Invoicing Currency and Financial Hedging*

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September 14, 2020

Abstract

We examine the link between exporters' currency choice decisions and the use of financial instruments to hedge exchange rate risks. On the empirical side, we find that large firms (either pricing in their own or in a foreign currency) are more likely to use hedging instruments, but the use of these instruments is more prevalent among firms pricing in a foreign currency. We then provide evidence that access to hedging instruments increases the probability of pricing in a foreign currency. A general framework of invoicing currency choice augmented with hedging can rationalize these facts. Consistent with our empirical findings, we show that large firms that would have chosen to price in their own currency in the absence of hedging instruments can decide to set prices in a foreign currency if they have access to such instruments.

Keywords: Currency choice, Hedging, Survey data
JEL classification: F31, F41, G32

*This paper is a substantially revised version of "Invoicing Currency, Firm Size, and Hedging" by Julien Martin and Isabelle Mejean. We thank the editor, Kenneth West, and two anonymous reviewers for their constructive comments, which helped us improve the manuscript. We are grateful to Edouard Challe, Lionel Fontagné, Denis Gromb, Philippe Martin, Mathieu Parenti, Cédric Tille, and Walter Steingress for helpful suggestions, and to seminar participants at Banque de France. We also wish to thank Tommaso Aquilante for his help with the data. Julien Martin acknowledges financial support from the FRQSC grant 2015-NP-182781, Victor Lyonnet from Investissements d'Avenir (ANR-11- IDEX-0003/Labex Ecodec/ANR-11- LABX-0047), and Isabelle Mejean from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 714597).

1 Introduction

This paper investigates the link between the choice of an invoicing currency and exchange rate risk management by exporting firms. We find large firms are more likely to use hedging instruments against exchange rate fluctuations, and to invoice their exports in a foreign currency. We also present suggestive evidence that access to financial hedging increases the probability a firm exports in a foreign currency. We develop a general framework of currency choice with hedging consistent with these empirical findings. Under plausible conditions, some large firms that would have chosen to price in their own currency in the absence of hedging instruments choose to price in a foreign currency if they have access to such instruments.

The currency denomination of exports is the topic of a large literature in international macroeconomics starting from Betts & Devereux (1996). Whether firms price their exports in their own or in a foreign currency has key implications for the international transmission of shocks, the optimal monetary policy or the choice of an exchange rate regime.[1] Although the literature has studied several determinants of the currency denomination of exports such as the curvature of the demand function, the extent of price rigidities, or the structure of costs (see Burstein & Gopinath 2014, for a survey), the possibility of firms hedging against exchange rate risk has been neglected.[2]

Risk management, including foreign exchange risk, ranks among the most important objectives of firms' financial executives.[3,4] In 2016, daily trading in foreign exchange markets averaged $5.1 trillion (BIS 2016). The volume of trade in hedging instruments has strongly increased over the past decades, with firms accounting for most of this increase.[5] Accounting for these financial hedging instruments is important because they provide firms with

[1] See Corsetti & Pesenti (2009), Devereux & Engel (2003), or Corsetti & Pesenti (2005) on the implications of pricing in the producer's versus the importer's currency. More recently, Gopinath et al. (2016) study the implications of choosing a vehicle currency such as the dollar.

[2] A notable exception is Friberg (1998).

[3] 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.

[4] Hedging instruments such as forwards, futures, swaps, and options are prominent tools for managing such risks, used by 94% of the world's largest corporations (Nance et al. 1993, ISDA 2009).

[5] See `http://www.bis.org/statistics/about_derivatives_stats.htm`, and Stulz (2004) for a discussion.

the opportunity to price their exports in foreign currency without bearing the risk associated with such pricing strategy. From both an empirical and theoretical viewpoint, we study how hedging and the currency denomination of exports interact.

On the empirical side, we exploit survey data collected in 2010 on almost 15,000 firms located in the European Union. We restrict our attention to about 3,000 firms located in five eurozone countries that export outside of the euro area and thus face exchange rate risks. In this sample, we study the relationship between currency choice decisions and the use of hedging instruments. Whereas 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 specific hedging instruments, such as derivatives. We use this information to investigate the interplay between hedging and invoice currency decisions.

Firms in the survey are asked whether they set their prices in euros or in another currency when exporting to foreign countries.[6] If firms set their prices in euro, they do producer currency pricing (PCP). If they don't, they either price in the currency of the trade partner (local currency pricing, LCP) or in a vehicle currency. The empirical results are thus about the use of the euro versus a foreign currency. In the theoretical section, we consider PCP and LCP strategies, and we discuss how the theoretical results generalize in presence of vehicle currency pricing (Goldberg & Tille 2008) or dominant currency pricing (Gopinath et al. 2016).

In our data, PCP is the main strategy used by the firms. Although around 90% of exporters declare pricing in euros when exporting outside of the EMU, only about 75% of the value of exports are priced in euros, because large exporters are more likely to price in another currency. Such heterogeneity is consistent with Goldberg & Tille (2016), who interpret the link between the currency of invoicing and the size of the transaction as a consequence of currency choices being influenced by the consumer's bargaining power. We further document that hedging instruments are mainly used by the largest firms, and that the prevalence of hedging is stronger among firms pricing in currencies other than the euro. Probit regressions reveal that firms using financial hedging are more likely to price in a foreign currency, controlling

[6]Unfortunately, the survey does not collect information on the currency denomination of exports, by destination country. We restrict the sample to firms that do export in non-euro countries, which are likely to report the currency denomination of their sales outside of the euro area. We also use a more restricted sample in which firms sell at least 15% of their exports outside of the euro area, and find results to go through. Based on this finding, we are confident that exposure to exchange rate risk in export markets is a relevant concern for the subsample of firms under study.

for other determinants of currency choices. To make progress regarding the causality of this relationship, we instrument the use of financial hedging by firms with a measure of access to risk management, and find the impact of hedging on the decision to price in a foreign currency is even stronger once we control for potential endogeneity. This finding suggests that large firms are more prone to price in a foreign currency *because* they have better access to financial hedging.[7]

We rationalize these findings using a model studying firms' invoicing decisions when they have the possibility to hedge against exchange rate risk. The model generalizes the analysis in Bacchetta & van Wincoop (2005) and Burstein & Gopinath (2014) to the case in which exporters can purchase exchange rate derivatives at a cost. In a one-period-ahead sticky-price environment with exchange rate uncertainty, the choice between pricing in domestic versus a foreign currency depends on the difference in expected profits that both strategies imply. As already discussed in the literature, optimal invoicing strategies then depend on the curvature of the demand function, the extent of returns to scale, and the sensitivity of marginal costs to the exchange rate. We depart from the usual framework by (i) assuming exporters risk averse[8] and (ii) enabling them to use financial instruments to hedge against exchange rate risk.[9] 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 strategies offered to exporters is thus: to price in her own or in a foreign currency and to hedge or not against exchange

[7]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 whereas small firms often do not conduct active risk management (see, e.g., Nance et al. 1993, Geczy et al. 1997, Rampini & Viswanathan 2013).

[8]According to the Modigliani and Miller theorem, risk management is irrelevant to the firm. Similarly, absent risk aversion, an exporter would not hedge exchange rate risk in equilibrium. However, Graham & Smith (2000), Graham & Harvey (2001), Graham & Rogers (2002*a*) provide empirical evidence that firm managers actively manage risks. Therefore, we depart from the Modigliani and Miller assumptions by modeling exporters' risk aversion as an outgrowth of managers' risk aversion (Stulz 1984). Exporters' risk aversion could also be due to convex tax schedules, or expected costs of financial distress (Smith & Stulz 1985). We discuss in Section 3.2 other rationales that can explain why firms optimally manage their risks, and argue they would not change our model's predictions.

[9]In our model, we allow the marginal production cost to depend on exchange rates, which can be a source of *operational* hedging against exchange rate fluctuations. However, we focus our analysis on *financial* hedging (i.e., using derivatives), which we implicitly assume to be the best hedging device. Indeed, financial hedging is cheaper than trying to borrow in the foreign currency or to accommodate exchange rate fluctuations by adjusting operational hedging continuously.

rate risk.

We study the determinants of this choice, as a function of the model's primitives. More specifically, we show the framework can provide theoretical grounds for the two facts uncovered in the empirical analysis. First, conditional on a currency choice, large firms are more likely to hedge against exchange rate risk. In our framework, this result rests on the assumption that a fixed component is present in the cost of hedging. 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 that banks charge on those products. Alternatively, we argue that a similar outcome could arise endogenously in the absence of fixed costs if small firms were more financially constrained as in Rampini & Viswanathan (2013). The fixed component can thus be viewed as a shortcut for this type of mechanism. In this simple framework, we can show analytically that the size threshold above which firms choose to hedge is higher for firms pricing in their own currency. These results are thus consistent with evidence that large firms are more likely to hedge, and that hedging is more prevalent among firms pricing in a foreign currency.

Our model can also account for the causal effect of hedging on currency invoicing. Namely, we show that some firms that would otherwise price in their own currency choose to price in a foreign currency and to hedge against exchange rate risk if they have access to hedging instruments. Large and more risk-averse firms are the most likely to switch from producer to foreign-currency pricing in this context. The intuition for this result is as follows. Without hedging, firms choose PCP if the expected profit is higher than in LCP. With hedging, a risk averse firm can reduce the variance of expected profits, more so if hedging is combined with LCP. The risk on revenues associated with LCP can indeed be hedged fully while the demand risk incurred by PCP firms is only partially covered by hedging instruments. A risk-averse firm can thus decide to switch to LCP in presence of hedging, despite incurring a lower expected profit, to reach the minimum variance of profits.[10] This finding is in line with our empirical finding that access to hedging instruments is a significant determinant of exporters' invoicing-currency decisions. It also implies that neglecting hedging can lead to misinterpret invoicing choices.

Our paper contributes to the literature on the determinants of invoicing-currency choices. Within this literature, the heterogeneity in invoicing cur-

[10] A corollary of this is that a firm that prices in LCP without hedging necessarily prices in LCP when hedging. Pricing in LCP under no hedging means that expected profits are higher in LCP than in PCP. Since the variance under financial hedging is necessarily lower in LCP than in PCP, a firm would never switch to PCP once getting access to hedging.

rency decisions along the distribution of firms' size is now well established. Goldberg & Tille (2016) find the invoicing currency depends on (i) macro determinants such as exchange rate volatility, (ii) product-level determinants such as market structure and product differentiation, and (iii) transaction-specific factors, namely, the size of the transaction. Devereux et al. (2017) also show evidence of the currency of invoicing being heterogeneous along the distribution of exporters' and importers' size. Finally, Amiti et al. (2019) show that large Belgian exporters are more likely to invoice exports outside the eurozone in a foreign currency. In comparison with these papers, our survey data do 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. (2016) use a survey of Japanese firms to document the correlation between firms' exchange rate exposure and their risk management strategy. They find the exposure to the YEN/USD exchange rate is positively correlated with the use of hedging instruments by Japanese firms that mainly price in USD. We make three contributions with respect to these papers. First, we are the first to document the invoicing currency of individual firms for a panel of eurozone countries. Because the euro is a vehicle currency, euro exporters mostly have to choose between pricing in euros or pricing in the importer's currency. Second, we highlight the link between firm size, financial hedging, and invoicing currency. Third, we identify a causal impact of access to hedging on the choice of the invoicing currency.

On the theoretical side, the literature has extensively examined the endogenous decision of an invoicing currency (see, e.g., Friberg 1998, Bacchetta & van Wincoop 2005, Devereux et al. 2004, Gopinath et al. 2010). Burstein & Gopinath (2014) propose a unified framework linking the different factors influencing this decision. 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 the presence of hedging options. 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 an 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 the use of financial instruments involves a fixed cost, which creates a link between firms' decision to use derivatives and their size.

The paper also contributes to the literature on exchange rate pass-through. Empirical differences in the choice of an invoicing currency by individual exporters relate 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 trade costs, import intensity, 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 foreign currency, we expect their local prices to be only somewhat responsive to exchange rate fluctuations. This is consistent with Berman et al. (2012) and Amiti et al. (2014) but differs from Auer & Schoenle (2016), Garetto (2016), or Devereux et al. (2017), who find a U-shaped relationship between pass-through and size.[11] 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. Compared with existing explanations put forward in the literature, ours is conceptually different because it implies the exchange rate risk is passed onto financial markets, whereas the literature has mostly discussed the identity of who is bearing the risk: the importer or the exporter. What we argue is that zero pass-through does not imply the exporter bears the risk of exchange rate fluctuations, although passing this risk onto financial markets incurs a cost.

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,

[11] One potential explanation for the linear relationship we uncover empirically is that the survey does not cover enough large firms to identify the upward-sloping part of the firm size–PCP relationship.We discuss in the theory how our model can account for this non-linearity, either using the same argument as in Auer & Schoenle (2016), or when assuming the degree of risk aversion is lower for large firms.

Hungary, Italy, Spain, and UK) were surveyed in 2010. Most of these firms belong to the manufacturing sector.[12] More than 150 items provide information on the structure of the firm, its 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 eight areas (EU15, rest of EU, non-EU European countries, China and India, other Asian countries, USA and Canada, rest of America, and the rest of the world). We keep firms that (i) declare exporting, (ii) report an export share lower than 100%, and (iii) are located in the EMU.[13]

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 shown in Figure 1, a large fraction of exporters report this question is not applicable: the geography of their sales does not 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 result, exporters that are not exposed to ER risk represent less than 40% of aggregate sales. This fact can be seen from a visual comparison of the black and grey bars in Figure 1, where we compare the exposure to ER risk for small and large firms. 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. Ninety-nine of these firms are located in Austria, 770 in France, 630 in Germany, 844 in Italy, and 670 in Spain.[14]

The use of survey data can raise concerns about sample representativeness. To address this concern, we use available information on a measure

[12]The survey also covers firms operating in the service sector. Most of these firms are excluded from the estimation sample though, as they do not face any exchange rate risk. Importantly, the survey does not cover firms in the agriculture, forestry, fishing, mining and quarrying sectors. In those sectors, invoicing currency choices are of less interest because commodities tend to be systematically priced in US dollars.

[13]Our analysis neglects firms located outside of the EMU, i.e., in the UK or Hungary. Thanks to this selection, we recover a sample of firms that all share the same currency, and can pool them to study the determinants of their invoicing strategies.

[14]Focusing on firms that are exposed to exchange rate risk naturally involves some selection. Figure A.1 in appendix displays the share of firms exposed to exchange rate risk across i) small and large firms, ii) firms invoicing in PCP and in an other currency, iii) firms that are hedged or not. As expected exposure to exchange rate risk varies substantially across these categories.

of the probability of each firm being 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. The sample 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. These sample weights allow us to document the behavior of the "representative firm" in each country. We further consider two alternative weighting schemes to account for potential heterogeneity in the behavior of small and large firms. First, we rescale the sample weights using data on firms' mean turnover in each strata. Thus, we obtain statistics that account for the relative weight of each firm in total sales. Second, 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?" for which the possible answers are Euro, Domestic, or Other. Based on firms' response to this question, we construct a dummy variable which is equal to one when the firm chooses either "Euro" or "Domestic", i.e. a "Producer Currency Pricing" (PCP) strategy, and zero otherwise. Unfortunately, the survey does not allow us to dig deeper into non-PCP firms' invoicing strategies and separate firms that price in the importer's currency ("Local Currency Pricing" or LCP) from firms that use a vehicle currency ("Vehicle Currency Pricing", VCP). We explain later how we deal with this issue, by testing the robustness of our results across sectors that are more or less prone to using a vehicle currency.[15]

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 setting their prices in euro (black bars in Figure 2). The use of PCP is thus prevalent. PCP is however less pronounced when weighting observations by the firms' size (light and medium grey bars in Figure 2). This is confirmed by results in Figure A.2 which show the prevalence of PCP

[15]Another caveat is that the invoicing dummy does not allow us to measure potential heterogeneity in a firm's currency choices across destinations. Instead, firms likely answer based on their invoicing strategy for their main export destinations. The lack of bilateral information precludes us from testing theories that explain the heterogeneity in a firm's invoicing strategy across destinations, such as the importance of firms' market power across destinations (Atkeson & Burstein 2008, Auer & Schoenle 2016). Amiti et al. (2014) and Bonadio et al. (2020) provide evidence consistent with these theories.

pricing by size bins. In both cases, we find that large firms are less likely to price in PCP.

How do these findings compare with previous studies of currency choices? Kamps (2006) reports that only 60% of EMU exports were invoiced in euros as of 2004. In the ECB (2011) report on the internationalization of the euro, this proportion reaches 68% for EMU exports to non-eurozone countries. These figures are aggregate. As such, one should therefore compare them with our size-weighted statistics. Once firm size is taken into account, around 75% of exports are found to be invoiced in euros (70% for Italy, 82% for Germany).[16] In unreported results, we compare currency choices in different subsamples of firms constructed based on the geography of their sales, their sector, or the nationality of their main competitor. We found the use of the euro 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. Although the results here are not especially conclusive, we use these variables as controls in the empirical framework.

We complement information on currency choices with variables measuring firms' risk management strategy. Our primary measure of financial hedging uses 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 and define a "hedging" dummy accordingly. 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 illustrates 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 claim they hedge against exchange rate risk. A substantial share of firms use trade insurance, 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 is that currency choices and hedging strategies are complementary from the exporter's point of view. Figure 4 shows statistics

[16]Note the weighting procedure is based on firms' size and total exports, whereas ECB figures are based on exports to non-eurozone countries. Because 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.

consistent with this view. The propensity of firms to use various hedging instruments is measured in the subsample of PCP firms ("PCP" bars) and in the subsample of firms using a foreign currency ("non-PCP" bars). Large firms appear to be more likely to hedge against exchange rate risk, and PCP firms tend to rely less on hedging instruments. In the next subsection, we investigate the statistical significance of this result and ask whether it can be interpreted in a causal way. Note that the correlation between firms' size, invoicing and the use of other financial instruments is less pronounced (see the last three graphs in Figure 4).

Before turning to the empirical analysis, it may be useful to discuss one last caveat of the data: the cross-sectional nature of the survey. Firms were surveyed in 2010 and one may be concerned that their responses were affected by the Great Financial Crisis of 2008–2009, or that they are no longer representative of firms' current behaviors. Unfortunately, we cannot completely rule out these concerns as the survey has not been replicated since then. However, we find reassuring evidence that on average, the two main variables of interest – firms' invoicing and hedging strategies – have not changed dramatically either during the financial crisis or in the last decade. Specifically, we use data from Boz et al. (2020) to study the prevalence of PCP pricing over the 2007–2018 period in the five countries in our sample. On average, firms' propensity to choose PCP remains fairly stable over this period. To the best of our knowledge, similar panel data on firms' propensity to use ER risk hedging do not exist. As a proxy, we use BIS data on the derivatives market.[17] The data reveal a positive trend in the volume of exchange in these markets, which may indicate that firms now have access to more hedging opportunities than they did ten years ago. Non-financial counterparts remain marginal in these markets, however, making it difficult to conclude that firms are responsible for the bulk of the increase in trading volume in derivatives markets. How much firms' hedging propensity has increased since 2010 remains an open question.

2.2 Standard 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 invoice their exports in a foreign currency more often than smaller ones. Moreover, currency-choice

[17]The BIS data are from various waves of the Triennal Central Bank Survey of Foreign Exchange and Over-The-Counter Derivative Markets. This survey is meant to obtain comprehensive and consistent information on the size and structure of global foreign exchange and OTC derivatives markets. It is accessible at https://www.bis.org/statistics/rpfx19.htm.

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 its 4-digit sector of activity.

We first study the correlation between firms' size and currency choices. To this aim, we control for different measures of size based on the 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.[18] As expected, results show the probability of choosing a PCP strategy is decreasing in firm size. The difference is significant for firms with more than €50 million sales or 50 employees. This result is consistent with previous evidence that firms of heterogeneous size make different currency choices and display heterogeneous degree of exchange-rate pass-through, e.g. Berman et al. (2011). Figure 5 does not show any non-linearity between size and invoicing though, which is in contrast with results from the previous literature (Auer & Schoenle 2016, Devereux et al. 2017, Bonadio et al. 2020). One possible explanation is that our data do not cover a large enough number of large firms, as only 3% of firms in the survey declare a turnover above €250 million. As the expected non-linearity should be triggered by very large firms, such small coverage at the top of the distribution may explain the inconsistency.[19] Based on these non-parametric results, we systematically control for firm 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 1 for firms with a turnover above €50 million.

Table 2 presents a set of benchmark regressions that test standard deter-

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

[19] In Auer & Schoenle (2016), the non-linearity kicks in above a market share of 72%, i.e. for firms that are close to a monopoly. We checked in unreported results that the absence of any non-linearity remains true in other specifications, including in the main specifications of Table 4. This implies that imposing linearity as is de facto done when using a dummy for large firms is not misleading in our case.

minants of currency choices. We start with the specification used in Figure 5 and add various proxies for the degree of exposure to exchange rate risk. In column (1), we use the share of exports in the firm's sales. In column (2), we add the contribution of various geographical area to the firm's export turnover. Column (3) further controls for the firm's pricing power. Namely, firms were asked how they decide on their price in their domestic market. One possible answer is that the price is fixed by the market which we interpret as the firm lacking market power. Using firms' answer to this question, we construct a dummy variable that identifies firms without market power. Their lack of market power is likely to push firms to choose a foreign currency to stick to the market price.[20] Finally, column (4) adds a dummy identifying firms that belong to a multinational company. Whereas our analysis implicitly focuses on firms' exposure to exchange rate risk through trade activities, firms involved in multinational activities may also be exposed through the consolidation of revenues made in various affiliates located in different monetary zones. Such "translation" risk may or may not influence both their invoicing strategy and their propensity to hedge.

Results displayed in Table 2 are broadly in line with expectations. The probability that a firm sets export prices in a foreign currency 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. Having no pricing power is also a significant predictor of the firm's invoicing strategy (column (3)). Empirically, we find that firms declaring their price to be set by the market are less likely to price in their own currency. Finally, mutinational companies may be less likely to price in domestic currency, although the impact is non-significant. 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.

These results are complemented in Table A.1 in Appendix with various robustness checks run on various subsamples of firms. Results are qualitatively unchanged if we focus on those firms that are the most likely to choose their invoicing currency strategically, i.e. firms with at least one of their main partner located outside of the EMU (Column (2)). They are virtually the same if we neglect firms that are part of a multinational company (Column (3)), based on the argument that such firms do not necessarily take decisions based on their sole profits or are confronted to different kinds of risk. Finally, we do not find evidence that firms that are the most likely to use a vehicule

[20]The impact of low market power on firms' invoicing strategies is however ambiguous. At the limit, firms that do not have market power may be forced to price at their marginal cost. If these are incurred in domestic currencies, PCP should instead prevail. Empirically, we find that firms whose price is fixed by the market are less likely to price in PCP.

currency are systematically biasing results. One may indeed be concerned that our inability to separately identify LCP and VCP pricing affects our results. Whereas this is a possibility that we can not rule out, results in Columns (4)-(5) in Table 2 offer some reassuring results. We propose two methodologies to identify firms that are the most likely to price in VCP. In column (4), we exclude firms related to commodity sectors (namely those producing petroleum and basic metal products), that represent less than 3% of observations though. In column (6), we exclude all firms belonging to a sector in which more than 50% of respondents say their price is fixed by the market. The rational for such restriction is that markets in which most firms are price-taker are likely to converge on a single price, potentially set in a single (vehicle) currency. Using this more stringent restriction does not change the results either (Column (5)).

We see these results as indicative that the data at hand are insightful to study firms' invoicing decisions. In the rest of the analysis, we use these variables as controls while focusing on the paper's main question, namely the interaction between firms' invoicing and hedging decisions.

2.3 Currency choice under financial hedging

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 reporting that they hedge against exchange rate risk are less likely to choose PCP (column (1)), as are 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 the 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

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

where $HEDG_f$ is a binary variable equal to 1 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. δ_1, δ_2, and β are vectors of coefficients to estimate. In Table 3, we implicitly assumed the correlation between ϵ_1 and ϵ_2 was nil. If the correlation is not nil, hedging is an endogenous variable in the currency equation. To have a consistent estimate of β, we must find a set of variables correlated with the hedging decision but uncorrelated with ϵ_1. We try two specifications.

In the first specification, we use two instrumental variables. The first variable is a dummy equal to one if the firm has subscribed to trade insurance. We argue that the subscription to trade insurance is likely to affect the firms' propensity to hedge against ER risk. Indeed, companies specialized in trade insurance often offer ER risk insurance to complement with their main products. Coface is a leading example of a (French) global credit insurer offering trade insurance products to French firms.[21] Whereas Coface offers a ER risk insurance, this is not their core business so that firms typically resort to Coface to purchase trade or credit insurance. It is only once they use Coface's services that firms are advised to purchase ER risk insurance. Therefore, we believe that firms using trade insurance are more likely to be aware and make use of hedging instruments against ER risk, satisfying the relevance assumption. There is no obvious mechanism explaining why trade insurance instruments would directly affect firms' currency choice, which would violate the exclusion restriction. Consistent with this argument, the results in Table 3 show that trade credit does not have a direct impact on currency choice. We complement this instrument with a second dummy variable recovered from a question regarding the firm's growth impediments. Among various dimensions of firms' growth which the survey covers, one question concerns the potential lack of management and organizational resources that would help the firm grow. We use firms' answer to this question to identify firms with "weak management" as those who answered that this dimension curbs their economic expansion. Our assumptions are that (i) weakly-managed firms are unlikely to engage in costly financial hedging, whereas (ii) management should not affect "operational" invoicing decisions. If both assumptions are true, the instrument satisfies the relevance assumption as well as the exclusion restriction. The results based on these two instruments are presented in Table 4, columns (2) and (3). The table also reports two tests. The "ρ co-

[21] Coface is widely known for its trade insurance activities and it is closely tied to the network of Chambers of Commerce and Industry in French regions. The US and German equivalents of Coface are Eximbank and Euler Hermes, respectively (see GAO (1995) for a comparative analysis of U.S. and European Union export credit agencies).

efficient" is the estimated correlation between the residuals of the two probit regressions which can be seen as equivalent to an Hausman endogeneity test as shown by Knapp & Seaks (1998). The "χ^2 statistics" tests the null that all coefficients of the second probit equation are equal to zero and can thus be seen as the equivalent of the F-test for weak instruments used in standard 2SLS models.

In the second specification, we augment the set of "instruments" with another two variables, namely a dummy identifying which firms subscribed to trade credit and the number of destinations served. The rationale for using the "Trade Credit" instrument is the same as for the Trade Insurance dummy as trade insurance companies also provide trade credit services. Following Froot et al. (1993), we expect that firms financing part of their exports using a trade credit (i.e., financially constrained firms) are more likely to hedge against their exchange rate risk while the dimension should be uncorrelated with invoicing decisions. The last instrument measures the number of foreign destinations served by the firm. The expected impact of having a wider set of export destinations on the probability of hedging is unclear a priori. If the number of destinations allows the firm to make a form of operational hedging, and if operational and financial hedging are substitutes, then the correlation could be negative. However, Allayannis et al. (2001) show using Compustat data that operational hedging is actually not an effective substitute for financial risk management. In their data as in ours, firms which sales are more geographically dispersed are more likely to use financial hedges. A possible explanation is that firms that are more geographically diversified have more incentive to use heging instruments or are more informed of their mere existence. Results based on the full set of instruments are reported in Table 4, columns (4) and (5).

Results for the bivariate probit are reported in Table 4. The correlations of the residuals of the currency choice and hedging specifications are around 37 and 48% in the first and second specifications respectively, but they are not significant. The fact that these correlations are not significant suggests endogeneity may not be a major concern. We nonetheless report and discuss the results of the bivariate probit.[22] Two main results emerge from the comparison of the univariate and bivariate probits. First, both specifications point to hedging being a significant driver of invoicing decisions, with the prevalence of LCP being significantly larger in the sub-sample of firms that are hedged. Second, the coefficient on the firm's size decreases and becomes insignificant in the invoicing equation of the bivariate probit. This implies

[22]Reassuringly, the "χ^2 statistics" tests reported in the table rejects the null that all coefficients in the first stage are equal to zero.

that, in our sample, the size-invoicing relationship is entirely explained by large firms having better access to financial hedging. The opportunity to hedge against exchange rate risk enables firms to invoice in the local currency without facing a risk on their marginal revenue.

Finally, note that all results are robust to restrictions on the sample of firms, as shown in Table 5. Results are virtually unchanged if we concentrate on firms that derive at least 15% of their export revenues from non-EMU countries (columns (1)-(2)), when we neglect sectors that are the most likely to display vehicule currency pricing (Columns (4)-(7)) or if we exclude mutinational companies (Columns (8)-(9)).

Having established the robustness of the relationship between invoicing strategies and hedging decisions, we now discuss the theoretical mechanisms that 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 of hedging against exchange rate risk. We build on Burstein & Gopinath (2014), who use a one-period-ahead sticky-price environment and consider the invoicing-currency choice in partial equilibrium. In this setup, the optimal invoicing strategy depends on the curvature of the profit function with respect to exchange rates at the pre-set optimal price, itself determined by the demand function, the extent of returns to scale, and the sensitivity of marginal costs to exchange rate variations. We then generalize the analysis to the case in which the exporting firm can purchase derivatives to hedge against exchange rate risk. Finally, we discuss how the augmented setup allows us to rationalize the evidence in Section 2.

3.1 Optimal invoicing strategy without hedging

We consider an exporting firm's choice of invoicing curency when the exchange rate is the only source of uncertainty in the economy. We start by studying the firm's choice in the absence of hedging. We assume markets are perfectly segmented so that the firm can adopt a different strategy in each export destination. The optimal invoicing choice then depends on the uncertainty about the firm's destination-specific expected profit 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. The firm's production cost $C(q, w(S))$ depends on the level q of output as well as the vector of input

prices $w(S)$, which we assume is linear in S. The cost function's dependence on $w(S)$ is meant to capture the possibility that the firm imports some of its inputs from the foreign country, in which case, a form of operational hedging occurs as the effect of exchange rate variations on export revenues can be partly compensated by its impact on costs.[23] We denote $mc \equiv \frac{\partial C(q,w(S))}{\partial q}$ as the firm's marginal cost of production, and $mc_S \equiv \frac{\partial \ln mc(.)}{\partial \ln S}$ and $mc_q \equiv \frac{\partial \ln mc(.)}{\partial \ln q}$ as the partial elasticities of its marginal cost with respect to the exchange rate and the quantity produced, respectively. When $mc_q \neq 0$, the marginal cost depends on q, for instance because of capacity constraints.[24] Finally, $\eta \equiv -\frac{d \ln D(p^*)}{d \ln p^*}$ denotes the price elasticity of demand.

Before the exchange rate is realized, the firm chooses whether to set its price in the domestic currency (PCP) or in the importer's (LCP). The firm's manager makes a choice between PCP and LCP 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 manager's expectation, $u(.)$ is her utility function, which we assume is increasing in profits ($du(\pi^i)/\pi^i > 0$), and $\pi^i(S)$ is the equilibrium profit under strategy $i = \{PCP, LCP\}$, as a function of the exchange rate:

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

where p^{PCP} and p^{LCP} respectively denote the optimal price under PCP and LCP.

Both under LCP and PCP, the firm's profit is subject to exchange rate risk. First, under LCP, exchange rate fluctuations create uncertainty about the unit revenue denominated in the exporter's currency Sp^{LCP}. Second, under PCP, exchange rate fluctuations affect the local currency price p^{PCP}/S such that the exporter faces uncertainty about demand $D(p^{PCP}/S)$. Third, exchange rate fluctuations can affect the firm's cost, both under PCP and LCP, through foreign input prices. Following the literature, we assume $\pi^{PCP}(\mathbb{E}[S]) = \pi^{LCP}(\mathbb{E}[S])$; that is, the invoicing strategy is irrelevant at

[23] We define bilateral exchange rates such that one unit of foreign currency is worth S units of domestic currency. Therefore, if parts of the exporter's inputs can be imported, marginal costs are increasing in the exchange rate S.

[24] Vannoorenberghe (2012) discusses how capacity constraints might lead firms to maximize profits on different markets simultaneously rather than independently of each other. Other studies such as Blum et al. (2013) and Soderbery (2014), also study capacity constraints. For simplicity, in our model, the firm maximizes in each market separately.

the expected exchange rate.[25] Under these conditions, Proposition 3.1 summarizes the determinants of the firm's choice between LCP and PCP.

Proposition 3.1. *An exporting firm chooses LCP (resp. PCP) when* $\pi^{PCP}(S)$ *is a concave (resp. convex) function of* S*. LCP is thus the optimal strategy if*

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

Proof. LCP is preferred whenever $\mathbb{E}\left[u(\pi^{PCP}(S))\right] < \mathbb{E}\left[u(\pi^{LCP}(S))\right]$. Because $u(.)$ is increasing and concave, $\mathbb{E}\left[u(\pi^{PCP}(S))\right] < \mathbb{E}\left[u(\pi^{LCP}(S))\right]$ if and only if $\pi^{LCP}(S)$ second-order stochastically dominates $\pi^{PCP}(S)$. A sufficient condition is that $\pi^{LCP}(S)$ first-order stochastically dominates $\pi^{PCP}(S)$. Given that $\pi^{LCP}(\mathbb{E}[S]) = \pi^{PCP}(\mathbb{E}[S])$, $\pi^{LCP}(S)$ first-order stochastically dominates $\pi^{PCP}(S)$ if $\pi^{PCP}(S)$ is concave in S. As a result, LCP (PCP) is preferred whenever $\pi^{PCP}(S)$ is a concave (convex) function of S. See Appendix A.1 for the derivation of Equation (1). □

Proposition 3.1 summarizes previous findings in the literature, as discussed in Burstein & Gopinath (2014). Using a general model is useful to later compare determinants of invoicing choices with and without hedging options. In particular, condition (1) captures the three key elements in a firm's choice between LCP and PCP that the previous literature has extensively discussed.[26] The first component is the convexity of the demand function, determining $d \ln \eta / d \ln \frac{p^{PCP}}{S}$, which role is discussed in the seminal Krugman (1987) paper on pricing-to-market behaviors and more recently in Berman et al. (2012). Everything else equal, low exchange-rate pass-through (i.e., choosing LCP) is more likely when the demand is subconvex ($d \ln \eta / d \ln \frac{p^{PCP}}{S} > 0$). The sensitivity of the firm's optimal invoicing strategy to the shape of the demand function also explains observed non-linear relationships between a firm's size and its pass-through (or invoicing decisions)

[25] 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 flexible price profits are the same regardless of the invoicing currency, and Bacchetta & van Wincoop (2005) and Friberg & Wilander (2008) make similar assumptions they dub "monetary neutrality." Even absent this assumption, the intuitions from lemma 3.1 remain valid, 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.

[26] When we refer to the previous literature, we mix results from the literature on the optimal exchange rate pass-through and on invoicing currency choices. See Engel (2006) for equivalence results for both decisions.

in models of oligopolistic competition.[27] The second component is the cost function, namely, the extent of returns to scale mc_q (Bacchetta & van Wincoop 2005), and of operational hedging, measured by mc_S. Both decreasing returns to scale and operational hedging favor LCP because the additional risk on marginal revenues is then somewhat compensated through the firm's costs. The third component is the elasticity of demand η, which also affects the firm's market power $(p^{PCP} - mc)/mc$.[28] Finally, the benefits of LCP are increasing in the amount of exchange rate uncertainty, illustrating another intuitive and well-known result that invoicing strategies matter more when exchange rates are more volatile.

Interestingly, the choice of invoicing currency does not depend on the manager's risk aversion (see Bacchetta & van Wincoop 2005), because profits are equal at the expected exchange rate, so that the invoicing currency only matters through its impact on the expected profit at pre-set prices. Whether LCP or PCP is chosen depends solely on the relative convexity of the PCP and LCP profit functions with respect to the exchange rate, which depends on the sign of the inequality in (1).[29]

[27] See for instance Auer & Schoenle (2016) or Amiti et al. (2014). We demonstrate in Appendix A.2 that our model encompasses their special case. Introducing oligopolistic competition à la Atkeson & Burstein (2008) in our model, we show that medium-size firms choose LCP while both small and large firms choose PCP if the elasticity of substitution between firms' products is large enough.

[28] Using the markup rule $p^{PCP} = \frac{\eta}{\eta-1} mc$, condition (1) rewrites:

$$(\eta - 1)\left(mc_s + \eta mc_q - 1\right) + \frac{d \ln \eta}{d \ln p^{PCP}/S} > 0,$$

where the euro marginal cost is decreasing in S, that is, $mc_S > 0$. With decreasing returns to scale ($mc_q > 0$), LCP is chosen by high-η firms. With increasing returns to scale ($mc_q < 0$), low-η firms choose LCP.

[29] The model neglects the possibility that the firm can invoice in a third currency, which might either be a vehicle currency or the dollar (dominant currency). Like in the LCP case, the use of a third currency makes unitary revenues uncertain (they depend on the ER between the producer currency and the third currency), but they also imply uncertainty regarding the demand due to fluctuations in the exchange rate between the local currency and the third currency. PCP would yield higher expected profits than third currency pricing under a condition on demand and costs similar to condition (1) involving the two exchange rates. Again, the exporter would prefer pricing in a currency with low variance relative to the importer's currency if the profit is a concave function of exchange rate surprises that affect demand. Therefore, the choice between a third currency and PCP would depend on the relative variance of the producer's and vehicle currencies (Friberg 1998). For recent development on vehicle currency pricing and dominant currency pricing, see Chen et al. (2018), Mukhin et al. (2018), Gopinath & Stein (2018) or Amiti et al. (2019).

3.2 Optimal invoicing strategy with hedging

So far, we have implicitly assumed the exporter has no choice but to bear the exchange rate risk, so that it either faces demand uncertainty (under PCP) or unit revenue uncertainty (under LCP). We now allow the firm to hedge against exchange rate risk by purchasing foreign exchange derivatives. We consider the firm's choice between PCP and LCP jointly with the option to hedge against exchange rate risk. We assume firms hedge through the forward currency market.

The firm's optimal invoicing and hedging choice stems from the comparison between the manager's expected utility under PCP and LCP, both when the exchange rate risk is hedged and when it is not. We use the superscript HPCP (respectively, HLCP) for the choice variables under *hedged* producer (local) currency pricing. The exporting firm's profits under HPCP and HLCP are

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

where $h \in [0, p^i D(p^i)]$ $(i = \{PCP, LCP\})$ is the transaction amount hedged against exchange rate changes under invoicing strategy i. f denotes the forward exchange rate, so that $(f - S)$ is the ex-post benefit of hedging on each unit of export revenue. We assume international financial markets are efficient so that the forward rate is equal to the expected spot rate: $f = \mathbb{E}(S)$. The benefit of hedging is therefore 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 hedging costs entail a fixed component F that represents investment in the knowledge necessary to design and buy the proper set of derivative instruments to hedge a firm's exchange rate exposure. For simplicity, we assume in the main text that the hedging costs do not entail any variable component; that is, $HC[h,f] = F$. But we generalize the analysis to a combination of fixed and variable hedging costs in Appendix A.5. We show our qualitative results are unchanged.

When considering the firm's expected utility maximization problem, we first prove the following Proposition 3.2.

Proposition 3.2. *The exporting firm chooses the maximum amount of hedging. Under HLCP, the firm is hedged fully and uncertainty is removed. Under HPCP, profits are not linear in exchange rate surprises and some exchange rate uncertainty remains.*

Proof. Maximization of the manager's expected utility with respect to h^i yields the first-order condition $\mathbb{E}\left[\frac{du(\pi^i(S))}{d\pi^i(S)}(-S+f)\right] = 0$. Together with $f = \mathbb{E}(S)$, this condition implies $\text{Cov}\left[\frac{du(\pi^i(S))}{d\pi^i(S)}, S\right] = 0$. Under HLCP, profits are linear in exchange rate surprises and the firm hedges fully, that is, $h^{*,HLCP} = p^{HLCP}D\left(p^{HLCP}\right)$. Under HPCP, profits are not linear in exchange rate surprises when condition (1) does not hold with equality. Therefore, under HPCP, the firm remains exposed to some exchange rate uncertainty. □

The findings in Section 3.1 did not rely on firms' valuation of the stabilization of their export revenues, whether from unit revenue (under LCP) or from demand stabilization (under PCP). The choice between LCP and PCP was then entirely determined by comparing the level of expected profits under both strategies. By contrast, the firm only chooses to hedge if it finds it optimal to stabilize export revenues. In line with the risk management literature, we assume it is the case because the exporting firm's manager is risk averse; that is, $\frac{d^2u(\pi^i)}{d{\pi^i}^2} < 0$.[30] Unlike a risk-neutral manager, a risk-averse manager values the benefit of stabilizing her export revenues, and trades off this benefit against the hedging cost. As shown in Proposition 3.2, the benefit tends to be larger under HLCP than under HPCP because hedging entirely removes uncertainty over unit revenues.

We show in Appendix A.3 that an exporting firm pricing in LCP chooses to hedge against exchange rate risk (i.e. $HLCP \succ LCP$) whenever the following inequality is satisfied:

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

When choosing whether to hedge against exchange rate risk, an exporting firm faces the following trade-off. On the one hand, the benefit from hedging is to remove the uncertainty associated with exchange rate risk. This benefit is represented by the left-hand side of inequality (2). It is positive when the manager is risk-averse, and increases as $d^2u(\pi^i)/d\,{\pi^i}^2$ becomes more negative. On the other hand, the hedging cost reduces the manager's utility. This cost is represented by the right-hand side of inequality (2).

An exporting firm pricing in PCP faces a similar trade-off (see Appendix A.3), except that HPCP profits remain exposed to exchange rate uncertainty (Proposition 3.2). Therefore, the mirror condition for a firm pricing in PCP

[30] Managers' risk aversion has been shown to explain why firms optimally manage their risks (see, e.g., Geczy et al. 1997). We discuss below other rationales that can explain why firms optimally manage their risks, and argue they would not change our model's predictions.

to hedge ($HPCP \succ PCP$) is

$$u\left[\pi^{PCP}\left(\mathbb{E}\left[S\right]\right)\right] - \mathbb{E}\left[u\left(\pi^{PCP}(S)\right)\right] > \frac{du(\pi^{PCP}\left(\mathbb{E}\left[S\right]\right))}{d\pi^{PCP}\left(\mathbb{E}\left[S\right]\right)}F + \Delta(S), \tag{3}$$

where the presence of $\Delta(S)$ is due to the remaining uncertainty under HPCP.

Finally, we show in Appendix A.3 that the firm's preference between HLCP and HPCP depends on the size of ΔS. Namely, HLCP is preferred over HPCP if and only if $\Delta(S) > 0$ which happens either if condition (1) is satisfied or if the manager's coefficient of absolute risk aversion is large enough, such that

$$-\frac{u''(.)}{u'(.)} > \frac{\pi''(.)}{(\pi'(.))^2}. \tag{4}$$

Whether they choose HLCP or HPCP, large firms are more likely to hedge because inequalities (2) and (2) are more likely to hold for high-profit firms for which $\frac{du(\pi^{PCP}(\mathbb{E}[S]))}{d\pi^{PCP}(\mathbb{E}[S])}$ is smaller. Given that larger firms typically have higher profits, we find they are more likely to hedge, both under LCP and PCP. Intuitively, the reason is that large firms can spread the fixed hedging cost over more units of revenue. This finding is in line with the empirical evidence in Section 2.2.

Our model relies on two key assumptions to explain why larger firms are more likely to hedge against exchange rate risk. First, we assume managers are risk averse. Without risk aversion, managers would not find it profitable to reduce profit uncertainty, and the left-hand side of inequalities (2) and (2) would be equal to zero. Managers would then not value the revenue stabilization due to hedging. The risk management literature provides support for our assumption that hedging can be an outgrowth of managers' risk aversion (Stulz 1984, Smith & Stulz 1985). However, many other rationales have also been shown to be consistent with firms' optimal management of risk.[31] We view our assumption of managerial risk aversion as a simple modeling shortcut, and we acknowledge that firms' risk averse behavior could also stem from other factors.

Second, we assume hedging costs entail a fixed component. Therefore, even if all firms would value the benefit from hedging, larger firms will find it more profitable. In Appendix A.5, we show our findings are robust to the

[31]The main theories of why firms hedge fall into two broad categories. The first category is market frictions (see, e.g., Smith et al. 1990, Stulz 1990, Froot et al. 1993, Smith & Stulz 1985). The second category is agency costs (see, e.g., Stulz 1984, Breeden & Viswanathan 1990, Stulz 1990, DeMarzo & Duffie 1991). Empirical tests of these theories are conducted in Nance et al. (1993), Tufano (1996), Geczy et al. (1997), Graham & Rogers (2002*b*).

introduction of variable hedging costs, as long as the variable component of the hedging cost is not too convex in the quantity hedged. Although the presence of a fixed cost of hedging remains key in explaining why only larger firms choose to hedge, the following complementary explanation is proposed by Rampini & Viswanathan (2010, 2013). When promises to both financiers and hedging counterparties need to be collateralized, both financing and risk management require net worth. Therefore, more constrained firms have a higher opportunity cost of hedging so that only larger firms find it optimal to hedge. Our survey includes questions regarding firms' financial constraints but with limited coverage. Based on these questions, we find some evidence consistent with financially constrained firms being less likely to use hedging instruments.[32] Because the evidence is not very robust and the model with a fixed hedging cost is substantially simpler, we stick to this assumption in the analysis.

Combining these various findings, Figure 6 summarizes an exporting firm's choice between LCP, PCP, HLCP, and HPCP, based on conditions (1), (2), (3), and (4). The choice of an invoicing strategy when firms have access to hedging options is non-trivial. The reason is that firms then trade-off the *level of expected profits* – which we have seen depends on the curvature of the profit function – against the *variance of profits* – which the firm cares about as long as its manager is risk-averse. Despite its complexity, Figure 6 reveals an interesting pattern that helps rationalize our empirical evidence. If condition (1) is verified, which means that the firm would choose LCP in the absence of hedging, then LCP or HLCP is always chosen. Choosing LCP in the absence of hedging implies that the expected profit is larger under LCP than under PCP. Since LCP also helps better stabilize expected profits, a firm's invoicing choice is unchanged, whether hedging options are available or not. However, if a firm prefers PCP in the absence of hedging, then introducing hedging may change its manager's currency choice because there is a trade-off between the first and second moments of profits under both invoicing options.

[32] Our measure of financial constraints is based on the survey's question "What are the factors preventing growth?". A firm is said to be financially constrained if the answer is "financial constraints." The unconditional correlation between this variable and the hedging dummy is negative and highly significant. In a probit explaining hedging by financial constraints and all the controls included in the baseline regressions but the sector fixed effects, the coefficient remains negative and highly significant. The coefficient loses significance once one controls for sector fixed effects, suggesting our data on financial constraints primarily capture cross-sectorial differences.

3.3 Implications for empirical results

The model delivers two predictions that are consistent with the evidence presented in Section 2.2. First, all else equal, large firms are more likely to hedge than small firms. In the context of our model, the reason is that the fixed hedging cost can be spread over more units of marginal benefit which increases the profitability of hedging. This prediction is in line with Figure 4 that shows large firms are more likely to use financial hedging instruments, under both LCP and PCP.

Second, the model is consistent with the evidence in Table 4 that, conditional on size, firms that hedge are more likely to choose LCP than firms that do not hedge. In the context of the model, this is because firms that use LCP in the absence of hedging never switch to PCP with hedging while the reverse can happen. A more intuitive way of explaining this is that hedging reveals the firm's manager degree of risk aversion. Since the variance of profits is minimized under LCP, it is likely that a firm that dislikes uncertainty in future profits will choose the full hedging option rather than the partial one.

While these two results hold true unconditionally, our choice to keep the model general makes it difficult to interpret the conditions entering the decision in terms of intuitive primitives of the model. As illustrated in Figure 6, various ranges of parameters regarding demand elasticity, marginal costs, hedging costs, or risk aversion may be consistent with the empirical findings. The model is nonetheless useful in that it highlights that introducing the option to hedge affects the fundamental determinants at the root of the invoicing decision. We now illustrate this point by focusing on a particular dimension of firms' invoicing strategies that has been extensively discussed in the previous literature; namely, the relationship between firm size and invoicing currency. We illustrate this point in three different contexts, a simple CES framework, an oligopolistic competition framework, and a framework in which risk aversion varies with firm size.

Let us consider first a standard CES model, with monopolistic competition, constant returns to scale, and no operational hedging. Using the notations introduced earlier, this implies $d \ln \eta / d \ln \frac{p^{PCP}}{S} = 0$, $mc_q = 0$ and $mc_S = 0$. Under these assumptions and without hedging, any firm would choose to price in its own currency as condition (1) cannot be met. The reason is that expected profits are always larger in PCP than in LCP. Such model is thus unable to explain the empirical relationship between firm size and invoicing currency choice. If one introduces the option to hedge instead, then, conditional on a homogenous degree of risk-aversion, the largest firms choose to hedge against exchange rate risk and price in the foreign currency,

whereas small firms keep choosing PCP. The presence of hedging thus shifts the invoicing currency choice of the largest firms, which induces a correlation between firm size and invoicing currency choice.

We have discussed earlier the emergence of a non-linear relationship between firm size and invoicing currency choice in the context of oligopolistic competition (see the derivation in Appendix A.2). Under constant returns to scale, no operational hedging, oligopolistic competition à la Atkeson & Burstein (2008), and in the absence of hedging, small and large firms choose PCP whereas medium-size firms choose LCP. The introduction of hedging in such a framework could however kill the hump-shaped relationship between size and invoicing currency. Indeed, if they are risk averse, the largest firms may find it optimal to hedge and price in the local currency (HLCP), despite such strategy reducing the level of expected profits.

The introduction of hedging in an oligopolistic competition model can thus overturn the non-linear relationship between size and invoicing currency that such models entail in the absence of hedging. Conversely, one can think of a model parametrization in which hedging can create the non-linearity which the empirical literature has documented. Namely, suppose that there is heterogeneity in risk aversion and large firms are less risk-averse.[33] For simplicity, start from a model in which all firms choose PCP without hedging. In such model, we might see in equilibrium both small and large firms pricing in PCP, while medium-size firms price in the importer's currency and subscribe hedging instruments. PCP decisions at the bottom and the top of the firm size distribution would then be due to small firms finding the fixed cost of hedging too large in comparison with the benefit, and large firms' low risk aversion would make them give preference to a higher expected profit. Instead, medium-size, risk-averse firms would choose the less uncertain HLCP strategy. The introduction of hedging together with heterogeneous risk aversion thus offers an alternative rationale for the hump-shaped relationship between firm size and ERPT uncovered by Auer & Schoenle (2016).

This discussion thus shows the relationship between firm size and invoicing currency choice depends on firms' option to hedge against exchange rate risk. For this reason, the sole observation of the impact of firm size on currency choice cannot be used to discriminate among models.

[33]The assumption that large firms are less risk averse is consistent with Froot et al. (1993). However, recent evidence suggest larger firms effectively behave as more risk averse because they own more collateral, which allows them to engage in risk management while maintaining their debt capacity (Rampini et al. 2020).

4 Conclusion

The paper offers three novel 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 a foreign currency are more likely to hedge against exchange rate risk. Third, hedging opportunities increase firms' propensity to set their prices in a foreign currency.

We rationalize these findings in a model of invoicing-currency choice augmented with risk aversion and hedging instruments. In our model, we assume managers are risk averse, thereby explaining why firms optimally hedge against exchange rate risk. In the presence of fixed hedging costs, however, hedging is solely profitable for large firms. We show that when a firm is able to hedge its exchange rate exposure, it can choose a different invoicing currency than in the case where it cannot hedge. This result emphasizes the importance of studying a firm's invoicing-currency choice jointly with its choice of whether to hedge against exchange rate risk.

Our results have three main implications. First, the results suggest the development of new technologies that facilitate the hedging of exchange rate risk for individual exporters should lead to an increasing use of foreign currency pricing strategies – be they local currency pricing or dominant currency pricing. These strategies, in turn, should have an end effect on the international transmission of shocks.

Second, the results on financial hedging have important implications for the costs of exchange rate fluctuations. As large firms tend to hedge against exchange rate fluctuations, they transfer the risk onto financial markets rather than bearing the risk or passing it to their trade partner.

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. This heterogeneity is related to firms' access to financial hedging – a dimension that has not yet been explored in the literature on exchange rate pass-through.

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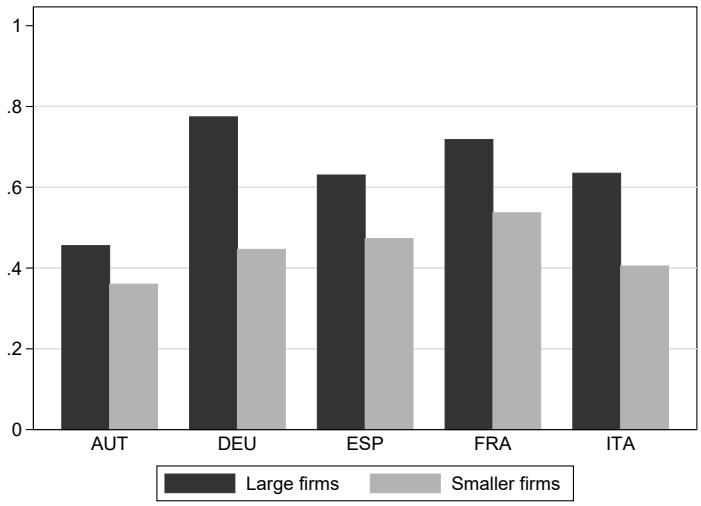
Figure 1 – Share of exporters facing exchange rate risks



Notes: This graph displays the share of firms from each country that claim they are exposed to exchange rate risks when selling their product abroad. The black bars correspond to the answer of large firms (sales above 50 million euros). The grey bars correspond to the answer of the smaller firms.

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
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

Continued on next page

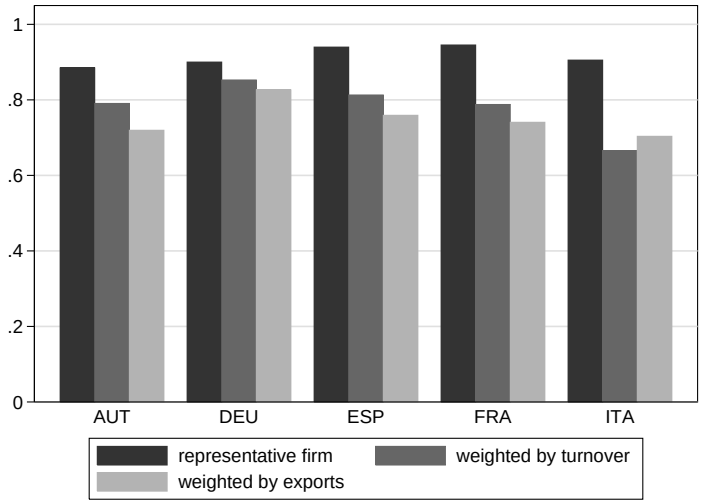
Question	Answer	Variable
In which of the following ranges falls the annual turnover in 2008 of your firm?	1- less than 1 million euro 2- 1-2 million euro 3- 2-10 million euro 4- 10-15 million euro 5- 15-50 million euro 6- 50-250 million euro 7- + 250 million euro	**One dummy for each interval** **Dummy 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

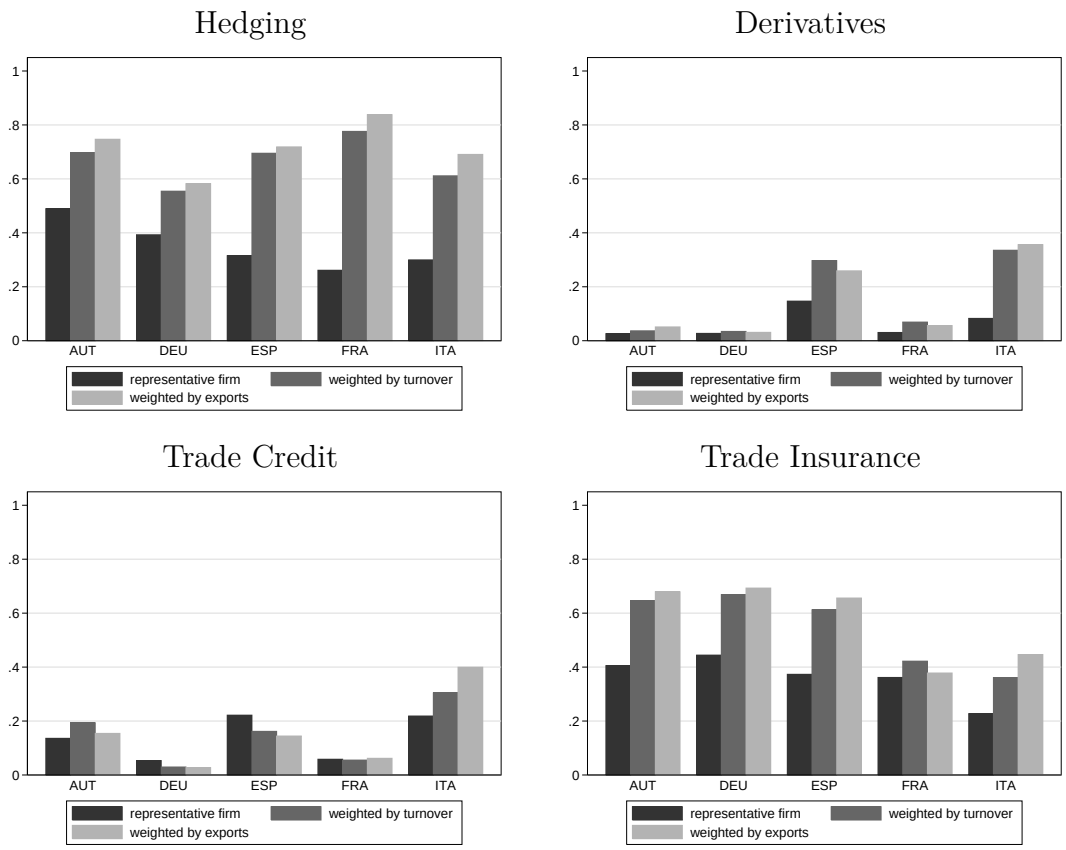
Notes: This table reproduces the questions exploited in our empirical analysis, the possible answers proposed in the survey, and the corresponding variables as used in the regressions.

Figure 2 – Share of firms pricing in euros



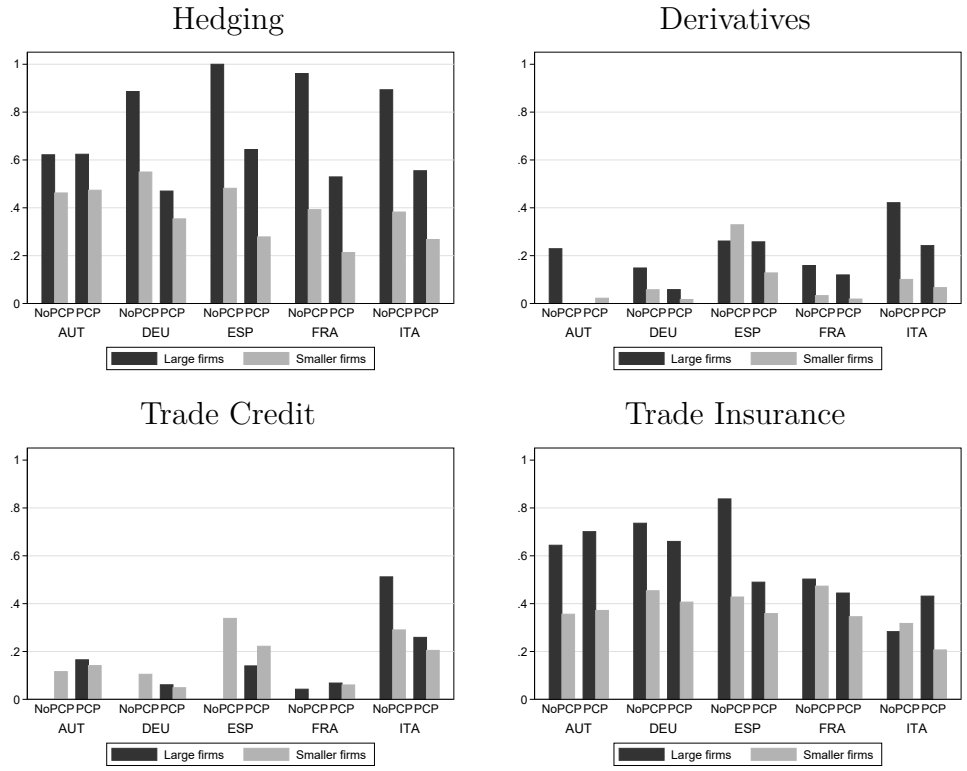
Notes: This graph displays the share of firms from each country that declare setting their price in euros. The black bars correspond to the answer of the representative firm, obtained by weighting individual answers using the absolute sample weights. The light grey bars weight individual firms by their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



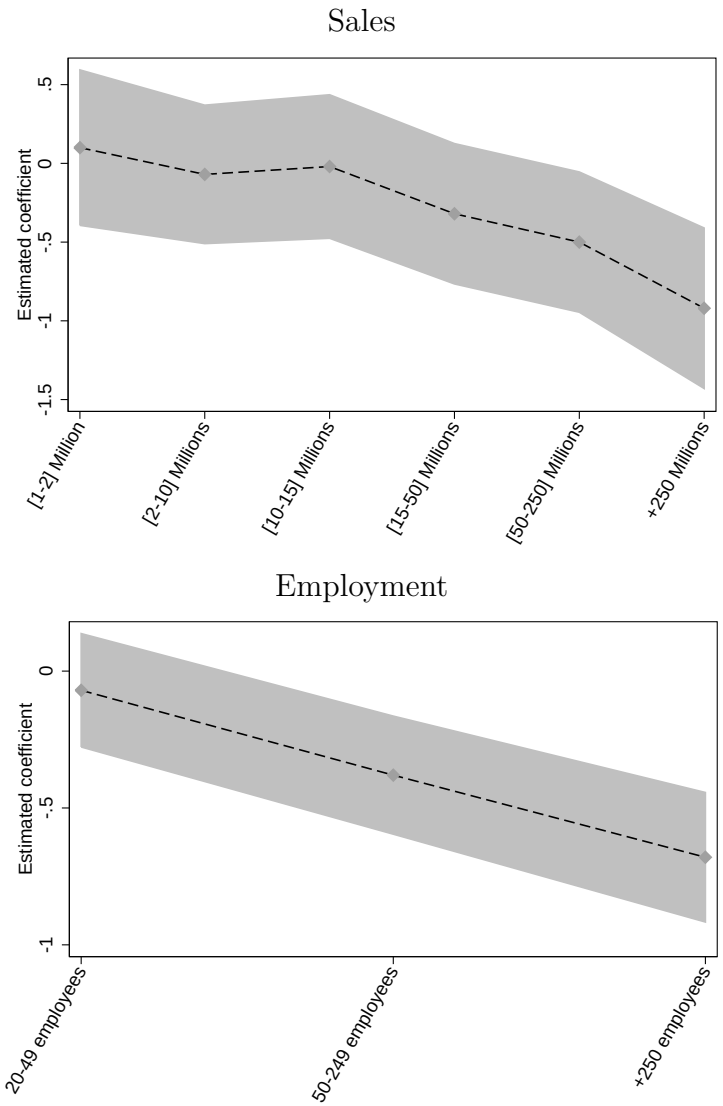
Notes: These graphs display the share of firms from each country that declare using financial hedging for dealing with their exchange rate exposure ("Hedging"), using financial derivatives ("Derivatives"), financing their export activity using a trade credit ("Trade Credit"), and being covered by a trade 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 in another currency ("noPCP" bars) and for the typical "large" firm (black bars) against the typical "small" firm (grey bars). The definition of large and small is based on turnover, with a threshold at 50 million euros.

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.

Table 2 – Determinants of currency choices: Baseline results

	Dep.Var: Probability(PCP)			
	(1)	(2)	(3)	(4)
Sales above 50 millions	-0.48***	-0.54***	-0.52***	-0.48***
	(-5.346)	(-5.784)	(-5.527)	(-4.841)
Share of exports	-0.71***	-0.56***	-0.56***	-0.54***
	(-5.427)	(-4.031)	(-4.040)	(-3.856)
Sh. Oth. EU		0.00	0.00	0.00
		(0.685)	(0.675)	(0.673)
Sh. Other Eur.		-0.00	-0.00	-0.00
		(-0.918)	(-1.063)	(-1.097)
Sh. Chn-Ind		-0.01***	-0.01***	-0.01***
		(-3.114)	(-3.079)	(-3.049)
Sh. Other Asia		-0.01**	-0.01**	-0.01**
		(-2.398)	(-2.531)	(-2.529)
Sh. North Am.		-0.01***	-0.01***	-0.01***
		(-6.134)	(-6.299)	(-6.322)
Sh. South Am.		-0.01***	-0.01***	-0.01***
		(-6.048)	(-5.982)	(-5.970)
Sh. Row		-0.00	-0.00*	-0.00*
		(-1.503)	(-1.721)	(-1.708)
No pricing power			-0.21**	-0.21**
			(-2.563)	(-2.537)
Multinational				-0.13
				(-1.340)
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 1 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), a dummy equal to 1 if the firm declares herself not having any pricing power ("No pricing power") and a dummy equal to 1 if the firm is part of a multinational company ("Multinational"). Regressions control for sector and country-of-origin fixed effects. T-statistics computed from robust standard errors are reported in parenthesis. ***, ** and *, respectively, indicate significance at the 1, 5, and 10% levels.

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

	Dep.Var: Probability(PCP)				
	(1)	(2)	(3)	(4)	(5)
Sales > 50 millions	-0.39***	-0.45***	-0.47***	-0.48***	-0.37***
	(-3.875)	(-4.461)	(-4.670)	(-4.891)	(-3.654)
Share of exports	-0.45***	-0.51***	-0.52***	-0.51***	-0.43***
	(-3.148)	(-3.657)	(-3.722)	(-3.632)	(-2.914)
No pricing power	-0.21**	-0.21***	-0.21***	-0.21**	-0.22***
	(-2.560)	(-2.601)	(-2.588)	(-2.566)	(-2.647)
Multinational	-0.09	-0.09	-0.12	-0.12	-0.05
	(-0.903)	(-0.912)	(-1.251)	(-1.259)	(-0.548)
Hedging	-0.38***				-0.34***
	(-4.716)				(-4.046)
Derivatives		-0.41***			-0.31**
		(-3.142)			(-2.283)
Trade Insurance			-0.10		-0.04
			(-1.274)		(-0.433)
Trade Credit				-0.14	-0.06
				(-1.259)	(-0.546)
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 1 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 1 if the firm claims it has no pricing power, a dummy equal to one if the firm is part of a multinational company 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 in parenthesis. ***, **, and *, respectively, indicate significance at the 1, 5, and 10% levels.

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	-0.39***	-0.24	0.55***	-0.20	0.54***
	(-3.877)	(-1.568)	(6.827)	(-1.343)	(6.634)
Sh. Exports	-0.49***	-0.30	0.69***	-0.26	0.56***
	(-3.019)	(-1.553)	(6.651)	(-1.385)	(4.742)
No Pricing Power	-0.21**	-0.20**	0.03	-0.20**	0.04
	(-2.560)	(-2.512)	(0.521)	(-2.494)	(0.655)
Multinational	-0.11	-0.03	0.23***	-0.02	0.20**
	(-1.075)	(-0.295)	(2.974)	(-0.151)	(2.547)
Hedging	-0.36***	-0.95**		-1.09***	
	(-4.469)	(-2.159)		(-2.666)	
Trade Insurance	-0.04		0.49***		0.44***
	(-0.454)		(8.093)		(6.890)
Trade Credit	-0.08				0.28***
	(-0.727)				(3.538)
Weak Management	0.22		-0.18**		-0.19**
	(1.636)		(-2.010)		(-2.211)
# destinations	0.04				0.06*
	(0.970)				(1.868)
Origin country FE	yes	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes
Shares areas	yes	yes	yes	yes	yes
# Observations	3,011	3,011	3,011	3,011	3,011
ρ coefficient (T-stat)		0.37 (1.224)		0.47 (1.582)	
χ^2 statistics (Prob)		1.498 (0.22)		2.501 (0.12)	

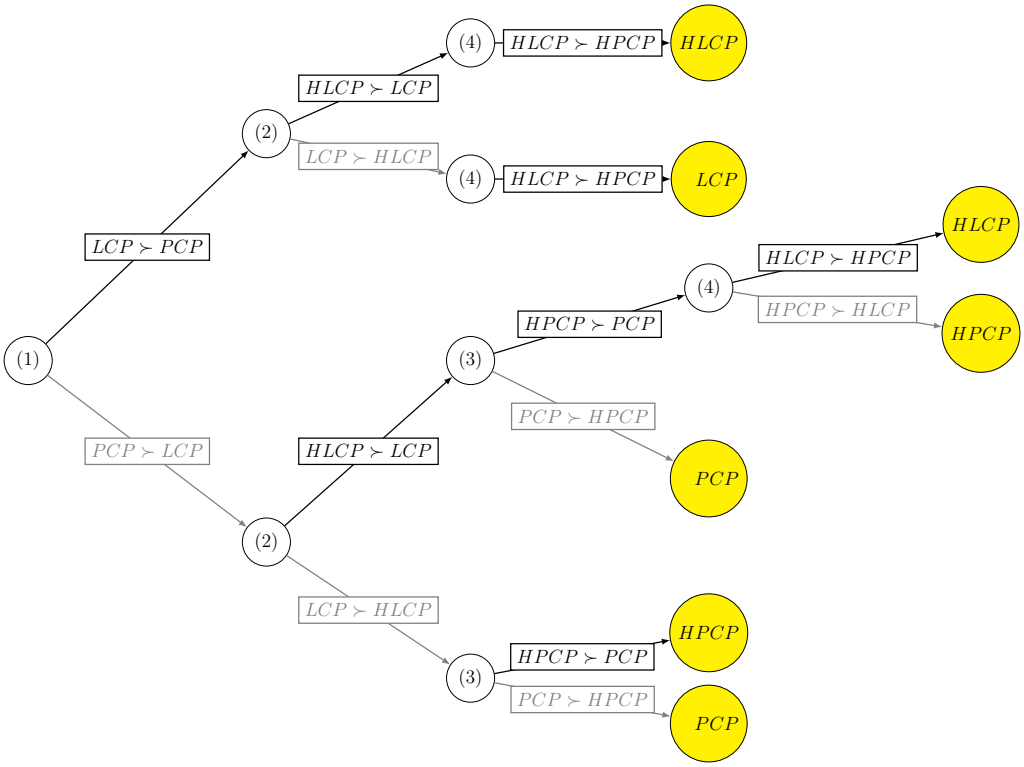
Notes: This table presents the results of two bivariate probit regressions. The explained variable in the second regression is a dummy equal to 1 if the firm invoices exports in euros. The "instrumented variable" in the first stage is a dummy equal to 1 if the firm hedges against ER risk. Other explanatory variables include a dummy equal to 1 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 1 if the firm claims it has no pricing power ("No Pricing Power"), a dummy for firms belonging to a multinational company ("Multinational"), a dummy for the firm's country of origin, a dummy for its 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 1 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 in parenthesis. ***, **, and *, respectively, indicate significance at the 1, 5, and 10% levels.

Table 5 – Determinants of currency choices: Restricted samples

	(1) Hedg. 1^{st} stp	(2) PCP 2^{st} stp	(3) Hedg. 1^{st} stp	(4) PCP 2^{st} stp	(5) Hedg. 1^{st} stp	(6) PCP 2^{st} stp	(7) Hedg. 1^{st} stp	(8) PCP 2^{st} stp
Sales > 50 millions	-0.20	0.63***	-0.23	0.54***	-0.25	0.54***	-0.14	0.56***
	(-0.768)	(5.365)	(-1.528)	(6.372)	(-1.628)	(6.312)	(-0.840)	(5.467)
Sh. Exports	-0.24	0.71***	-0.28	0.52***	-0.25	0.52***	-0.22	0.54***
	(-0.732)	(4.359)	(-1.496)	(4.411)	(-1.364)	(4.301)	(-1.140)	(4.191)
No Pricing Power	-0.23**	-0.00	-0.20**	0.03	-0.19**	0.03	-0.22**	0.01
	(-2.138)	(-0.032)	(-2.456)	(0.514)	(-2.348)	(0.516)	(-2.520)	(0.109)
Multinational	0.06	0.26**	-0.04	0.19**	-0.05	0.19**		
	(0.432)	(2.483)	(-0.401)	(2.479)	(-0.431)	(2.478)		
Hedging	-1.21*		-1.02**		-1.06**		-1.13***	
	(-1.835)		(-2.364)		(-2.569)		(-2.837)	
Trade Insurance		0.40***		0.43***		0.43***		0.43***
		(4.217)		(6.739)		(6.699)		(6.407)
Trade Credit		0.34***		0.30***		0.31***		0.26***
		(3.190)		(3.714)		(3.887)		(2.999)
Weak Management		-0.19		-0.19**		-0.19**		-0.17*
		(-1.527)		(-2.144)		(-2.139)		(-1.729)
# destinations		0.01		0.06*		0.06*		0.07**
		(0.179)		(1.808)		(1.833)		(2.143)
Additional controls	Origin country FE, Sector FE, Shares areas							
Obs.	1,470	1,470	2,929	2,929	2,876	2,876	2,496	2,496

Notes: This table presents the results of two bivariate probit regressions on various sub-samples. The specification is the same as in Table 4, columns (4)-(5). Columns (1)-(2) keep firms which sell at least 15% of their exports outside of the EMU. Columns (3)-(4) drop firms producing oil or metal products. Columns (5)-(6) drop sectors in which at least 50% of firms declare their price is fixed by the market. Columns (7)-(8) neglect firms that belong to a multinational company. T-statistics computed from robust standard errors are reported in parenthesis. ***, **, and *, respectively, indicate significance at the 1, 5, and 10% levels.

Figure 6 – This Figure summarizes the exporting firm's optimal currency and hedging choices as a function of conditions (1), (2), (3), and (4).



Notes: This figure describes firms' invoicing strategies in a world with hedging opportunities, as a function of the model's primitives summarized in equations (1), (2), (3), and (4). Starting from each condition, the upward black line shows what happens if the condition is true whereas the downward grey line corresponds to the condition being untrue.

A Proofs

A.1 Proposition 3.1

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

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

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 allow the marginal cost of production to depend 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. To simplify, we assume $\frac{\partial^2 w(.)}{\partial S^2} = 0$, that is, that $w(S)$ is linear in S. Under this assumption, the second derivative of $\pi^{PCP}(S)$ with respect to S writes:

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

with

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

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

respect to the exchange rate. We finally obtain:

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

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

A.2 Special case in the absence of hedging: Oligopolistic Competition

As discussed in the existing literature (Auer & Schoenle 2016, Amiti et al. 2014), the relationship between exchange rate pass-through / invoicing currency choices and firm size is non-linear under oligopolistic competition. We now show that our general model encompasses this situation. Following Auer & Schoenle (2016), we assume that preferences display nested CES with an upper layer in which consumers substitute across goods and/or across source countries at the elasticity σ and a lower layer in which consumers substitute across varieties produced by individual firms at the rate ρ. As is standard in this literature, we assume $1 < \sigma < \rho$. In this set-up, the demand addressed to a firm f producing a good g displays a constant elasticity:

$$q_g(f) = \left(\frac{p_g(f)}{P_g}\right)^{-\rho} Q_g$$

with P_g and Q_g respectively denoting the price index and real consumption addressed to producers of good g. Under CES, $Q_g = \left(\frac{P_g}{P}\right)^{-\sigma} Q$ with P and Q the aggregate price index and aggregate real consumption, respectively.

At the lower level, a finite number of non-atomistic firms are assumed to compete in quantities.[34] Under this assumption, the perceived elasticity of demand is decreasing in the firm's market share:

$$\eta_g(f) = \left[\frac{1}{\rho}(1 - s_g(f)) + \frac{1}{\sigma}s_g(f)\right]^{-1}$$

with $s_g(f) \equiv \frac{p_g(f)q_g(f)}{P_g Q_g} = \left(\frac{p_g(f)}{P_g}\right)^{1-\rho}$.

Based on these assumptions, one can rewrite condition (1) and derive the parametric conditions for the non-linearity. We do this here in the case in

[34] As shown in Auer & Schoenle (2016), qualitative results are robust to assuming firms to compete in prices.

which the technology displays constant returns to scale and the marginal cost is independent of exchange rates ($mc_q = mc_S = 0$). Under these assumptions, LCP is optimal if:

$$\begin{aligned} & \eta_g(f) - 1 - \frac{d \ln \eta_g(f)}{d \ln p_g(f)} < 0 \\ \Leftrightarrow \quad & \eta_g(f) - 1 - \frac{(\rho - \sigma)(\rho - 1)}{\sigma \rho} \eta_g(f) s_g(f)(1 - s_g(f)) < 0 \\ \Leftrightarrow \quad & (\rho - \sigma)(\rho - 1) s_g(f)^2 - \rho(\rho - \sigma) s_g(f) + \sigma(\rho - 1) < 0 \end{aligned}$$

One can then derive optimal invoicing choices as a function of the firm's market share given the roots of the quadratic equation:

$$s_1 = \frac{\rho(\rho - \sigma) - \sqrt{\Delta}}{2(\rho - \sigma)(\rho - 1)}, \quad s_2 = \frac{\rho(\rho - \sigma) + \sqrt{\Delta}}{2(\rho - \sigma)(\rho - 1)}$$

where $\Delta \equiv (\rho - \sigma)[\rho^2(\rho - \sigma) - 4\sigma(\rho - 1)^2]$

There are two regimes depending on the value of the ρ parameter. If the elasticity of substitution between firms is low enough (namely, if $\rho \leq 2$), the relationship between invoicing and size is linear, with small firms (such as $s_g(f) \leq s_1$) pricing in PCP whereas large firms choose LCP. Instead, if $\rho > 2$, we find a non-linear relationship between firm size and invoicing currency choices: Firms with intermediate market shares ($s_1 < s_g(f) < s_2$) price in LCP while both small and large firms price in their own currency.

A.3 Hedging conditional on invoicing

In this sub-section, we derive the conditions under which the firm chooses to hedge, considering the two possible invoicing strategies sequentially.

LCP case. From the firm's program, we can show the firm chooses HLCP over LCP whenever

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

From lemma 3.2, we know that, conditional on hedging, the firm hedges fully. Therefore, conditional on hedging, profits are certain ex ante:

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

The first-order conditions of expected utility maximization with respect to prices and the hedging quantity are

$$\mathbb{E}\left[\frac{du(.)}{d\pi(.)}\left(S\left(p^{*,j}\frac{dD(.)}{dp^{*,j}}+D(.)\right)-mc\frac{dD(.)}{dp^{*,j}}\right)\right]=0 \tag{A.1}$$

$$\mathbb{E}\left[\frac{du(.)}{d\pi(.)}\left(-S+f\right)\right]=0, \tag{A.2}$$

where $j \in \{LCP, HLCP\}$. Rearranging and substituting (A.2) into (A.1) implies:

$$f\left(p^{*,j}\frac{dD(.)}{dp^{*,j}}+D(.)\right)=mc\frac{dD(.)}{dp^{*,j}}. \tag{A.3}$$

Condition (A.3) is independent of both the shape of the utility function and the stochastic properties of the exchange rate. This independence is a version of the "separation theorem" result that exchange rate uncertainty does not influence prices or traded quantities. We then write:

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

We approximate $u\left(\pi^{LCP}\left(\mathbb{E}(S)\right)-F\right) \simeq u\left(\pi^{LCP}\left(\mathbb{E}(S)\right)\right)-\frac{du(\pi^{LCP}(\mathbb{E}[S]))}{d\pi^{LCP}(\mathbb{E}[S])}F$. Inequality (2) obtains. A firm chooses HLCP over LCP if and only if:

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

PCP case. As before, a PCP firm chooses HPCP whenever

$$\mathbb{E}\left[u\left(\pi^{HPCP}(S)\right)\right]-\mathbb{E}\left[u\left(\pi^{PCP}(S)\right)\right]>0.$$

Again, using lemma 3.2, we know that, conditional on hedging, the firm hedges fully. However, in contrast to the LCP case, expected utility from HPCP profits is not certain ex-ante:

$$\mathbb{E}\left[u\left(\pi^{HPCP}(S)\right)\right]=u\left(\pi^{HPCP}(\mathbb{E}[S])\right)-\Delta(S),$$

where $\Delta(S)$ is higher the more risk averse the firm's manager, and the sign of $\Delta(S)$ depends on condition (1). $\Delta(S)=0$ if PCP profits are linear in the exchange rate.[35] If PCP profit is concave in the exchange rate (condition (1)

[35]The demonstration would then be similar to that above when firms choose between LCP and HLCP.

is satisfied), $\Delta(S) > 0$. Instead, if PCP profit is convex in the exchange rate (condition (1) is not satisfied), the sign of $\Delta(S)$ depends on the value of the manager's absolute risk aversion relative to PCP profit convexity. Indeed, we then have $\Delta(S) > 0$ if and only if equation (4) is met:

$$-\frac{u''(.)}{u'(.)} > \frac{\pi''(.)}{(\pi'(.))^2}.$$

Note the separation theorem does not hold under PCP or HPCP. Indeed, risk aversion affects the optimal price because in contrast to the LCP case, exchange rate surprises affect demand under PCP and HPCP. Therefore, one cannot get a condition equivalent to (A.3). However, if prices could be set *after* the exchange rate were known, PCP and HPCP would yield the same profits: All variables are then known and the exporter can set p^{PCP} and p^{HPCP} optimally. Therefore, we have

$$u\left(\pi^{HPCP}(\mathbb{E}[S])\right) = u\left(\pi^{PCP}(\mathbb{E}[S]) - F\right),$$

so that similar to condition (2) in the case of LCP, the firm hedges as much as it can under PCP if the condition (3) is satisfied:

$$u\left(\pi^{PCP}(\mathbb{E}[S])\right) - \mathbb{E}\left[u\left(\pi^{PCP}(S)\right)\right] > \frac{du\left(\pi^{PCP}(\mathbb{E}[S])\right)}{d\pi^{PCP}(\mathbb{E}[S])} F + \Delta(S).$$

Depending on the sign of $\Delta(S)$, condition (3) is more or less stringent than (2). If condition (1) is met, (3) is more stringent than (2). Instead, if condition (1) is not met, (3) is more stringent than (2) only if (4) is also satisfied. Otherwise, it is less stringent. QED.

A.4 Invoicing conditional on hedging

The last stage to characterize the firm's joint decision of hedging and invoicing consists in comparing the HLCP and HPCP strategies, i.e. the decision of invoicing, conditional on hedging. From the firm's program, we can show that firm chooses HLCP over HPCP whenever:

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

As shown in section A.3, we have:

$$\begin{aligned}\mathbb{E}\left[u\left(\pi^{HLCP}(S)\right)\right] &= u\left(\pi^{HLCP}(\mathbb{E}[S])\right). \\ &= \mathbb{E}\left[u\left(\pi^{LCP}(S)\right)\right] - \frac{du\left(\pi^{LCP}(\mathbb{E}[S])\right)}{d\pi^{LCP}(\mathbb{E}[S])}F\end{aligned}$$

and

$$\begin{aligned}\mathbb{E}\left[u\left(\pi^{HPCP}(S)\right)\right] &= u\left(\pi^{HPCP}(\mathbb{E}[S])\right) - \Delta(S) \\ &= \mathbb{E}\left[u\left(\pi^{PCP}(S)\right)\right] - \frac{du\left(\pi^{PCP}(\mathbb{E}[S])\right)}{d\pi^{PCP}(\mathbb{E}[S])}F - \Delta(S)\end{aligned}$$

From this, it comes that HLCP is preferred to HPCP if $\Delta(S) > 0$ which, as discussed in Section A.3, happens if either condition (1) or condition (4) is met.

A.5 Extension to a more general hedging cost

On top of the fixed cost assumed in Section 3.2, we could assume hedging costs entail a variable component. Although, in reality, the variable costs of hedging are likely 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, which is the only situation that may eventually overturn some of the results in the text. We now explain why the qualitative results in Section 3.3 are not modified when we add a hedging cost component that increases in the quantity hedged h. Assume

$$HC[h] = c(h) + F,$$

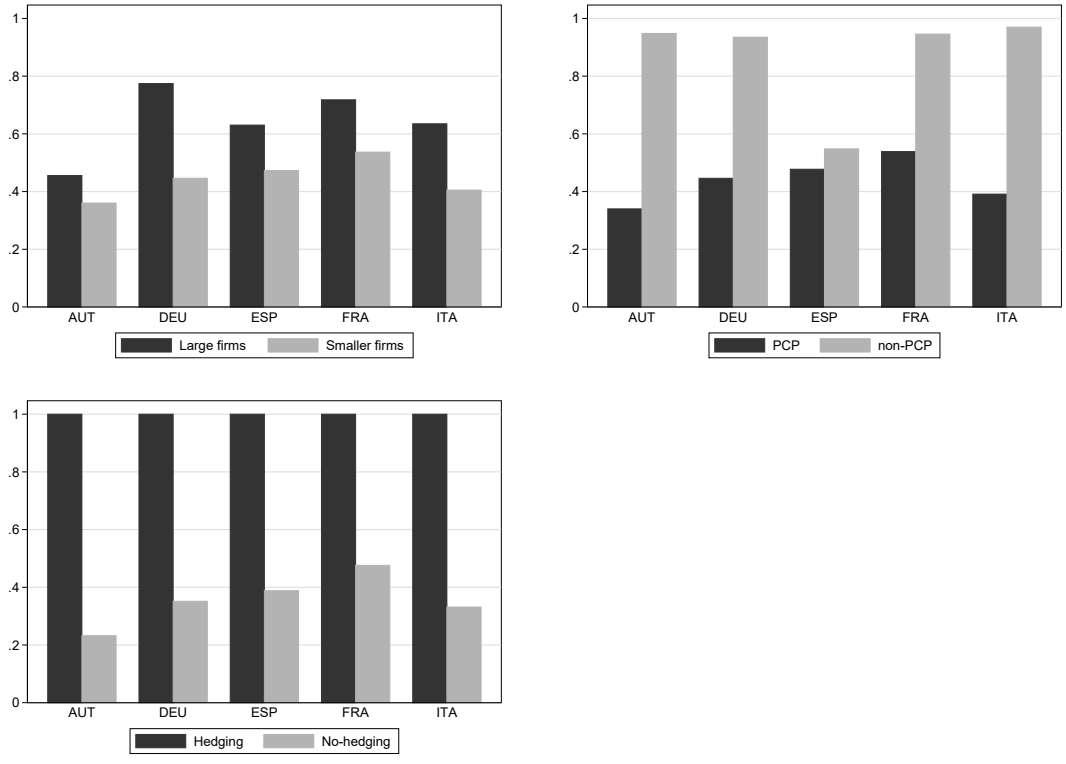
where $c(h)$ is the variable cost component. With a variable cost component that is increasing in h (i.e., when $c'(h) > 0$), the optimal strategy no longer necessarily involves full hedging. Instead, the firm chooses h to maximize expected utility $\max_{p^i,h} \mathbb{E}\left[u\left(\pi^i(S)\right)\right]$. The first-order condition with respect to h is $\mathbb{E}\left[\frac{du\left(\pi^i(S)\right)}{d\pi^i(S)}\left(-S + f - c'(h)\right)\right] = 0$. This condition, together with $f = \mathbb{E}(S)$, implies $\text{Cov}\left[\frac{du\left(\pi^i(S)\right)}{d\pi^i(S)}, -S\right] = \mathbb{E}\left[\frac{du\left(\pi^i(S)\right)}{d\pi^i(S)}\right]c'(h)$, so that the exporter does not necessarily fully hedge when hedging costs entail a variable component. We are not able to determine the optimal quantity hedged without further assumptions on the relative curvature of the utility function and the hedging cost.

To highlight the fact that our qualitative results continue to hold, note $\frac{d^2u\left(\pi^i(S)\right)}{d(\pi^i(S))^2} < 0$ so that the term $\mathbb{E}\left[\frac{du(\pi^i(S))}{d\pi^i(S)}\right]$ is lower for larger (more profitable)

firms. As long as the variable cost of hedging $c(h)$ is not too convex in the quantity hedged h, we have that Cov $\left[\frac{du\left(\pi^i(S)\right)}{d\pi^i(S)}, -S\right]$ is lower for larger firms. In words, our main result that larger firms are more likely to hedge therefore continues to hold except for extreme cases in which the variable cost is very convex in the quantity hedged. In the realistic case in which the variable cost is decreasing in h (i.e., $c(h)$ is concave in h), larger firms with larger hedging demand are even more likely to hedge than smaller firms, reinforcing our model's prediction.

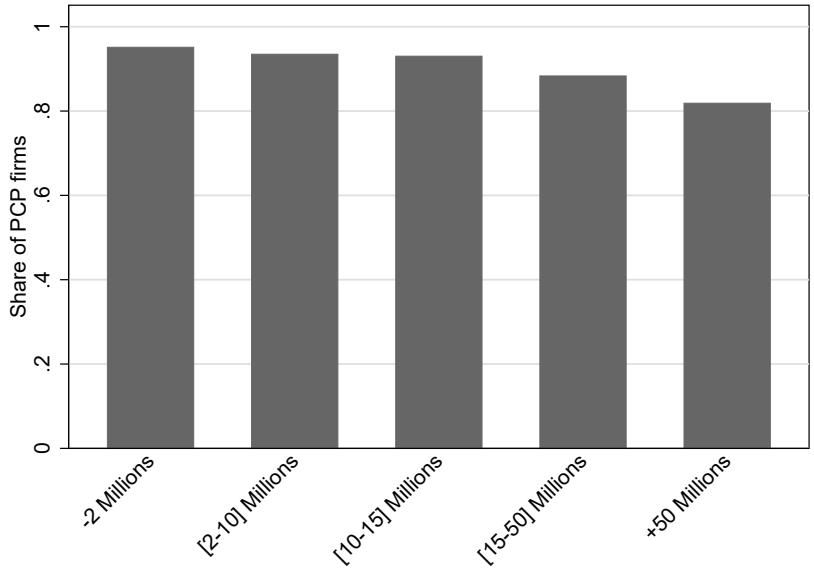
The more risk averse the exporting firm's manager, the more likely the benefits from hedging are to outweigh the costs for larger firms. When hedging costs entail a variable cost component, this latter should not be too convex for hedging to be optimal.

Figure A.1 – Heterogeneity in exchange rate exposure



Notes: This graph displays the share of firms from each country that are exposed to exchange rate risks in various populations of i) small and large firms, ii) PCP and non-PCP firms and iii) firms that are hedged against firms that are not. Large and small firms are defined as **to be completed**.

Figure A.2 – Heterogeneity in invoicing strategies across size bins



Notes: This graph displays the share of firms that declare pricing in their own currency, bvy size bins.

Table A.1 – Determinants of currency choices: Baseline results over subsamples of firms

	Dep.Var: Probability(PCP)				
	(1)	(2)	(3)	(4)	(5)
Sales above 50 millions	-0.48***	-0.54***	-0.46***	-0.49***	-0.53***
	(-4.841)	(-4.067)	(-3.485)	(-4.847)	(-5.048)
Share of exports	-0.54***	-0.61***	-0.51***	-0.53***	-0.51***
	(-3.856)	(-3.047)	(-3.303)	(-3.743)	(-3.539)
No Pricing Power	-0.21**	-0.23**	-0.22**	-0.20**	-0.19**
	(-2.537)	(-2.094)	(-2.395)	(-2.435)	(-2.329)
Multinational	-0.13	-0.08		-0.15	-0.16
	(-1.340)	(-0.612)		(-1.541)	(-1.623)
Sh. Oth. EU	0.00	0.00	0.00	0.00	0.00
	(0.673)	(0.752)	(0.281)	(0.562)	(0.517)
Sh. Other Eur.	-0.00	0.01	-0.00	-0.00	-0.00
	(-1.097)	(1.531)	(-1.276)	(-1.130)	(-1.186)
Sh. Chn-Ind	-0.01***	-0.01**	-0.01***	-0.01**	-0.01***
	(-3.049)	(-2.476)	(-2.748)	(-2.480)	(-2.608)
Sh. Other Asia	-0.01**	-0.01*	-0.01*	-0.01**	-0.01***
	(-2.529)	(-1.830)	(-1.831)	(-2.545)	(-2.600)
Sh. North Am.	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***
	(-6.322)	(-3.652)	(-5.798)	(-6.160)	(-5.990)
Sh. South Am.	-0.01***	-0.01***	-0.02***	-0.01***	-0.01***
	(-5.970)	(-3.961)	(-5.741)	(-5.640)	(-5.314)
Sh. Row	-0.00*	-0.00	-0.00	-0.00*	-0.00*
	(-1.708)	(-0.399)	(-0.876)	(-1.787)	(-1.766)
Origin country FE	yes	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes
# Observations	3,011	1,437	2,496	2,929	2,876

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 specification is the same as in Table 2, column (4), reproduced in column (1). Column (2) is restricted to firms with at least one main partner outside of the EMU. Column (3) neglects firms which are part of a mutinational company. Column (4) neglects firms producing oil or metal products. Column (5) neglects firms in sectors in which at least 50% of firms declare that their price is fixed by the market. T-statistics computed from robust standard errors are reported in parenthesis. ***, ** and *, respectively, indicate significance at the 1, 5, and 10% levels.