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Exchange Rate Exposure under Liquidity Constraints

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Abstract

We develop a simple model where exporting firms are characterized by heterogeneous productivity and may face a liquidity constraint, which in turn is affected by exchange rate changes. This setup is used to analyze exchange rate exposure, i.e. the sensitivity of profits to exchange rate changes, and to derive testable implications that we bring to the data. The key innovation of our setup is to assume that exchange rate changes can either boost or depress liquidity: this allows us to study exposure profits under different scenarios. We find that profits of more productive firms should be more sensitive to exchange rate fluctuations. Moreover, an increase in the cost of external funds (relative to cash flow) makes profits less sensitive to exchange rate shocks for firms whose liquidity is positively affected by an appreciation of the exchange rate. We test these predictions derived from the model using a large dataset of French exporting firms. Results confirm that exposure tends to increase with productivity but in a non linear way. Furthermore, empirical results confirm that for firm whose cash flow is negatively correlated with exchange rate movements, an increase in financial costs lowers exposure.

JEL Codes: F23, F31, G32

Keywords: export, exchange rate, exposure, financial constraints, heterogeneity, productivity

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1 Introduction

In this paper we analyze the exposure of exporting firms' profits to exchange rate changes in presence of liquidity constraints. The topic is particularly relevant in the present context, where access to external financial resources is still scarce as a result of the 2007 financial crisis, and wide fluctuations in the relative value of currencies are under way. The paper therefore contributes to the growing literature that addresses the role played by financial factors in determining firm behavior in international markets.

Exchange rate volatility is an important part of the risk faced by exporting firms. Strong and increasing international cost competition requires firms to consider exchange rate changes when planning their internationalization strategies. Assessing the extent to which firm profits are affected by exchange rate fluctuations is complicated because costs and revenues react differently, and firms may or may not respond to exchange rate changes. Import prices will not entirely reflect movements in the exchange rate because of the strategic pricing behavior of exporters (see, among others, Dornbusch, 1987; Krugman, 1987; Gagnon and Knetter, 1995; Goldberg and Knetter, 1997; Guillou and Schiavo, 2009). The empirical evidence of incomplete exchange rate pass-through at the firm level implies that adjustments in mark-ups will compensate part of the exchange rate change and limit the effect on prices and, eventually, market shares. If part of the movement in the exchange rate is passed-through to the final foreign consumer though, market shares of the exporting firms will still be affected. Revenues then change because of the variation in both the quantity sold (the market share), and the price (mark-ups). Quantities in turn react to changes in the final price, i.e. to the fraction of exchange rate changes that are passed-through to the consumer.

Exchange rate changes affect in opposite ways revenues and costs as long as a part of the latter is due to imported inputs used in production. The importance of this cost channel is growing thanks to the increasing internationalization of the supply chain (see for instance, De Backer and Yamano, 2008). While an appreciation of the domestic currency reduces the price competitiveness of the domestic exports and hence depresses export revenues, it also decreases the cost of imported inputs and therefore may improve a firm's overall position vis-à-vis foreign competitors.

The empirical literature has recently analyzed the role of this cost channel in determining the sensitivity of exports to exchange rate changes (Greenaway et al., 2010). Bodnar et al. (2002) present a model that features exchange rate effects on both revenues and costs, and look at the overall effect on firm profits. In this literature, however, the financial side is often overlooked, whereas exchange rate considerations play a crucial role in the financial strategy of firms, such as hedging behavior or currency denomination of debt. The way firms react to exchange rate could be linked to their financial structure. More, the exchange rate change could affect directly or indirectly the financial conditions of firms.

In parallel, the relationship between financial factors and firm export behavior has recently attracted new interest (Greenaway et al., 2007; Bellone et al., 2010; Minetti and Zhu, 2011): results show that exporting firms are more liquid and less financially constrained, though there is no consensus on the direction of causality. Greenaway et al. (2007) support the idea that exporting facilitates access to external financial resources, whereas Bellone et al. (2010) and Minetti and Zhu (2011) show that firms enjoying better financial health are more likely to become exporters. On the theoretical side, Chaney (2005) embeds a liquidity constraint in the Melitz (2003) model and shows that constrained firms are less likely to export because of their difficulty to overcome the fixed cost needed to enter foreign markets. Moreover, an exchange rate appreciation increases the value of domestic assets in foreign currency, eases the financial constraint and may allow previous constrained firms to export. Muûls (2008) further shows that financial frictions may well prevent productive firms from entering foreign markets, and that credit constraints mainly matter for the extensive margin of trade, something confirmed also by Bellone et al. (2010) and Buch et al. (2010).

We bridge the literature on heterogeneity, finance and export with the more classic issue of exchange rate exposure. The latter has long been studied in the finance literature (see Muller and Verschoor, 2006, for a survey), by relating firms' stock market return to exchange rate changes. Our work focuses more on competitive forces set in motion by exchange rate changes when the financial condition of each firm is itself affected by the exchange rate. In particular, we show that explicitly considering financial costs makes financial conditions an essential determinant of a firm's profit sensitivity to exchange rate changes. By considering profits instead of simply looking at exports, we focus on what really matters for firms. Moreover, this also has macroeconomic implications: apart from the direct effect of exchange rate appreciation on export and on the current account, our work sheds light on the mechanism through which exchange rate change impact on firm's ability to invest and grow.

The paper is organized as follows: the next Section presents the model and derives the main testable implications; Section 3 describes the data used in the empirical analysis and present the econometric specification. Section 4 discusses the various results. The last Section highlights a few open path for future research and concludes.

2 The Model

2.1 Baseline specification

The paper builds on a recent contribution by Buch et al. (2010) to derive a model populated by heterogeneous firms engaged in export activities, which may be confronted with a liquidity constraint, defined as the need to finance their fixed and variable costs by means of (costlier) external financial resources.

Although our work is rooted in the new-new trade theory and belongs to the family of Melitz-type (2003) models, we abstract from explicitly modeling the selection effect that results in the usual segmentation between exporting and non-exporting firms, but rather concentrate directly on the former group.

Firms face a fixed entry cost F, plus a constant marginal cost $(ec+d)/\beta_i$, where β_i captures firm idiosyncratic productivity, and ec is the cost imported component, e being the exchange rate. They face a demand that is derived from the usual Dixit-Stiglitz monopolistic competition setup where consumers' utility is characterized by love of variety:

$$U = \left(\int_i x(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$$

where $x(i)$ is the consumption of variety i and $\sigma > 1$ is the elasticity of substitution. Utility maximization subject to the constraint of total expenditure being lower or equal to R yields the demand faced by each firm, which takes the usual form:

$$x_i = \frac{Rp_i^{-\sigma}}{P^{1-\sigma}} \tag{1}$$

with p_i is the price charged by firm i (i.e. the price of variety i) and $P = \left(\int_i p(i)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}$ is the overall price index.

We further assume —again following Buch et al. (2010)— that the firm is endowed with an amount of cash L_i that can be used to finance its fixed and variable costs. The idea here is that these costs need to be financed in advance. The opportunity cost of internal finance (i.e. the outside option for investing L_i) is normalized to 1. When firms have to finance their costs by means of external financial resources (i.e. when $L_i < \frac{ec+d}{\beta_i}x_i + F$), they have to pay a firm-specific premium $\tilde{\phi}_i > 1$. This premium is firm-specific because it depends on firm's debt structure, financial situation and also on its reputation. Last, exporting firms face also an iceberg transport cost $\tau > 1$, that is assumed common to all exporting firms.

Profits are given by the following expression:

$$\pi_i = \frac{ep_i x_i}{\tau} - \phi_i \left(\frac{ec+d}{\beta_i} x_i + F - L_i \right) - L_i \tag{2}$$

where, e is the exchange rate defined as the number of domestic currency per unit of foreign currency. Firms maximize profits in their own currency and set price in foreign currency.

As suggested above, $\phi_i = \begin{cases} 1 & \text{if } L_i \geq \frac{ec+d}{\beta_i}x_i + F \\ \tilde{\phi}_i > 1 & \text{if } L_i < \frac{ec+d}{\beta_i}x_i + F \end{cases}$

The first order condition for profit maximization is

$$\frac{\partial \pi_i}{\partial p_i} = \frac{ex_i}{\tau} - \frac{eRp_i\sigma p_i^{-\sigma-1}}{\tau P^{1-\sigma}} + \frac{\sigma\phi_i(ec+d)Rp_i^{-\sigma-1}}{P^{1-\sigma}\beta_i} = 0 \tag{3}$$

The optimal price charged by firm i thus results

$$p_i^* = \frac{\phi_i \tau (ec+d)}{\beta_i e} \frac{\sigma}{\sigma - 1} \tag{4}$$

and the optimal quantity exported, i.e the intensive margin, takes the form

$$x_i^* = \frac{R}{P^{1-\sigma}} \left(\frac{\phi_i \tau (ec+d)}{\beta_i e} \frac{\sigma}{\sigma - 1} \right)^{-\sigma} \tag{5}$$

2.1.1 Impact of exchange rate changes on sales

Changes in the exchange rate have a direct impact on the quantity produced and exported. In order to get the elasticity of quantity with respect to change in exchange rate, η_i, we derive the logarithm of the optimal quantity (equation 5) relative to the exchange rate.

$$\eta_i = \frac{d\ln(x_i^*)}{d\ln(e)} = -\sigma \frac{d\ln(ec+d)}{d\ln(e)} + \sigma \frac{d\ln(\beta_i e)}{d\ln(e)}$$

$$\eta_i = \frac{-\sigma ce}{ec+d} + \sigma = \frac{\sigma d}{ec+d} \quad = \quad \sigma(1-\gamma) > 0 \tag{6}$$

where $\gamma = \frac{ec}{ec+d}$ is the share of imported marginal costs.

A one percent increase in exchange rate, i.e a one percent depreciation, leads to a positive increase in exports. The percentage increase is higher the elasticity of substitution, σ. Actually, when the elasticity of substitution is strong, it means the firm has a lower monopolistic power than when substitution is weak. Firms belonging to industry where products are facing strong competition from local products (for example, a Moroccan firm exporting textile in China) will be more sensitive to exchange rate change. The share of imported cost plays a negative role. Last, it is important to highlight that the export elasticity to exchange rate is not affected by the liquidity constraint: indeed, η_i is independent of ϕ_i.

The sensitivity of exports to exchange rate is linked to the exchange rate pass-through. It is easy to show that, $\eta = \sigma\varepsilon_{PT}$ where ε_{PT} is the elasticity of pass-through.[1] The reaction of exports depends on how price will vary in response to exchange rate changes.[2]

2.1.2 Exposure

Optimal profits can be obtained by plugging the expressions for optimal price (4) and quantity (5) into equation (2):

$$\begin{aligned}
\pi_i^* &= \frac{eR}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma} - \phi_i \frac{ec+d}{\beta_i}\frac{R}{P^{1-\sigma}} p_i^{-\sigma} - \phi_i F + (\phi_i - 1) L \\
&= \frac{eR}{\tau\sigma}\left(\frac{\phi_i \tau (ec+d)}{\beta_i e P}\frac{\sigma}{\sigma-1}\right)^{1-\sigma} - \phi_i F + (\phi_i - 1) L \qquad (7)
\end{aligned}$$

The sensitivity of profits to exchange rate changes can be computed as

$$\begin{aligned}
\delta_i &= \frac{d\pi_i}{de} = \frac{R}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma} + \frac{eR(1-\sigma)}{\tau\sigma}\frac{p_i^{-\sigma}}{P^{1-\sigma}}\left(-\frac{\phi_i \sigma \tau d}{e^2 \beta_i (\sigma-1)}\right) \\
&= \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left(\frac{\gamma + \sigma - \gamma\sigma}{\sigma}\right) > 0 \qquad (8)
\end{aligned}$$

As we can see from equation (8), the sensitivity of profits with respect to exchange rate changes is not affected by the potential liquidity constraint faced by the firm

[1] See Appendix A for details.

[2] Since demand elasticity does not depend on exchange rate, pass-through depends only on the share of imported marginal cost. The higher the amount of imported cost relative to the total cost, the less the export price will reflect an exchange rate change. This comes from the fact that an appreciation lowers imported costs.

since δ_i is not a function of ϕ_i.[3]

Similarly, by taking the second cross derivative of profits with respect to the aggregate shock and the productivity parameter β_i we can show that the profits of more productive firms are more sensitive to exchange rate shocks.

$$\frac{d^2\pi_i}{d\beta\partial e} = \frac{\sigma-1}{\sigma}\frac{R}{\beta\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}(\gamma+\sigma(\gamma-1)) > 0 \tag{9}$$

As it is often the case with this class of models à la Melitz (2003) productivity, profitability and size are jointly determined by the parameter β_i and therefore move together. The result presented in equation (9) is driven by the fact that more productive firms export more and therefore their profit is consequently more exposed to the vagaries of the exchange rate.

2.2 Cash Flow and Exchange Rate Shocks

In this Section we relax the assumption that firm cash flow L_i is exogenously given and we build into the model a relationship between liquidity and exchange rate shocks, in a way similar to Dekle and Ryoo (2007). To do this we need first to assume that the exchange rate is hit by a random macroeconomic shock ε with zero mean and finite variance ν_ε.

$$e = \bar{e} + \varepsilon \tag{10}$$

The shock can be either positive, implying a depreciation, or negative implying an apreciation of the domestic currency given our definition of the exchange rate.

At the same time, we suppose that this macroeconomic shock, ε, will affect the amount of liquidity a firm can rely on. It is a simple way of considering that the exchange rate and projected sales are jointly determined by underlying macroeconomic variables (see Russ, 2007).

$$L_i = \bar{L}_i(1+\alpha\varepsilon) \tag{11}$$

where —as in Dekle and Ryoo (2007)— α represents the correlation between the firm's cash flow, hence its liquidity, and the macroeconomic shock. This formulation says that the effect of the macroeconomic shock on firm liquidity depends on the

[3]Under the assumption of no imported costs ($\gamma = 0$) the expression for profits is the same as in equation (7), but the sensitivity of profits to exchange rate changes is larger than in the previous case: $\frac{d\pi_i}{de} = \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}$ since $\sigma > 0$ implies $\frac{\gamma+\sigma-\gamma\sigma}{\sigma} < 1$ in equation (8).

Table 1: Effects of shocks depending on α

	$\alpha > 0$ Monetary policy shocks	$\alpha < 0$ Supply side shocks
Depreciation ($\varepsilon > 0$)	increases the liquidity eases the constraint	decreases the liquidity tightens the constraint
Appreciation ($\varepsilon > 0$)	decreases the liquidity tightens the constraint	increases the liquidity eases the constraint

correlation between the latter and movements in the exchange rate.[4]

Although modeling the determinants of the correlation α is beyond the scope of the paper, we can nevertheless conjecture that α depends on the type of macroeconomic shocks (monetary, fiscal or trade policy changes, productivity or labor supply shocks, ...) as well as on firm- and industry-specific characteristics that affect the reactions to these shocks.

First, a positive α implies that a depreciation is associated to an increase of firm liquidity. It refers typically to a situation of expansionary monetary policy leading to low interest rate and higher demand. On the contrary, an appreciation is associated to a decrease in liquidity. This account is consistent with the mechanism included in Chaney (2005)'s model where a depreciation increases the value of domestic assets in foreign currency and then eases the liquidity constraint.

Second, a negative α can arise from supply side shocks. For instance, an unexpected increase in the oil price may lower revenues and cash flows and trigger a depreciation of the exchange rate aimed at restoring the equilibrium in the balance of payments. The Table 1 summarizes the different possibilities. In the rest of the paper we take an agnostic view with respect to the sign of α and simply assume $\alpha \neq 0$.

At this point we can study the effect of an unexpected change (i.e. a shock) in the exchange rate on profits. We assume that when the liquidity constraint is binding, so that firms have to rely on external financial resources, this entails higher cost compared to the use of internal finance, whose opportunity cost is normalized

[4]This formulation states also that the extent of the macroeconomic shock on the liquidity available depends on the given endowment in liquidity. This is coherent with the idea that liquidity reflects the history of the firm performance. More productive firm should have more liquidity as a result of higher profits accumulation. At the same time, more productive firms are likely larger exporters. Thus firms with higher liquidity endowment are likely to be the larger exporters and the more exposed firms.

to one:

$$\phi_i = \begin{cases} 1 & \text{if } \bar{L}_i(1+\alpha\varepsilon) \geq \frac{ec+d}{\beta_i}x_i + F \\ \tilde{\phi}_i > 1 & \text{if } \bar{L}_i(1+\alpha\varepsilon) < \frac{ec+d}{\beta_i}x_i + F \end{cases}$$

We can now rewrite the profit equation (2) as

$$\pi_i = \frac{eR}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma} - \phi_i F + (\phi_i - 1)\left(\bar{L}_i(1+\alpha\varepsilon)\right). \tag{12}$$

Profit sensitivity then becomes

$$\begin{aligned} \tilde{\delta}_i = \frac{d\pi_i}{de} &= \frac{R}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma}\left[1 + \frac{e(\sigma-1)}{p_i}\frac{\phi_i\sigma\tau d}{\beta_i(\sigma-1)e^2}\right] + (\phi_i - 1)\bar{L}_i\alpha \\ &= \frac{R}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma}\left[1 + (\sigma-1)(1-\gamma)\right] + (\phi_i - 1)\bar{L}_i\alpha \\ &= \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left[\frac{\gamma + \sigma(1-\gamma)}{\sigma}\right] + (\phi_i - 1)\bar{L}_i\alpha \end{aligned} \tag{13}$$

using the definition of ϕ_i given above we can easily see that

$$\frac{d\pi_i}{de} = \begin{cases} \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left[\frac{\gamma+\sigma(1-\gamma)}{\sigma}\right] & \text{no liquidity constraint} \\ \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left[\frac{\gamma+\sigma(1-\gamma)}{\sigma}\right] + \left(\tilde{\phi}_i - 1\right)\bar{L}_i\alpha & \text{liquidity constraint} \end{cases} \tag{14}$$

From these two expressions we can conclude that adding a liquidity constraint and assuming that cash flow is affected by exchange rate shocks, implies a relationship between exposure and financial conditions. In particular, the sensitivity of profits to exchange rate changes may increase or decrease relative to the benchmark case of no liquidity constraint, depending on the sign of the correlation between cash flow and aggregate shocks (α).[5]

We can further investigate the effect of exchange rate shocks on profits of different firms by taking the second derivatives: First, how financial cost affects exposure is given by:

$$\frac{d^2\pi_i}{d\tilde{\phi}_i de} = \bar{L}_i\alpha \tag{15}$$

Equation (15) tells that an increase in the relative cost of external finance relative to internal funds may increase or reduce the sensitivity of profits to exchange rate

[5]In the derivation of equation (13) we have implicitly assumed that the overall price index P is not affected by exchange rate changes ($dP/de = 0$). While this hypothesis greatly simplifies the analysis, it is clearly not verified in general. It is still a reasonable representation of relatively closed economies or of situations where pass-though is very small.

shocks depending on the sign of α, i.e. on whether aggregate shocks are positively or negatively correlated with firm cash flow. Table 2 summarized the different cases.

Table 2: Effects of financial costs on exposure depending on α

	$\alpha > 0$ More exposed if financial costs increase	$\alpha < 0$ Less exposed if financial costs increase
Depreciation (positive shock)	increases the liquidity Firms benefit more from $\varepsilon > 0$	decreases the liquidity Firms benefit less from $\varepsilon > 0$
Appreciation (negative shock)	decreases the liquidity Firms suffer more from $\varepsilon < 0$	increases the liquidity Firms suffer less from $\varepsilon < 0$

Similarly, how liquidity endowment affects exposure is given by the second derivative:

$$\frac{d^2\pi_i}{d\bar{L}_i de} = (\tilde{\phi}_i - 1)\alpha \tag{16}$$

Equation (16) tells that an increase in the liquidity endowment, for firms which are liquidity constrained and for a given amount of financial cost, may increase or reduce the sensitivity of profits to exchange rate shocks depending on the sign of α.

2.3 Testable hypotheses

The model yields two sets of implications concerning exchange rate exposure: the first concerns its relationship with firm's characteristics; the second deals more specifically with its dependence on the liquidity constraint.

First of all, the model is consistent with existing empirical evidence associating export and productivity. Equation (9) tells that profits of more productive firms are more sensitive to exchange rate fluctuations, the reason being that more productive firms export more.

Second, Equation (14) shows that an exchange rate depreciation leads to higher profits for non-financially constrained firms. The presence of a liquidity constraint will increase or reduce the positive impact of an exchange rate shock depending on the sign of the its correlation with the firm cash-flow.

From these observations we can derive a set of formal hypotheses to bring to the data, namely:

H1: The profit increases with liquidity, productivity and exchange rate (depreciation), and decreases with financial costs.

H2: The sensitivity of profits to exchange rate shocks grows with productivity.

H3: The sensitivity of exposure to the cost of external finance depends on the sign of the correlation between aggregate shocks and firm liquidity, namely the sign of α (equation (15)).

3 Empirical analysis

3.1 Data

We use data on French firms derived from an annual survey conducted by the French Ministry of Industry (*Enquête Annuelle d'Entreprises*). This gathers information on all manufacturing firms with at least 20 employees, plus some smaller firms with large sales (beyond 5 million euros), and contains data mainly derived from the income statement of participating firms. For the period 1995–2007, the original dataset comprises around 250 000 observations for nearly 35 000 French firms, 75 percent of which are exporters.

We focus our attention on exporting firms only, as the decision whether or not to export is not modeled. We perform some basic cleaning operations on the data: in particular we drop observations for which profits are negative, and set liquidity equal to zero when liquidity is negative.[6] Moreover, we winsorize the top and bottom 1 percent of the observations in the key variables we use in the analysis (profit, liquidity, financial costs, size and productivity).[7] This leaves us with a sample of roughly 30 000 exporting firms, totaling some 186 500 observations.

3.2 Variable Definition

Exchange rate: Our exchange rate measure is an effective exchange rate computed at ISIC 4-digit industry level, on the basis of 26 partner countries representing the main destinations for French export.[8] Weights are calculated from the share of exports of each industry to the different destinations. An increase of the effective

[6]Given the double log specification of our regression equations the former operation is irrelevant as those observations would be dropped from the analysis anyway. In the second case, the truncation is aimed at keeping the observations in the analysis.

[7]Winsorizing a variable entails setting its extreme realizations, e.g. those pertaining the top/bottom 1 percent, to a specified percentile of the data, say the 99th percentile.

[8]The destination markets are: Germany, Austria, Italy, Belgium-Luxembourg, Denmark, United Kingdom, Netherlands, Spain, Portugal, Greece, Ireland, Finland, United-States, Japan, Canada, China, Poland, Norway, Sweden, Switzerland, Russia, Turkey, Hong Kong, Singapore, Thailand, South Korea.

exchange rate means a depreciation of the domestic currency relative to the basket of the 26 currencies-partners, that is a gain in price-competitiveness.

Profit: To measure profit, we rely on earnings before interest, taxes, depreciation and amortization (EBITDA), or gross profits.[9] This measures the economic performance of a firm before its financing operations are taken into account, so it should not be influenced by how a firm finances its activities. Note that while the model refers to profits from export sales only, in the empirical analysis we cannot determine the origin of revenues and therefore have to consider total profits. We use industry-specific producer price indexes computed by the national statistical office (INSEE) to deflate profits in order to work on real variables.

Productivity and size: Firm productivity is defined as both labor productivity (valued added over number of hours worked) and total factor productivity (TFP). The latter is computed according to the so-called *multilateral productivity index* (Caves et al., 1982; Good et al., 1997; Aw et al., 2000). We use two measures of firm size: number of employees and total sales (in real terms).[10]

Liquidity and cost of finance: To proxy for liquidity we take the ratio between firm cash flow and fixed tangible and intangible assets, while the cost of external financial resources is measured as interest and financial expenses over fixed assets.[11] Data limitations prevent us from computing financial costs as a ratio of debt, which would probably be a better measure of the cost associated to external finance.

Correlation between liquidity and exchange rate: The correlation between liquidity and the exchange rate (α in the model) can be computed either by year (across all 4-digit sectors present in the data, that are 107), or by sector (across the whole 1995–2007 period), not by firm since the exchange rate is industry specific. The former account for time-specific macroeconomic shocks common to all firms, whereas the latter assumes the correlation to be a structural feature of each sector that does not change over time.[12] Table 3 gives summary statistics of these two

[9] In the French data this is represented by *Excédent Brut d'Exploitation*.

[10] Appendix C shows results using also hours worked, and capital stock computed according to the permanent inventory method.

[11] These variables correspond to the French *Capacité d'autofinancement* and *Intérêts et charges assimilées* respectively.

[12] Since we are mainly concerned with the sign, rather than the actual magnitude, of the correlation coefficient, both these assumptions are less demanding.

different coefficients of correlation.

Table 3: Summary Statistics on Correlation Coefficients

	YEAR (1)	ISIC4 (2)
max	-0.006	0.020
min	-0.055	-0.054
st. dev.	0.016	0.016
mean	-0.033	-0.009
coeff.	13	107
coeff.< 0	13	50

Regarding the correlation by year, it is always negative, so that an exchange rate depreciation is associated with a deterioration of liquidity. When considering the correlation by 4-digit industry, we find an almost equal occurrence of positive (57) and negative coefficients (50).

3.3 Empirical Strategy

The first hypothesis we wish to bring to the data (H1) aims at testing the main intuition of the model, i.e. the idea that profits are positively affected by exchange rate depreciations, and that firms featuring higher liquidity and lower financial costs enjoy higher profits. To perform a formal test of H1 we estimate the following regression equation:

$$\begin{aligned} PROFIT_{ist} = a_0 + a_1 EER_{st} + a_2 PROD_{ist} + a_3 SIZE_{ist} + a_4 LIQ_{ist} \\ + a_5 FINC_{ist} + \nu_i + \varepsilon_{ist} \quad (17) \end{aligned}$$

where i, s and t index firms, sectors and time respectively, EER_{st} is the effective exchange rate for industry s, $PROD_{ist}$ measures productivity, LIQ_{ist} stands for liquidity, $FINC_{ist}$ for the cost of financial resources, and ν_i is a firm-specific fixed effect. Variables are defined as in Section 3.2 above and all enter the regression in logs.[13] Since our main concern is the effect of the exchange rate, which is a sector-specific variable, on firm-level profits we need to correct the downward bias introduced by the fact that error terms across firms are not independent Moulton (1990). This is done by clustering standard errors within each 4-digit sector.

[13]More precisely, for each variable (X), except TFP, entering the regression equation we apply the transformation $\hat{X} = log(X + 1)$ and use $\hat{X}$ in the analysis. This is done in order to avoid loosing observations featuring zero in any of the relevant variables.

The model yields further predictions concerning the effect of exchange rate changes on profits for firms with different characteristics in terms of productivity and financial costs. These conditional effects can be best evaluated by means of interaction terms. Hence, we build indicator variables for firms belonging to different quartiles of the productivity (or financial costs) distribution (Q^k), and interact them with the exchange rate, to investigate whether the marginal effect of EER changes across productivity (financial costs) levels.[14] We end up with the following regression equation:

$$PROFIT_{ist} = a_0 + a_1 EER_{st} + a_2 PROD_{ist} + a_3 SIZE_{ist} + a_4 LIQ_{ist} + a_5 FINC_{ist} + \sum_{k=2}^{4} \left(d_k \times Q^k_{ist}\right) + \sum_{k=2}^{4} \left(b_k Q^k_{ist} \times EER_{st}\right) + \nu_i + \varepsilon_{ist} \quad (18)$$

where Q^k is a dummy identifying firms belonging to the k^{th} quartile of the productivity (financial costs) distribution, and the d_k coefficients represent quartile-specific constant terms.[15] The coefficient b_k indicates the additional effect of exchange rate changes on profits for firms belonging to the k^{th} quartile of productivity (financial costs) above and beyond the baseline effect for the reference group (a_1), i.e. the impact of EER on firms with the lowest productivity (financial costs).

For what concerns the last prediction of the model (H3), we need to further discriminate among firms depending on the sign of the correlation between liquidity and the exchange rate. We do so by estimating equation (18) on the two subsamples identified by the sign of α.

4 Results

4.1 Testing H1: the determinants of profits

Table 4 reports results for the estimation of equation (17). We use both Total Factor Productivity, TFP (columns 1–2) and Labor Productivity, LP (columns 3–4) to proxy for productivity and employ two different measures of size (sales and

[14] The vast literature on interaction terms recommends to include all constituent terms of any interaction effect, not only the interaction itself (see for instance Aiken and West, 1991; Brambor et al., 2006).

[15] Hence,the constant term is a_0 for the reference group, i.e. the first quartile of the distribution, and $a_0 + d_k$ for observations pertaining to the k^{th} quartile.

number of workers).[16] All coefficients have the expected sign across the different specifications of the empirical model. Larger firms enjoy higher profits, irrespective of how we proxy for size. Similarly, more productive firms are more profitable, and results do not change whether we use average labor productivity or TFP. Liquidity also exerts a positive impact on profits, consistently with the model, while firms facing higher financial costs tend to report lower profits. Finally, the estimated coefficients confirm that exchange rate depreciations are associated with an increase in profits as predicted by the model.

Table 4: Test of H1 – Determinants of firm profits

	TFP		LP	
size as:	sales	workers	sales	workers
	(1)	(2)	(3)	(4)
EER	1.273***	1.140***	0.810***	0.879***
	[0.204]	[0.220]	[0.148]	[0.163]
PROD.	1.208***	2.322***	0.064**	1.002***
	[0.069]	[0.080]	[0.029]	[0.022]
SIZE	0.836***	0.751***	1.014***	0.957***
	[0.020]	[0.027]	[0.026]	[0.026]
LIQ	1.977***	2.006***	2.138***	2.161***
	[0.086]	[0.083]	[0.087]	[0.086]
FINC	-1.679***	-1.536***	-1.864***	-1.845***
	[0.188]	[0.212]	[0.203]	[0.205]
Obs.	130,997	130,997	130,997	130,997
Firms	23,144	23,144	23,144	23,144
R^2	0.399	0.377	0.383	0.376

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
clustered standard errors in brackets.

4.2 Testing H2: exposure and productivity

Moving to the next testable implication of the model (H2), we expect to see the sensitivity of profits to exchange rate changes to increase with productivity. Empirically, this should be captured by the coefficients b_k in equation (18), and we expect exposure to be larger for more productive firms. The marginal effect of the effective exchange rate (EER) on profits for a firm belonging to quartile k of the productivity distribution is $a_1 + b_k$, so that the model predicts $b_4 > b_3 > b_2$. Estimation results are reported in Table 5. In all columns the baseline regressors keep the correct sign and are significant, so that larger, more productive and more liquid firms feature larger profits, an exchange rate depreciation has a positive effect on profits, whereas

[16]Appendix C provides results with hours worked and capital stock (Table C.1).

Table 5: Test of H2 – Exchange rate effect on profits, conditional on productivity

	TFP		LP	
	1	2	3	4
EER	1.241***	1.242***	1.104***	1.104***
	[0.399]	[0.398]	[0.248]	[0.247]
PROD	1.719***	1.718***	0.902***	0.903***
	[0.082]	[0.082]	[0.028]	[0.028]
SIZE	0.754***	0.753***	0.948***	0.950***
	[0.028]	[0.028]	[0.026]	[0.026]
LIQ	2.001***	2.001***	2.163***	2.163***
	[0.082]	[0.082]	[0.085]	[0.085]
FINC	-1.507***	-1.507***	-1.830***	-1.830***
	[0.207]	[0.207]	[0.204]	[0.204]
EXP INTENS		0.001		-0.005*
		[0.003]		[0.003]
PROD 2nd qrt x EER	0.566**	0.565**	0.001	0.00
	[0.281]	[0.281]	[0.124]	[0.125]
PROD 3rd qrt x EER	0.347	0.347	-0.064	-0.066
	[0.403]	[0.403]	[0.174]	[0.174]
PROD 4th qrt x EER	-0.604	-0.604	-0.625***	-0.627***
	[0.410]	[0.410]	[0.231]	[0.231]
Obs.	130 997	130 997	130 997	130 997
Firms	23 144	23 144	23 144	23 144
R^2	0.384	0.384	0.377	0.377

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Clustered standard errors in brackets.
Constant term a_0 and dummies d_k not shown.
Size measured as number of workers.

higher financial costs impact negatively on them. When we use TFP (columns 1–2), the estimate for the interaction term with the second quartile (b_2) is positive and significant, indicating that there is a jump in profit sensitivity moving from the first to the second group of firms: the premium associated with productivity is 0.57 percent. Then, the total average effect of EER on profits for firms in the second quartile of the TFP distribution is given by $a_1 + b_2 = 1.241 + 0.566$, which means that a 1 percent depreciation implies a 1.8 percent increase in profits for firms belonging to the second quartile, compared to a 1.24 percent rise for those in the first quartile. For the last two quartiles, by contrast, the relationship between the exchange rate and profits flattens as both b_3 and b_4 are not significant.[17]

When we use labor productivity instead of TFP (columns 3–4), the premium associated with higher productivity disappears. On the contrary, the coefficient which identifies firms belonging to the fourth quartile of the productivity distribution, b_4, is negative and significant, meaning that profit from firms with the highest productivity is less sensitive to exchange rate fluctuations.

[17] This result holds irrespective of the measure of size, see Table C.2 in Appendix C.

To better assess the impact of EER on profits conditional of productivity we can plot the marginal effects for different groups of firms, as reported in Figure 1. The Figure plots the estimated effect of EER on profits for different groups of firms, together with a 5 percent confidence interval computed as 1.96 times the standard error associated with the average effect.[18] We see that exposure does show a jump when moving from the first to the second quartile of the TFP distribution; then the relationship flattens before turning negative so that firms in the upper quartile of TFP display a lower sensitivity of profits to exchange rate changes.[19]

A similar effect appears in the bottom panel of Figure 1, which depicts results obtained using average labor productivity instead of TFP. In line with the results presented in Table 5 the relationship is much flatter than in the case of TFP and we cannot observe any significant difference in the exposure of firms belonging to the first three quartiles of the productivity distribution. On the contrary, one still observes a drop in the sensitivity of profits for the most productive firms.

In order to further investigate the role of productivity on exposure, we use export intensity to test the channel through which higher productivity may affect exposure. Remind that this result comes from the way productivity is introduced in the profit function: firms with higher productivity have also larger size (because they are able to sell at cheaper prices). Since we focus on export sales only (firms are only exporters), firms with larger sales export more. While in the model we only look at profits from foreign sales, in the empirical analysis profits come both from domestic sales and export. If more productive firms are more exposed just because they export more, then we would expect that the conditional effect of EER on profits should disappear once we control for export intensity. Columns 2 and 4 of Table 5 show the regression results when we add this further control to equation (18). Irrespective of whether TFP or LP is used, the introduction of export intensity does not alter the overall picture and, in particular, does not modify the effect of the exchange rate on profits. It suggests the existence of other channels through which productivity interacts with the exchange rate in affecting profits.

Overall, the empirical analysis on the link between productivity and exchange

[18]For example, the average effect of EER on profits for firms in the second quartile of the TFP distribution is given by $a_1 + b_2 = 1.241 + 0.566$, and the standard error is computed as $\sqrt{\mathrm{var}\,(a_1) + \mathrm{var}\,(b_2) + 2\mathrm{cov}\,(a_1, b_2)}$.

[19]This nonlinear effect explains why a regression that includes an interaction among the continuous variables EER and TFP yields a negative slope, seemingly contradicting the model. Indeed, imposing a linear relationship implies that the difference between the second and the fourth quartiles of the TFP distribution generates an exposure that appears negatively related with TFP.

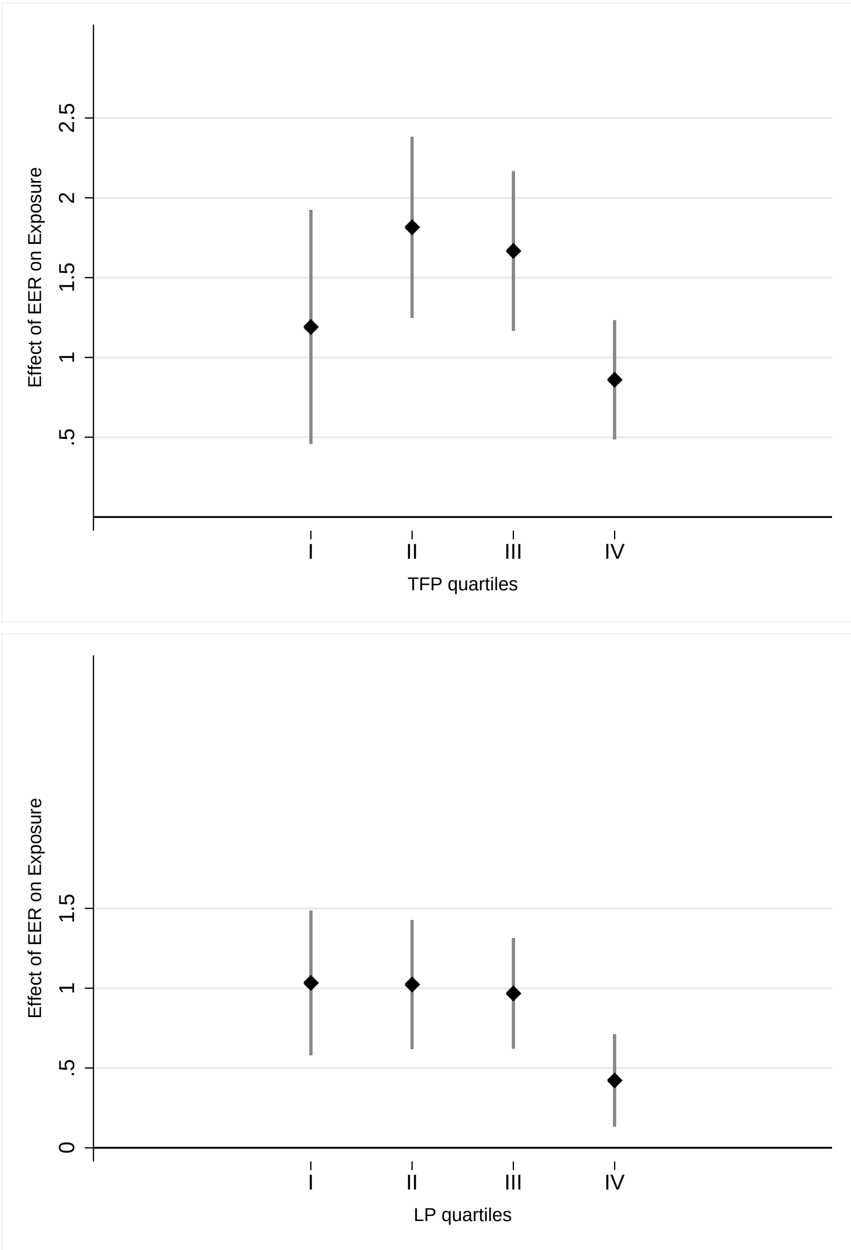

Figure 1: Exchange rate effect on profits across quartiles of the productivity distribution. Productivity is measured in terms of TFP (top panel) and average labor productivity (bottom panel).

rate exposure is ambivalent. When we restrict the focus to the bottom half of the productivity distribution, we do observe a positive effect of TFP on exposure. But this effect vanishes when looking at higher quartiles and becomes negative for the group of most productive firms, both in terms of TFP and labor productivity. Hence, the data suggest the existence of nonlinear effects whereby beyond a certain productivity threshold profits become less affected by exchange rate fluctuations. The simple model sketched in Section 2 is probably ill-equipped to capture such complex phenomena and more work on the topic is needed.

One possible way to explain the negative effect of productivity on exposure that emerges for the top quartile of the distribution is to assume that beyond a certain threshold higher productivity has to do with human capital and managerial ability, so that high productivity firms have ability to better manage exchange rate fluctuations (for instance by hedging). The simple linear relationship built in the model, which is based on the fact that higher productivity implies more exports and therefore makes firms more vulnerable, is unable to capture such effects.

4.3 Testing H3: exposure and financial costs

Let us turn now to the last testable implication derived from the model (H3), which relates exposure to the presence of liquidity constraints and the need to apply for external financial resources. To test H3, we have to consider the sign of the correlation between a firm's liquidity and the exchange rate (α). Indeed, equation (15) suggests that (everything else equal) higher financial costs exert a positive impact on exposure if $\alpha > 0$, otherwise they are associated with lower profit sensitivity.

Table 6 presents results obtained with both TFP and average labor productivity, size measured as number of workers, and the correlation α computed in two different ways.[20] As mentioned above (see Table 3), when we let the correlation change over time, and therefore impose it to be equal across all sectors), α is always negative and we should see higher financial costs implying lower exposure. Thus the coefficients b_k should be negative and $b_2 > b_3 > b_4$, so as to have a less exposure for firms belonging to upper quartiles of the distribution of financial costs. Results displayed in columns (1) and (4) of Table 6 (using TFP and LP respectively) support H3 only for what concerns the fourth quartile: b_4 is negative and significant meaning that very high financial costs reduce exposure when a firm's liquidity is negatively affected by depreciation.

[20]Results obtained using alternative measures of size are reported in Appendix C (Table C.3).

Table 6: Test of H3 – Exchange rate effect on profits, conditional on financial cost and α

	TFP			Avg Labor Prod		
alpha computed:	**by time**	**by isic4**		**by time**	**by isic4**	
	(1)	(2)	(3)	(4)	(5)	(6)
	$\alpha_t < 0$	$\alpha_i < 0$	$\alpha_i > 0$	$\alpha_t < 0$	$\alpha_i < 0$	$\alpha_i > 0$
EER	1.232***	0.709**	1.740***	0.925***	0.535***	1.299***
	[0.261]	[0.290]	[0.294]	[0.180]	[0.168]	[0.235]
PROD	2.345***	2.383***	2.340***	1.004***	1.009***	1.005***
	[0.080]	[0.159]	[0.094]	[0.022]	[0.030]	[0.030]
SIZE	0.749***	0.771***	0.735***	0.957***	0.993***	0.937***
	[0.027]	[0.038]	[0.033]	[0.026]	[0.037]	[0.030]
LIQ	2.007***	1.903***	2.057***	2.162***	2.039***	2.228***
	[0.084]	[0.109]	[0.113]	[0.087]	[0.101]	[0.117]
FINC	-1.707***	-1.407***	-1.897***	-1.909***	-1.636***	-2.082***
	[0.243]	[0.296]	[0.319]	[0.231]	[0.242]	[0.330]
FINC Q^2 x EER	0.003	-0.295**	0.206	0.101	-0.217	0.328**
	[0.122]	[0.146]	[0.182]	[0.117]	[0.132]	[0.155]
FINC Q^3 x EER	-0.117	-0.279	-0.153	-0.015	-0.155	-0.026
	[0.171]	[0.213]	[0.246]	[0.140]	[0.159]	[0.225]
FINC Q^4 x EER	-0.500*	-0.203	-0.830**	-0.397*	-0.131	-0.690**
	[0.265]	[0.275]	[0.317]	[0.222]	[0.227]	[0.261]
Obs.	130997	41301	89696	130997	41301	89696
Firms	23144	7751	15393	23144	7751	15393
R^2	0.378	0.41	0.365	0.376	0.409	0.362

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Clustered standard errors in brackets.
Constant term a_0 and dummies d_k not shown.

To go further, we then assume that the relevant correlation α is sector specific, and does not change over time. When computed like this, the correlation coefficients that emerge from the data are both negative and positive (see Table 3). The model suggests that the estimated b_k should be positive when $\alpha > 0$ and negative when $\alpha < 0$. Moreover, the absolute value of the coefficients should increase with the level of financial costs. Columns (2–3) and (5–6) display the results obtained using TFP and average labor productivity. In the former case, we do observe a significant drop in exposure when moving from the first to the second quartiles of the distribution of financial costs and the correlation is negative (col 2), whereas the interaction coefficients for the last two quartiles have the correct negative sign but are not significant. When the correlation between liquidity and the exchange rate is positive (col 3), b_2 is positive as predicted by the model, but not significant, while the other two interactions terms turn negative (with the last being significantly different from zero). Using LP instead of TFP to measure productivity does not alter the main message (cols 5–6). When $\alpha < 0$ the coefficients have the expected sign, but are never significant, whereas in col 6 we see that the interaction term concerning the second quartile displays a positive and significant coefficient (b_2), in accordance with the model, and the last one (b_4) is again negative and significant.

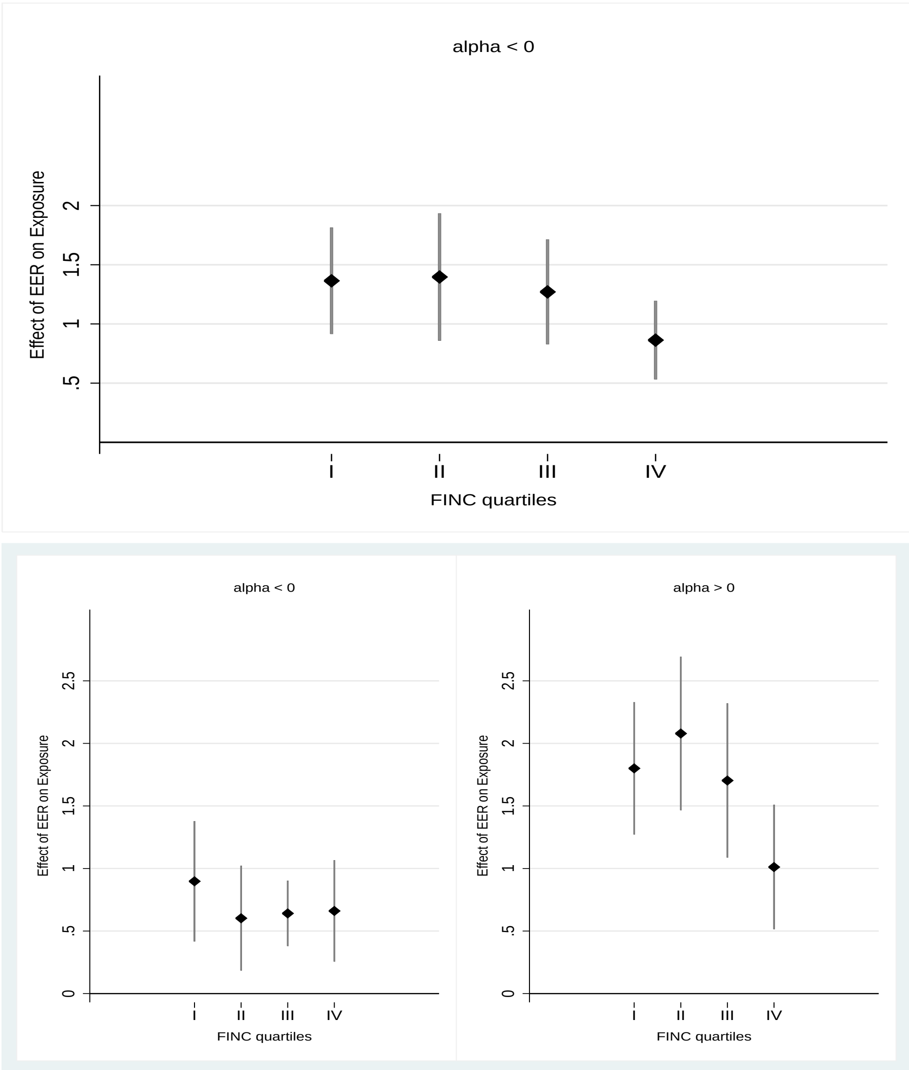

Figure 2: Exchange rate effect on profits across quartiles of the distribution of financial costs. The correlation between firm liquidity and the exchange rate (α) is computed by year (top panel), and by 4-digit ISIC sector (bottom panel).

To get a better feeling of the effect of exchange rate movements on profits conditional on financial costs, we compute the average marginal effects associated with the groups of firms defined by the quartiles of the distribution of $FINC$ and plot them along with their 95% confidence interval. Figure 2 is based on results obtained using TFP, while results coming from the regressions that use average labor productivity are reported in the Appendix (Figure C.1). In the top panel of the Figure, based on the correlation computed by year, we observe a downward trend, with exposure getting lower for higher financial costs. This is in line with the predictions of the model, although the results are not very strong and we cannot rule out the possibility of an almost flat relationship.

In the bottom panel, where correlations are computed by sector, we are able to discriminate among observations for which the correlation is positive and negative. In the latter case we still find a downward trend for exposure, with a steeper drop marking the passage from the first to the second quartile of the $FINC$ distribution. Then, looking at the case when $\alpha > 0$, we find a sort of inverted-U shape that is reminiscent of the results obtained in Section 4.2 in the case of productivity: a sharp increase in exposure marks the move from the first to the second quartile of the distribution, then exposure starts declining and falls below the reference group for firms characterized by the highest values of financial costs. Hence, although the confidence intervals reported in Figure 2 remain quite large, we do find support for the idea that the sign of the correlation between a firm's liquid position and exchange rate movements play a role in determining exposure.

All in all the graphs provide an overall support to the main prediction of the model, though the results are not very strong in terms of statistical significance. Furthermore, for both H2 and H3 there are marked differences in the behavior of firms belonging to the bottom half of the productivity and financial costs distributions.

5 Conclusion

The paper develops a simple model where exporting firms are characterized by heterogeneous productivity and may face a liquidity constraint. This setup is used to analyze exchange rate exposure, namely, the sensitivity of profits to exchange rate changes, and to derive testable implications that we bring to the data.

Overall, empirical results provide a good support to the general framework of the model: the analysis of a large panel of French exporting firms confirms that exchange rate depreciations tend to boost profits, and that size, liquidity and lower financial costs exert a positive effect on profits.

Regarding the main prediction of the model, the sign of the correlation between a firm's liquidity and the exchange rate does matter for profit exposure. Liquidity constraint affect differently the exchange rate exposure depending on the nature of the exchange rate shocks exporting firms face, and their ability to react to them. More generally, our investigation of the effects of exchange rate on profits conditional on either productivity or financial costs show a marked different in the behavior of firms belonging to the bottom half of the distributions, which comply with the model, and those in the upper quartiles, which do not. Our conclusions confirm the main message emerging from the literature on firm heterogeneity, i.e. that distinctive firm characteristics result in differentiated responses to exogenous shocks.

The analysis can be further refined, both theoretically and empirically, along several dimensions. With respect to the model, possible extensions entails allowing firms to hedge, at least partially, their exchange rate risk.[21] From the empirical point of view, access to firm-level data on export destinations would allow one to compute firm-specific effective exchange rate and correlations α, greatly augmenting the information fed to the analysis.

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[21] This however requires modifying the way the liquidity constraint is modeled: in fact, in the present setup, with all terms entering linearly the profit function, optimal hedging turns out to be undetermined. See Appendix A for the details.

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Appendices

A Derivations

A.1 Impact of exchange rate changes on sales

In order to get the elasticity of quantity with respect to change in exchange rate, η_i, we first take the logarithm of the optimal quantity (equation 5).

$$\ln(x_i^*) = \ln\left(\frac{R}{P^{1-\sigma}}\right) - \sigma \ln\left(\frac{\sigma}{\sigma-1}\right) - \sigma \ln\left[\phi_i \tau (ec+d)\right] + \sigma \ln(\beta_i e) \quad \text{(A.1)}$$

$$\begin{aligned}
\eta_i = \frac{d\ln(x_i^*)}{d\ln(e)} &= -\sigma \frac{d\ln(ec+d)}{d\ln(e)} + \sigma \frac{d\ln(\beta_i e)}{d\ln(e)} \\
&= -\sigma \frac{d(ec+d)}{de} \frac{e}{ec+d} + \sigma \frac{d(\beta_i e)}{d(e)} \frac{e}{\beta_i e} \\
\eta_i &= \frac{-\sigma ce}{ec+d} + \sigma = \frac{\sigma d}{ec+d} = \sigma(1-\gamma) > 0 \quad \text{(A.2)}
\end{aligned}$$

A.2 Pass-through

We can compute the elasticity of pass-through, defined as the percentage change in price in response to a percentage change in the exchange rate, as follows:

$$\begin{aligned}
\varepsilon_{PT} = -\frac{d\ln p_i}{d\ln e} &= -e\left[\frac{c}{ec+d} - \frac{1}{e}\right] \\
&= 1-\gamma < 1.
\end{aligned}$$

A.3 Exposure

Optimal profits can be obtained by plugging the expressions for optimal price (4) and quantity (5) into equation (2):

$$\begin{aligned}
\pi_i^* &= \frac{eR}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma} - \phi_i \frac{ec+d}{\beta_i} \frac{R}{P^{1-\sigma}} p_i^{-\sigma} - \phi_i F + (\phi_i - 1) L \\
&= R\left(\frac{p_i}{P}\right)^{1-\sigma}\left(\frac{e}{\tau\sigma}\right) - \phi_i F + (\phi_i - 1) L \\
&= \frac{eR}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma} - \phi_i F + (\phi_i - 1) L
\end{aligned}$$

$$\pi_i^* = \frac{eR}{\tau\sigma}\left(\frac{\phi_i\tau(ec+d)}{\beta_i eP}\frac{\sigma}{\sigma-1}\right)^{1-\sigma} - \phi_i F + (\phi_i - 1)\, L$$

The sensitivity of profits to exchange rate changes can be computed as

$$\begin{aligned}
\delta_i = \frac{d\pi_i}{de} &= \frac{R}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma} + \frac{eR(1-\sigma)}{\tau\sigma}\frac{p_i^{-\sigma}}{P^{1-\sigma}}\left(-\frac{\phi_i\sigma\tau d}{e^2\beta_i(\sigma-1)}\right) \\
&= \frac{R}{\tau\sigma}\left(\frac{p_i}{P}\right)^{1-\sigma}\left(1-(1-\sigma)\frac{d}{ec+d}\right) \\
\delta_i &= \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left(\frac{\gamma+\sigma-\gamma\sigma}{\sigma}\right) > 0
\end{aligned}$$

Which can be rewritten first considering the export elasticity η_i as:

$$\delta_i = \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left(\frac{\gamma+\eta_i}{\sigma}\right) \tag{A.3}$$

Or alternatively as:

$$\delta_i = \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}\left(\frac{\gamma(1-\sigma)}{\sigma} - 1\right)$$

If we set $(\sigma-1)/\sigma = \rho$, then

$$\delta_i = \frac{R}{\tau}\left(\frac{p_i}{P}\right)^{1-\sigma}(\gamma\rho - 1)$$

A.4 Hedging

To see this, let us introduce hedging in the form of a share $h \in [0,1]$ representing the amount of cash flow that is hedged against macroeconomic shocks. Cash flow then can be written as $L = \bar{L}_i(1+(1-h_i)\alpha\varepsilon)$. By maximizing expected profits with respect to h we end up with the following first order condition:

$$E\left[\frac{\partial\pi_i}{\partial L}\cdot\frac{\partial L}{\partial h}\right] = E\left[\frac{\partial\pi_i}{\partial L}\right]E\left[\frac{\partial L}{\partial h}\right] + \mathrm{cov}\left(\frac{\partial\pi_i}{\partial L},\frac{\partial L}{\partial h}\right) = 0$$

$E\left[\frac{\partial L}{\partial h}\right] = E\left[-L_0\alpha\varepsilon\right] = 0$ because $E[\varepsilon] = 0$. Then, $E\left[\frac{\partial\pi_i}{\partial L}\cdot\frac{\partial L}{\partial h}\right] = \mathrm{cov}\left(\frac{\partial\pi_i}{\partial L},\frac{\partial L}{\partial h}\right)$, but since $E\left[\frac{\partial\pi_i}{\partial L}\right] = (\phi_i - 1)$ is constant and does not depend on ε, then $\mathrm{cov}\left(\frac{\partial\pi_i}{\partial L},\frac{\partial L}{\partial h}\right) = 0$ and therefore the first order condition is verified for every value of h, and the optimal hedging strategy is undetermined.

B Additional information on Data and Variables

Table B.1 gives the mean value per industry after the variables have been winsorizing. The dataset is made up of exporting firms only.

Table B.1: Average values by 2-digit sector: selected variables

Industry	# Firms	Profit	Employees	Liquidity	FINC	Capital	XINT
ALL	27288	2565.7	143.1	0.3	0.1	8521.1	0.2
Textiles 17-19	1414	1251.8	93.8	0.39	0.094	3814.6	0.26
Wood 20	307	1222.7	83.2	0.22	0.049	6425.1	0.19
Paper products 21-22	1217	2604.6	119.5	0.34	0.046	8786.9	0.11
Petroleum prod. 23	28	18140.0	455.2	0.21	0.032	56622.2	0.18
Chemicals 24	864	7518.0	241.0	0.33	0.048	21634.7	0.33
Rubber plastics 25	1024	2049.2	143.6	0.23	0.039	9403.5	0.19
Oth. non-metallic prod. 26	410	4112.9	193.8	0.19	0.031	16984.0	0.21
Metallic prod. 27	320	4141.6	244.4	0.19	0.036	19571.6	0.30
Fabricated metal prod. 28	2406	1013.8	91.9	0.24	0.040	4494.8	0.16
Machinery & equip. 29	1421	2153.2	137.6	0.34	0.045	5587.4	0.28
Office & comput. mach. 30	40	6644.8	280.3	0.54	0.057	12825.7	0.42
Electrical machinery 31	437	406.4	215.3	0.32	0.043	9796.4	0.26
Radio, TV & comm. 32	280	3919.2	208.3	0.35	0.045	11156.4	0.26
Medical & optical inst. 33	548	2184.5	126.3	0.35	0.050	3169.3	0.31
Motor vehicles 34	359	5231.3	297.9	0.27	0.040	19498.2	0.24
Oth. transp. 35	184	5285.4	303.6	0.35	0.050	15294.5	0.33
Manuf. nec; recycling 36-37	802	1388.9	105.3	0.29	0.065	4166.9	0.20

C Additional Results

Table C.1: Test of H1 – Alternative measures of size

	TFP		LP	
size as:	Capital	Hours	Capital	Hours
	(1)	(2)	(3)	(4)
EER	1.260***	1.079***	0.472***	0.793***
	[0.251]	[0.210]	[0.151]	[0.147]
PROD.	2.801***	2.411***	0.828***	1.056***
	[0.072]	[0.084]	[0.032]	[0.022]
SIZE	0.710***	0.803***	0.504***	1.017***
	[0.020]	[0.027]	[0.023]	[0.026]
LIQ	2.083***	1.986***	2.313***	2.140***
	[0.090]	[0.083]	[0.094]	[0.086]
FINC	-1.161***	-1.554***	-1.725***	-1.885***
	[0.184]	[0.211]	[0.204]	[0.203]
Obs.	130,997	130,997	130,997	130,997
R-squ.	0.398	0.383	0.339	0.382
Firms	23,144	23,144	23,144	23,144

** $p < 0.01$, * $p < 0.05$; clustered standard errors in brackets

Table C.2: Test of H2 – Alternative measures of size

	TFP			Avg Labor Prod		
size measured as:	Sales	Capital	Hours	Sales	Capital	Hours
	(1)	(2)	(3)	(4)	(5)	(6)
EER	1.191***	1.339***	1.171***	1.033***	1.032***	1.023***
	[0.373]	[0.407]	[0.376]	[0.231]	[0.281]	[0.225]
PROD	0.767***	2.236***	1.783***	-0.023	0.667***	0.953***
	[0.065]	[0.084]	[0.085]	[0.030]	[0.032]	[0.028]
SIZE	0.824***	0.708***	0.810***	1.006***	0.504***	1.010***
	[0.021]	[0.020]	[0.028]	[0.027]	[0.023]	[0.026]
LIQ	1.974***	2.083***	1.980***	2.141***	2.317***	2.143***
	[0.085]	[0.090]	[0.081]	[0.086]	[0.093]	[0.085]
FINC	-1.658***	-1.139***	-1.524***	-1.849***	-1.700***	-1.869***
	[0.185]	[0.181]	[0.207]	[0.202]	[0.205]	[0.203]
PROD Q^2 x EER	0.625**	0.618**	0.550**	-0.01	-0.282**	-0.025
	[0.275]	[0.292]	[0.272]	[0.114]	[0.122]	[0.110]
PROD Q^3 x EER	0.476	0.316	0.35	-0.066	-0.470**	-0.08
	[0.370]	[0.423]	[0.386]	[0.162]	[0.202]	[0.160]
PROD Q^4 x EER	-0.331	-0.599	-0.566	-0.611***	-1.082***	-0.604***
	[0.374]	[0.404]	[0.392]	[0.218]	[0.280]	[0.218]
Obs.	130997	130997	130997	130997	130997	130997
Firms	23144	23144	23144	23144	23144	23144
R^2	0.384	0.404	0.39	0.377	0.342	0.383

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; clustered standard errors in brackets
Constant term a_0 and dummies d_k not shown.

Table C.3: Test of H3 – Size measured by firm sales

	TFP			**Avg Labor Prod**		
α **computed:**	**by time**	**by isic4**		**by time**	**by isic4**	
	(1)	(2)	(3)	(4)	(5)	(6)
	$\alpha_t < 0$	$\alpha_i < 0$	$\alpha_i > 0$	$\alpha_t < 0$	$\alpha_i < 0$	$\alpha_i > 0$
EER	1.365***	0.898***	1.800***	0.856***	0.489***	1.197***
	[0.229]	[0.245]	[0.269]	[0.163]	[0.154]	[0.214]
PROD	1.229***	1.204***	1.259***	0.065**	0.052	0.076**
	[0.068]	[0.117]	[0.088]	[0.028]	[0.046]	[0.035]
SIZE	0.834***	0.843***	0.826***	1.014***	1.030***	1.003***
	[0.020]	[0.031]	[0.025]	[0.026]	[0.043]	[0.031]
LIQ	1.978***	1.864***	2.035***	2.139***	2.013***	2.207***
	[0.086]	[0.104]	[0.117]	[0.088]	[0.101]	[0.119]
FINC	-1.795***	-1.546***	-1.951***	-1.886***	-1.615***	-2.059***
	[0.215]	[0.228]	[0.305]	[0.226]	[0.232]	[0.326]
FINC Q^2 x EER	0.032	-0.295**	0.279	0.091	-0.214	0.317**
	[0.119]	[0.132]	[0.167]	[0.118]	[0.130]	[0.154]
FINC Q^3 x EER	-0.094	-0.257	-0.097	-0.011	-0.139	-0.020
	[0.152]	[0.185]	[0.225]	[0.135]	[0.154]	[0.214]
FINC Q^4 x EER	-0.501**	-0.237	-0.789***	-0.343*	-0.075	-0.622**
	[0.235]	[0.244]	[0.281]	[0.205]	[0.201]	[0.255]
Obs.	130997	41301	89696	130997	41301	89696
Firms	23144	7751	15393	23144	7751	15393
R^2	0.400	0.431	0.387	0.383	0.415	0.37

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.
Clustered standard errors in brackets.
Constant term a_0 and dummies d_k not shown.

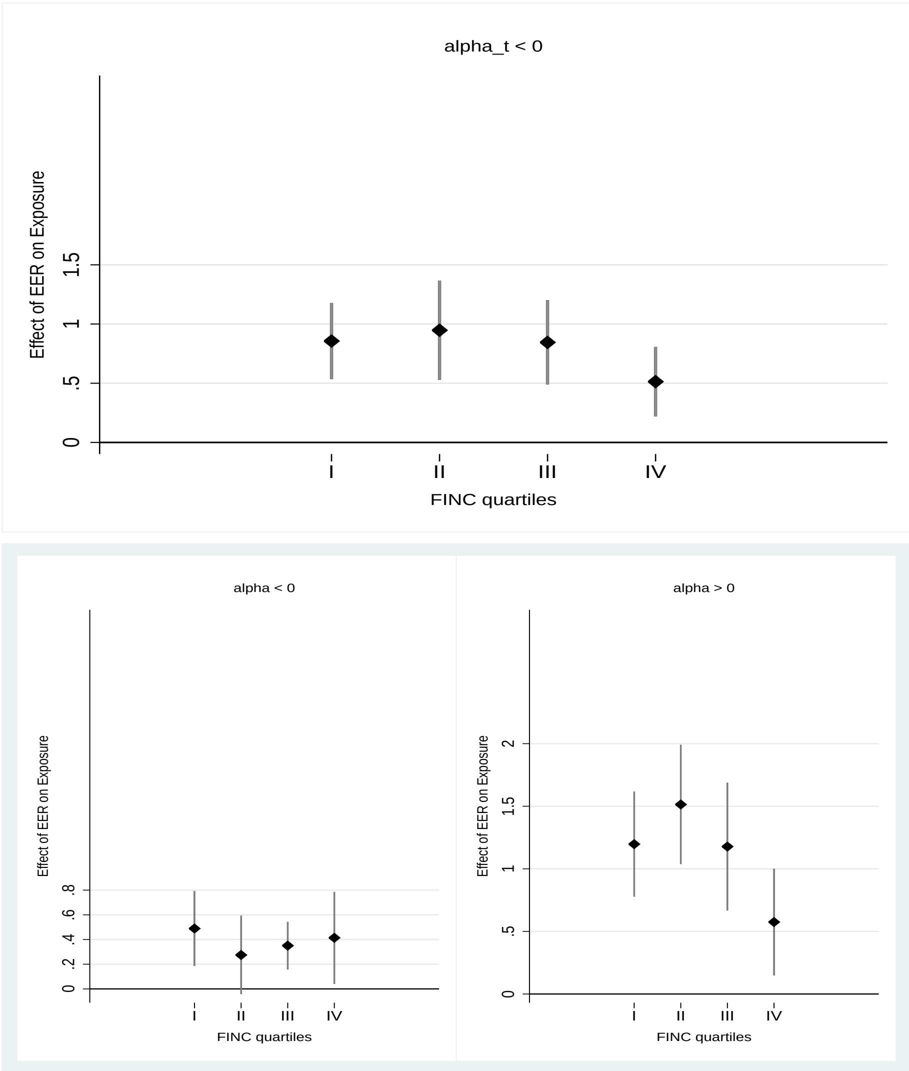

Figure C.1: Exchange rate effect on profits across quartiles of the distribution of financial costs, using average labor productivity. The correlation between firm liquidity and the exchange rate (α) is computed by year (top panel), and by 4-digit ISIC sector (bottom panel).