.53***	-0.43***
	(-3.259)	(-3.783)	(-3.883)	(-3.785)	(-2.976)
No pricing power	-0.21***	-0.21***	-0.21***	-0.21***	-0.22***
	(-2.582)	(-2.622)	(-2.615)	(-2.593)	(-2.664)
Hedging	-0.38***				-0.34***
	(-4.796)				(-4.072)
Derivatives		-0.42***			-0.32**
		(-3.304)			(-2.368)
Trade Insurance			-0.11		-0.04
			(-1.347)		(-0.458)
Trade Credit				-0.14	-0.06
				(-1.327)	(-0.545)
Origin country FE	yes	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes
Shares areas	yes	yes	yes	yes	yes
Obs.	3,011	3,011	3,011	3,011	3,011

Notes: This table presents the estimated coefficients of a probit model. The explained variable is the probability that the firm set prices in euros (PCP strategy). The explanatory variables are a dummy equal to one if the firm's turnover is above 50 million euros ("Sales > 50 millions"), the share of exports in total sales ("Share of exports"), a dummy equal to one if the firm declares herself not having any pricing power (ŞNo pricing powerT̃) and dummies for the use of hedging instruments ("Hedging"), financial derivatives ("Derivatives"), trade insurance ("Trade Insurance"), or trade credit ("Trade Credit"). All regressions also control for country of origin and sector dummies, and the share of different areas in the firm's export sales. T-statistics computed from robust standard errors are reported under parenthesis. ***, ** and * respectively indicate significance at the 1, 5 and 10% level.

Table 4 – Determinants of currency choices: bivariate probit regressions

	(1) PCP -	(2) PCP 2^{st} stp	(3) Hedg. 1^{st} stp	(4) PCP 2^{st} stp	(5) Hedg. 1^{st} stp
Sales > 50 millions	-0.42***	-0.23	0.59***	-0.18	0.56***
	(-4.308)	(-1.421)	(7.420)	(-1.184)	(6.979)
Sh. Exports	-0.49***	-0.28	0.70***	-0.24	0.54***
	(-3.040)	(-1.447)	(6.668)	(-1.269)	(4.533)
No Pricing Power	-0.21***	-0.20**	0.03	-0.19**	0.03
	(-2.588)	(-2.441)	(0.459)	(-2.420)	(0.574)
Hedging	-0.37***	-0.95**		-1.10***	
	(-4.544)	(-2.089)		(-2.715)	
Trade Insurance	-0.04		0.50***		0.44***
	(-0.482)		(8.263)		(6.940)
Trade Credit	-0.08				0.29***
	(-0.768)				(3.708)
Weak Management	0.22		-0.16*		-0.18**
	(1.607)		(-1.884)		(-2.108)
# destinations	0.03				0.07**
	(0.810)				(2.256)
Origin country FE	yes	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes
Shares areas	yes	yes	yes	yes	yes
Obs.	3,011	3,011	3,011	3,011	3,011

Notes: This table presents the results of two bivariate probit regressions. The explained variable in the second regression is a dummy equal to one if the firm invoice exports in euro. The "instrumented variable" in the first stage is a dummy equal to one if the firm hedges against ER risk. Other explanatory variables include a dummy equal to one if the firm's turnover is above 50 million euros ("Sales > 50 millions"), the share of exports in her total sales ("Sh. Exports"), a dummy equal to one if the firm declared herself as having no pricing power ("No Pricing Power"), a dummy for the firm's country of origin, a dummy for her sector of activity and a set of export shares measuring the geographic composition of her exports. The instruments are dummies for the use of a trade insurance ("Trade Insurance"), or a trade credit ("Trade Credit"), a dummy equal to one if the firm reports lacking organizational or management resources ("Weak Management") and the log of the number of destinations served ("# destinations"). T-statistics computed from robust standard errors are reported under parenthesis. ***, ** and * respectively indicate significance at the 1, 5 and 10% level.