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How Multi-Destination Firms Shape the Effect of Exchange Rate Volatility on Trade: Micro Evidence and Aggregate Implications

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How Multi-Destination Firms Shape the Effect of Exchange Rate Volatility on Trade: Micro Evidence and Aggregate Implications[1]

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Abstract: Based on a large French firm-level database that combines information on balance-sheet and destination-specific export values and volumes over the period 1995-2009, this article investigates how heterogeneous exporters react to real exchange-rate volatility. We find that strongly multi-destination firms tend to reduce both their export values and volumes to a destination that face higher exchange-rate volatility, while firms serving only a few destinations increase their market share. This result is robust to various specifications, samples, potential omitted variables, as well as hedging strategies, and is not specific to multinational firms. We also show that, following an exchange-rate volatility shock in a given country, export values and volumes to all other destinations served increase with the number of destinations served by the firm. These results are consistent with models under uncertainty, where the risk increases with firm size, and risk-averse behavior is equivalent to a preference for diversification. Therefore, this paper proposes an additional potential explanation for the macro puzzle of the muted reaction of aggregate exports to exchange-rate volatility. Since big multi-destination firms, which account for the bulk of aggregate exports, minimize their overall risk exposure by diverting their exports from high- to low-volatility markets, this contributes to exports at the macro level remaining unchanged in the main.

Keywords: Real Exchange Rate Volatility, Multi-destination Exporters, Diversification, Aggregation.

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De quelle façon les entreprises multi-destinations façonnent-elles l'impact de la volatilité du taux de change sur le commerce : résultats microéconomiques et implications agrégées

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Abstract : A l'aide d'une grande base de données d'entreprises françaises, contenant des informations très détaillées à la fois au plan comptable et sur les exportations par produit et par destination sur la période 1995-2009, cet article analyse la façon dont la volatilité du taux de change réel affecte différemment des exportateurs hétérogènes. Nous montrons que les entreprises multi-destinations réduisent davantage leurs exportations suite à un accroissement de la volatilité du taux de change d'une destination donnée, tandis que les entreprises servant un nombre limité de marchés accroissent à l'inverse leur part de marché. Ce résultat perdure quels que soient les spécifications estimées, les échantillons retenus, les variables de contrôle rajoutées, ou avec la prise en compte des stratégies de couverture ; il n'est en outre pas propre aux firmes multinationales. Nos résultats soulignent également que suite à un choc de volatilité dans un pays donné, les valeurs et volumes exportés vers toutes les autres destinations servies s'accroissent avec le nombre de destinations servies par l'entreprise. Ces résultats sont cohérents avec plusieurs modèles en incertitude dans lesquels le risque croît avec la taille de l'entreprise, et l'aversion au risque équivaut à une préférence pour la diversification. Aussi, cet article propose une nouvelle explication à l'énigme de la faible réaction des exportations agrégées à la volatilité du taux de change. Dans la mesure où les grandes entreprises servant beaucoup de marchés, qui réalisent la majeure partie des exportations agrégées, minimisent leur exposition globale au risque en réallouant leurs exportations vers les marchés à plus faible volatilité, les exportations au niveau macroéconomique demeurent, pour l'essentiel, inchangées.

Mots-clefs : Volatilité du taux de change réel, entreprises multi-destinations, diversification, agrégation.

1 Introduction

The increasing volatility of real exchange rates after the fall of the Bretton-Woods agreements has been a source of concern both in policy and business circles. Governments tried a variety of strategies to handle the problem, from multilateral arrangements (Louvre and Plaza's Agreements in the 1980s, European Monetary System...) to fixed pegs, the Euro Area appearing as an extreme case of the latter. Exchange-rate volatility remains a serious issue nowadays, as indicated by business surveys: according to the 20^{th} Annual Global CEO Survey by PWC,[1] 70% of CEOs are concerned to some extent by exchange-rate volatility. This is consistent with the idea that exchange-rate risk increases trade costs and reduces the gains from international trade (Ethier, 1973), and also with recent evidence at the firm-level (see Cheung and Sengupta, 2013 on India; Héricourt and Poncet, 2015 on China, and Tunc and Solakoglu, 2016 on the US). Surprisingly, however, macroeconomic evidence on the effect of exchange-rate volatility on trade has been quite mixed, pointing to either a small or an insignificant effect on aggregate outcomes (see among others Tenreyro, 2007, Greenaway and Kneller, 2007 and Byrne et al., 2008). Among other things, the present paper aims to bridge the gap between the two types of evidence. Why does the documented microeconomic trade-deterring effect of exchange-rate volatility fail to translate into elastic aggregate trade outcomes?

Following the paper by Berman et al. (2012), a flourishing literature (see, e.g., among others, Chatterjee et al., 2013 and Amiti et al., 2014) has extensively documented the heterogeneous pricing-to-market behavior of firms facing exchange-rate variations: high-productivity firms absorb the latter in their price, limiting the impact on their exported quantity. Since these firms account for the bulk of aggregate exports, this mechanism provides an explanation for the weak impact of exchange-rate movements on aggregate exports. All these papers assume implicitly a context of certainty and absence of risk regarding exchange-rate movements. Put simply, all happens as if the direction and size of the exchange-rate variations had been set once and for all, and were therefore integrated without cost in firms' profit maximization strategy.

However, the issues raised by exchange-rate volatility are different: it implies multiple and unpredictable movements of the exchange rate, which creates a risky[2] environment for firms.

[1] http://www.pwc.com/gx/en/ceo-agenda/ceosurvey/2017/fr

[2] Following the practice by Bloom (2014) and De Sousa et al. (2017), we will use the terms "risk" and "uncertainty" interchangeably.

In such an uncertain context, risk-averse firms are likely to adapt other strategies for managing their export flows and destination choices. However, there is little evidence on how firms respond heterogeneously to uncertainty shocks, and what could be the aggregate implications. This is what we study in the present paper, by investigating the firm-level impact of Real Exchange Rate (RER) volatility[3] shocks on firms' bilateral exports. More specifically, we study the heterogeneous responses of firms' export values and volumes to RER volatility, i.e. how the impact of the latter changes with the performance of the firm, embodied by the number of destinations served. We also investigate how these firm-level results can provide a new, additional explanation for the muted reaction of aggregate exports to RER volatility.

To do the above, we use a French yearly firm-level dataset containing country- and product-specific trade data from the French Customs, along with balance-sheet information over the period 1995-2009. In a standard firm-level gravity-style model, we find, first, that the negative impact of RER volatility on export value is magnified for strongly multi-destination firms; besides, the major part of this amplified impact comes from the decrease in export volumes. More precisely, following a 10% increase in RER volatility, the net impact on the firms at the top 10% of the distribution in terms of number of destinations served, relative to the bottom 10%, is -3.7% for export values, and -2.1% for export volumes. Similar computation for the differential effect between the top and bottom 1% gives a decrease by 6.2% for values, and 3.6% for volumes. These effects are robust to various specifications and robustness checks. In particular, the trade-deterring impact is robust to the inclusion of variables related to the potential hedging behavior of firms, either natural (through imports) or financial (through proxies for access to financial markets). The effect is also robust to the inclusion of potential omitted variables, such as the quality of political governance, capturing country-specific risks, or the first moment of the exchange rate. Besides, we also find that RER volatility has an amplified negative impact on the extensive margin (entry and participation) of exports for strongly multi-destination firms, but the size of the effect is much more modest: -0.4% is the differential impact on entry between firms at the top and firms at the bottom 10% of the number of destinations served, -0.6% for the differential impact between top and bottom 1%. Secondly, we also find that, for

[3] Although the volatility of the real exchange rate differs conceptually from that of the nominal exchange rate, as shown by Clark et al. (2004), they do not differ much in reality. Beyond the fact that the literature shows a strong preference for volatility indicators based on real exchange rates, our study includes Euro zone members with a fixed nominal exchange rate after 1999. Therefore, the choice for RER volatility was straightforward.

an RER volatility shock on a given destination, both firm-level exported values and volumes to other destinations served tended to increase, the effects growing once again with the number of destinations served. Nevertheless, for a 10% increase in RER volatility in a given destination, we find that exports to all other destinations increase for the top 10% relative to the bottom 10% by 0.8% for values, and 1.1% for volumes; similar computations for the top 1%-bottom 1% difference gives a rise of 1.4% for values, and almost 2% for volumes. Therefore, it appears that multi-destination firms are able to reallocate exports across destinations so as to minimize the overall impact of exchange-rate volatility on their total exports.

These two results - of a magnified reaction of multi-destination firms and increased exports to other destinations after a bilateral RER volatility shock - are consistent with recent models studying the export behavior of heterogeneous firms in an uncertain environment. Esposito (2016) proposes a general equilibrium framework where risk aversion is a factor affecting all firms, including the large ones, due to financial motives; consequently, risk aversion increases in proportion to the costs of default risk. Taking into account the correlation of demand shocks between countries, firms export more to countries where they can better hedge their demand risk. In a partial equilibrium framework, De Sousa et al. (2017) assume both risk-averse decision-makers and variance in a firm's profits proportional to the square of its output. Therefore, high-performing firms, which produce more, are more prompted to reduce their supply on a given market when aggregate uncertainty increases. In a context where risk-averse behavior is equivalent to a preference for diversification (due to the expected utility theory), multi-destination firms minimize their overall risk exposure by diverting their exports from high- to low-volatility markets. In another, different partial equilibrium framework where uncertainty comes from the provision of intermediate inputs, Gervais (2016) shows that risk-averse entrepreneurs will try to diversify the geographic origins of their inputs to reduce the variability of profits.

This heterogeneous response of multi-destination firms' exports to RER volatility also has potential important consequences for the reaction of aggregate trade. The reallocation of highly multi-destination firms' exports across markets helps keep their overall exports mainly unchanged - this is, indeed, what we find in the last step of our empirical exercise: estimations run on variables reaggregated at the firm level show that the exports of highly multi-destination firms are more insensitive to the average, firm-specific RER volatility. Since aggregate exports are driven by this small group of large firms serving many destinations,[4] total exports are mainly unaffected by bilateral RER volatility. This is confirmed in our sample by estimations performed at a very aggregated sectoral level, with a lack of significant reaction of exports to RER volatility. Therefore, the preference for diversification of risk-averse firms leads to a firm-level reallocation of exports between destinations, which provides a new explanation for the weak reaction of aggregate exports to exchange-rate movements. The latter, therefore, complements the explanation proposed by Berman et al. (2012) and other papers on the subject. In a certainty context, high-performing firms use their pricing-to-market power to buffer the impact on export volumes at the destination level; in an uncertainty context, they use their portfolio of destinations to reallocate from high- to low-volatility markets, in order to keep their overall level of exports mostly unaffected.

Note also that this mechanism provides an interesting alternative to the hedging strategies that large firms predominantly use to cope with RER risk. For instance, Lyonnet et al. (2016) confirm, using survey data on a sample of Euro-area firms, that large firms have better access to financial instruments, and explain this finding in a theoretical setting where hedging involves a fixed cost that large firms are more prone to pay. At the aggregate level, this may constitute a plausible explanation for the lack of response of trade to exchange-rate volatility, since these instruments are precisely designed to dampen the effect of exchange-rate volatility on trade. However, several pieces of evidence cast some doubt on the reality of this mechanism. Using bilateral trade data for 63 countries over the 1975-1990 period, Wei (1999) found substantial evidence against the idea that exchange-rate volatility is hedged: no effect of exchange-rate volatility on trade could be found for country pairs with small potential trade, whereas country pairs with large potential trade showed a negative effect of volatility. In the financial literature, Guay and Kothari (2003) found, on a sample of 234 large US firms, that the latter under-invest in hedging instruments; based on an even larger sample of 425 large US corporations, Guay and Kothari (2003) concluded that such instruments often failed to reduce risks. Besides, our own results document that firm-destination exports flows are on the contrary very sensitive to

[4] In our sample, firms in the top 1% in terms of value exported represent 63% of aggregate exports, and firms in the top 10% represent 91% of aggregate exports; shares are averages over the 1995-2009 period. Those figures are very similar to those found by earlier studies on French firm-level exports; see, in particular Mayer and Ottaviano (2007).

changes in RER volatility for large firms, and we provide evidence that this result is driven by efficient diversification through reallocation of exports across destinations.

The paper is structured as follows. In the next section, we survey different theoretical mechanisms generating magnified reaction by multi-destination firms and reallocation of exports after a bilateral RER volatility shock. Section 3 presents the dataset and our empirical strategy. Section 4 reports the first set of results of the paper, detailing the amplifying reaction of multi-destination firms to bilateral RER volatility. In Section 5, we provide evidence of reallocation of exports from high to low RER volatility markets. We then assess the aggregate implications of our results in Section 6, and provide concluding remarks in Section 7.

2 Exporting Behavior, Exchange Rate Volatility and Risk: Theoretical Underpinnings

This paper builds on two recent strands of the literature on heterogeneous firms and trade. The first one deals with the way heterogeneity in firms' performance alters the impact of exchange rate on their exports, while the second, even more recent, analyzes how exports are impacted by the introduction of risk and uncertainty.

2.1 Heterogeneous Firms' Exports and Exchange Rate Changes

While the low exchange rate impact on both prices and quantities traded internationally has been a long-time concern of the literature (see, e.g., Goldberg and Campa, 2010, on prices, and Hooper et al., 2005, on quantities), these outcomes were not explicitly related to firm-level characteristics until a few years ago. Based on the same French firm-level data we use in our own analysis (but on a slightly shorter period), Berman et al. (2012) showed that more productive firms reacted to an exchange-rate shock by adjusting their prices rather than their exported quantities. Since these high-productive firms account for the bulk of aggregate exports, their magnified pricing-to-market behavior may help to explain the lack of reaction to exchange rate movements of aggregate exports.

This finding concerning heterogeneous pricing-to-market behavior has generated since then several replications and extensions, based on firm-level data for other countries. Li et al. (2015) follow closely the methodology of Berman et al. (2012), and find similar results on a database of Chinese exporters. Berthou et al. (2016) extend Berman et al. (2012) in a multi-country setting based on data for 11 European countries, and reach roughly identical conclusions. Based on Brazilian data, Chatterjee et al. (2013) extend the approach to a multi-product setup, and predict that facing an exchange rate depreciation, firms increase their product range and raise prices in producer currency. The pricing-to-market behavior is magnified for products closer to the core, and increases with firm performance.Amiti et al. (2014) add the import intensity and destination-specific market shares as other sources of heterogeneity, and find consistent result on Belgian data: large (i.e., with high market shares) import-intensive exporters have lower pass-through than small, non-importing firms.[5] Since the largest exporters appear to be mostly also the largest importers, these results provide an additional explanation to the low impact of exchange rate on aggregate exports.

In a few words, recent literature finds strong evidence supporting heterogeneous pricing-to-market of firms facing an exchange-rate movement: big/high performing firms absorb the latter in their price, limiting the impact on their exported quantity, and therefore on aggregate exports. However, all these papers stand implicitly in a certainty, riskless context regarding the exchange rate variation. All happens as if the direction and size of the exchange-rate variations were set once and for all, and were therefore integrated without cost in firms' profit maximization strategy. Empirically, this translates into the use of the first moment of exchange-rate variations in econometric regressions.

2.2 Heterogeneous Firms' Exports and Risk

However, a recent, but flourishing literature emphasizes the importance of second-order moments in international trade.[6] At the aggregate level, di Giovanni and Levchenko (2012) show that, when sectors differ in volatility, export patterns are conditioned not only by comparative advantage but also insurance motives. At the firm level, a few recent papers provide theoretical settings to explain the negative impact of demand volatility on firms' exporting decision: De Sousa et al. (2017) and Esposito (2016) in a heterogeneous firms environment, Gervais (2016) in a homogeneous firms framework. They rely on a couple of fundamental assumptions, namely

[5] We also study the specificity of importing firms in our context; although importing provides some natural hedging, it does not alter significantly our key results. See Section 4.2 below, more specifically Table 8.

[6] This is part of a more general trend in research, focusing on the role of uncertainty n a wide variety of economic outcomes, such as investment, production and pricing decisions (see Bloom, 2014)

risk-averse entrepreneurs facing uncertainty coming from the volatility of demand (De Sousa et al., 2017; Esposito, 2016) or the provision of intermediate inputs (Gervais, 2016), and all predict a contraction of trade flows when uncertainty increases. However, they also differ on a number of important features, as they tend to shed light on different implications of the inclusion of risk in firm-based international trade theory. Since we are especially interested in the different reactions of firms according to their performance level, we will focus mostly on De Sousa et al. (2017) and Esposito (2016).

Behavior of high-performance firms: The elasticity of a firm's trade flows (i.e. of the value of exports in home currency) to an uncertainty shock is equal to the sum of the elasticity of the firm's export volume and the elasticity of the firm's export price - Berman et al. (2012) provide an extensive analysis of these elasticities when firms face an exchange-rate variation.

In an uncertainty context, the above-mentioned papers propose several mechanisms to explain an amplified negative response of export volumes by high-productivity firms facing a volatility shock. De Sousa et al. (2017) provide a partial equilibrium model in which decision-makers are averse to both risk and downside losses, and make entry/exit and production/pricing decisions before industry-level uncertainty (identical for all firms) in market expenditures is revealed. They focus on a differential impact of uncertainty according to firm performance. Following the production theory under uncertainty, they assume that the variance in firm profits is proportional to the square of its output. Put differently, as high-productivity firms produce large quantities, the profits of those firms are more sensitive to a rise in expenditure fluctuations. Hence, more productive firms are more prompted to reduce their supply on a given market when aggregate uncertainty increases.[7] Such an effect is also implicitly present in Esposito (2016)'s general equilibrium framework, where risk aversion is a factor affecting the behavior of large firms as well, with underlying rationales rooted in financial theory. Risk aversion increases in proportion to the costs of default risk, which rise with the variability of the net cash flows of the firm (see Froot et al., 1993 and Rountree et al., 2008). Besides, stock-based compensation exposes managers to firm-specific risk (e.g., Parrino et al., 2005 or Panousi and Papanikolaou,

[7] One could argue that large firms have better access to financial markets and hedging instruments, which could dampen the impact of volatility on their profit and therefore on their supply. However, as highlighted by Esposito (2016), even large firms under-invest in financial instruments (see Guay and Kothari, 2003) and, when they do, such instruments often do not successfully reduce risks (see Hentschel and Kothari, 2001).

2012). These mechanisms are also compatible with high-performing firms reducing more their supply on a given destination when facing increased volatility.

As for export prices, predictions are less clear-cut. Esposito (2016) does not deliver explicit predictions on export prices, but his model does imply a contraction of trade *values* at the firm level when uncertainty increases. In De Sousa et al. (2017), export volume is the key variable. In their setting, under uncertainty, the markup increases with the variance of the expenditure. Consequently, an uncertain demand curve increases export prices through a higher markup; however, the effect only weakly shows up in the data. Besides, De Sousa et al. (2017)'s setting is an extension of Melitz (2003): consequently, the various indicators of performance, especially productivity, size and the number of destinations served, tend to confound perfectly. Other settings, such as Gervais (2016) or Esposito (2016), show that the number of destinations actually have an analytical specificity compared to productivity or size, since geographic diversification may help to reduce the variability of profits. Put differently, multi-destination firms may well adjust their export prices following a volatility shock differently from "strictly speaking " high-productivity firms. This is discussed in further details in section D of the online appendix.

In any case, these theoretical approaches clearly predict that both export values and volumes decrease disproportionately for high performance firms following a volatility shock, and that part of the impact on the former should be driven by the impact on the latter. This has important consequences for the redistribution of market shares following an uncertainty shock.

Reallocation of market shares: Two important implications arise in terms of reallocation of market shares, both within destinations between firms, and within firms between destinations. First, a direct implication of De Sousa et al. (2017)'s approach is that, for a considered destination, the fall in export sales due to uncertainty is greater for high-productivity than for low-productivity firms. For a given destination, market shares are therefore partly reallocated from the high- to low- performing firms, and the export sales of the latter will grow following an uncertainty shock.[8]

[8] These theoretical insights are confirmed by descriptive evidence on a large sample of French firms that is very similar to ours: it appears that the 25% most productive firms export, on average, 3.9 times more than the 25% least productive firms in less volatile markets, while this difference shrinks to 2.3 in the most volatile markets. It is also confirmed that the less productive firms export more when there is more volatility. Note that this positive impact of volatility on small firms' exports could also be rationalized through the mechanism put forward in De Grauwe (1988): an increase in exchange rate risk raises the expected marginal utility of export revenue, and therefore increases export activity.

Second, De Sousa et al. (2017)'s setting also relies on expected utility theory, implying that risk-averse behavior is equivalent to a preference for diversification (Eeckhoudt et al., 2005). A consequence is that multi-destination firms minimize their overall risk exposure by diverting their exports from high- to low- volatility markets. Esposito (2016) reaches an identical conclusion, by focusing on the correlation of demand shocks between countries. A key feature of Esposito (2016)'s model is how much demand in a given destination is correlated with demand in all other countries. Exports to a given destination will increase with its Sharpe ratio, a measure that summarizes the diversification benefits that a country provides to firms. An inverse measure of country risk, the Sharpe ratio decreases in both the volatility of the shocks and in the correlation of demand with other countries. As a consequence, firms export more to countries where they can better hedge their demand risk.[9] In a partial equilibrium framework where uncertainty comes from the provision of intermediate inputs, Gervais (2016) shows that risk-averse entrepreneurs will try to diversify the geographic origins of their inputs to reduce the variability of profits. In all these papers, entrepreneurs behave in very similar way to financial portfolio managers, who try to reduce the variance of their portfolio's return by increasing the number of assets with imperfectly correlated returns, in the spirit of Markowitz (1952, 1991)'s portfolio theory.

2.3 Wrap-up: Exchange-Rate Volatility and Export Behavior

We now characterize the main testable relationships arising from the combination of the main insights from these models for export values and volumes:

Testable Relationship 1: The elasticity of export values and volumes to bilateral uncertainty becomes increasingly negative according to the performance of the firm.

The elasticity of export values to uncertainty is the sum of the elasticity of exported quantities and export prices. If both volumes and values are expected to respond negatively to uncertainty, in an amplified manner for high-performance firms, a simple and direct corollary is that the elasticity of the exporter price in home currency to bilateral uncertainty has a positive, upper bound, equal to the absolute value of the export quantity elasticity. Under that condition, the

[9] In addition, Esposito's approach implies a partial disconnection between productivity and export status: a small firm may enter a given market because it provides a good hedge from risk, while a larger firm does not enter the same market since it prefers to diversify risks by selling to other markets, where the small firm is not able to export. This provides another theoretical, though more indirect, justification for the increase in low-performance firms' market shares following a volatility shock.

elasticity of export values is lower or equal to zero with a negative elasticity of export volumes, consistently with the theoretical frameworks presented above.

Testable Relationship 2: For a given destination, market shares are partly reallocated from the high- to low- performing firms following an uncertainty shock, pushing up the export volumes and values of the latter.

Testable Relationship 3: High-performance firms minimize their overall risk exposure by diverting their exports from high- to low- volatility markets: the elasticity of export values and volumes towards all other destinations served by the firm to uncertainty in a given destination is increasingly positive in the performance of the firm.

As for Relationship 1, we do not need to assume a specific direction for the reaction of prices: all that is required is that values and volumes both go the same way, with the latter driving (at least partly) the former. Note that for Relationship 3, the notion of export prices is not entirely relevant: since we are considering how firm exports to all other destinations react, this would require the computation of some sort of average price over all these destinations, which would be difficult to interpret.

We propose an empirical test of these theory-grounded relationships, in a context where exchange-rate volatility is the source of uncertainty. First, if the literature has extensively studied the impact of the first moment of the exchange rate on firm-level exports in a certainty context, this is not the case for the exchange-rate second-order moment, i.e. volatility, in an uncertainty context. Recent papers (noted above) emphasize that uncertainty implies additional, specific costs that may be handled differently by firms according to their performance level.[10] Second, exchange-rate volatility has some actual merits for empirical implementation and identification: it is a country-wide source of uncertainty, which ensures that endogeneity with firm-level trade is not an issue. Conversely, the shock studied in Esposito (2016) is variety-country specific, or industry-year/industry-country in De Sousa et al. (2017), which may raise more problems on that ground. It may be argued, however, that, compared to smaller firms, big firms are

[10] Cheung and Sengupta (2013), Héricourt and Poncet (2015) and Tunc and Solakoglu (2016) provide firm-level evidence that real exchange-rate volatility deters export values; however, they do not investigate precisely how firms could react differently according to their performance level, nor study the differential impact on values and volumes or the aggregate implications.

particularly able to handle exchange-rate risks. The difference between large and small firms in access to financial instruments to hedge against exchange-rate risk is widely confirmed by survey data (e.g. Ito et al., 2015; Lyonnet et al., 2016). Note that, as already mentioned, the efficiency of these hedging instruments is likely to be very limited in practice (see among others Hentschel and Kothari, 2001); in any case, we will provide evidence that proxies for hedging do not alter the effects predicted by the theoretical literature on heterogeneous firms' trade and risk.

Another key variable to choose is the measure of firm performance. The firm-level number of destinations served appears as the analytically consistent choice in a theoretical environment where risk aversion leads to a preference for diversification of countries served, leading to diversion of exports from high- to low- volatility markets. This is also consistent with the idea that high-performing firms behave as portfolio managers, using the imperfect correlation of exchange-rate volatility across markets to minimize their risk exposure, for a given level of profit.

It is well known that these multi-destination firms are also the biggest and the most productive, thus accounting therefore for the bulk of aggregate exports (Bernard et al., 2011; Eckel et al., 2011). In that spirit, the theoretical insights summarized above may also explain the small trade elasticity to RER volatility at the aggregate level. If firm-destination trade flows are increasingly elastic to RER because of optimal reallocation of exports across destinations, trade diversion across destinations leaves aggregate exports mainly unchanged - this will also be explicitly tested in our empirical exercise. This provides a new explanation for the weak reaction of aggregate exports to exchange rate movements in an uncertainty context, complementary to the one proposed by Berman et al. (2012) and others, relying on the markup behavior of big firms, in a certainty context.

3 Empirics: Data and methodology

3.1 Data

RER Volatility Indicators: The bilateral, real exchange-rate volatility towards destination j is computed as the yearly standard deviation of monthly log differences in the real exchange rate. Because we rely on an indirect quotation (that is, one unit of foreign currency equals e

units of euros), we compute the real exchange rate as follows: $\text{RER}_{j,m,t} = e_{j,m,t} \times \frac{p_{j,t}}{p_{\text{dom},t}}$, where $e_{j,m,t}$ is the nominal exchange rate of the domestic currency with respect to the destination j's currency at month m of year t, $p_{j,t}$ is the CPI of country j in year t and $p_{dom,t}$ is the French CPI in year t. Nominal exchange-rate data are monthly averages, and come from the IMF's IFS dataset.

Firm-level data: Our database covers the period 1995-2009. We use, first, firm-level trade data from the French customs. This database reports exports for each firm, by destination and year over our sample period. It reports the volume (in tons) and value (in euros) of exports for each CN8 product (European Union Combined Nomenclature at 8 digits) and destination, for each firm located on French metropolitan territory. Some shipments are excluded from this data collection. Inside the European Union, firms are required to report their shipments by product and destination country only if their annual trade value exceeds the threshold of 150,000 euros. For exports outside the EU, all flows are recorded, unless their value is smaller than 1,000 euros or one ton. Those thresholds eliminate only a very small proportion of total exports. We exclude from our sample intermediate goods using the Broad Economic Categories classification. The underlying intuition is that exports of intermediates should not react to RER volatility in their export destination, but to greater RER volatility in destinations' exports of the products that these imports are used to produce.

We also use firm-level data contained in the dataset called "BRN" ("Bénéfices Réels Normaux"), which provides balance-sheet data - i.e. value added, total sales, employment, capital stock and other variables. The period for which we have the data is again from 1995 to 2009. The BRN database is constructed from reports of French firms to the tax administration, which are transmitted to INSEE (the French Statistical Institute). The BRN dataset contains between 650,000 and 750,000 firms per year over the period (around 60% of the total number of French firms). Importantly, this dataset is composed of both small and large firms, since no threshold applies on the number of employees. A more detailed description of the database is provided by Eaton et al. (2004, 2011). Depending on the year, these firms represent between 90% and 95% of French exports contained in the customs data. As is standard in the literature, we restrict the observations to manufacturing firms, which excludes wholesalers. Balance-sheet and customs data can be merged using the firm identifier (SIREN number) and the year. The dataset, finally, contains between 17,000 and 35,000 exporting firms per year, and between 137 and 151 destinations served per year. Contrary to Berman et al. (2012), our sample also includes Eurozone destinations, for two main reasons. First, our focus on the standard deviation of the RER (and not on the first moment) leaves us with sufficient variability, even after fixing of nominal exchange rates in 1999. Second, since one of our main goals in this paper is to check the existence of between-countries reallocation behavior, the inclusion of Eurozone members, which are key markets for most French firms, seems essential for proper identification.

Other macroeconomic variables come from the Penn World Tables and the IMF's International Financial Statistics.

For the reasons mentioned above, we use the number of export destinations as our key indicator of firm performance. We also use as an alternative performance indicator the Total Factor Productivity in estimations provided in Section B.2 of the online appendix.

Summary statistics of key variables are given in Tables 1 and 2. They are consistent with previous evidence about French firms: exporting firms are highly heterogeneous in their performance and size, implying a large variance in our dataset. The average firm-country exported value is slightly above 560,000 thousand euros, while the average number of employees and value of assets are also quite small: the average exporter is a small firm, with modest values of exports. Performance indicators distributions, reported in Table 2, deliver a similar message: there is only a small number of high-performing firms, exporting to a significant number of destinations. Half of the French firms export to at most 2 destinations, which is consistent with previous studies on the subject (Eaton et al., 2011; Mayer and Ottaviano, 2007) and supports the representativeness of the sample.

Table 1: Summary Statistics of the Key Variables

Variable	Mean	Std. Dev.	Min	Max
Firm-level variables				
Firm Export value (millions of Euros)	14.61	134.65	0.00	11,163.93
Firm-country Export value (millions of Euros)	0.56	11.09	0.00	4,322.94
Start Dummy	0.16	0.37	0	1
Participation Dummy	0.25	0.44	0	1
Assets (Thousands of Euros)	191.47	5264.46	0.00	1,266,499
Employment (# Employees)	191.47	5264.46	0	298,487
Macro variables				
Bilateral RER Volatility	0.018	0.023	0.001	1.318
GDP (Billions of US dollars)	1,043.066	2,173.799	0.174	13,122.22
Price Index (Real Effective Exchange Rate)	0.693	0.451	0.000	3.33

Note: The summary statistics are computed on the 2,107,382 firm-country-year observations that make up our final regression sample, used in Table 3, to study the intensive margin. The only exceptions are the statistics for the start and participation dummies which are computed, respectively, on the 6,996,200 firm-country-year observations used in the left panel in Table 9, and on 9,392,868 firm-country-year observations used in the right panel in the same table. Source: authors' computations from BRN, French Customs and IFS data.

Table 2: Distribution of Performance Indicators

Sample	Firm-Dest-Year			Firm-Year		
Variable	Productivity	Assets	# Dest.	Productivity	Assets	# Dest
1%	11.35	0.15	1	9.64	0.089	1
10%	29.16	0.68	3	27	0.39	1
50%	55	5.86	12	50.25	2.67	2
90%	121.93	119.09	38	110.24	37.12	12
99%	385.29	1739.52	72	329	603.44	35

Note: Productivity (value added per employee) and assets are in thousands of euros. For the first two columns, the summary statistics are computed on the 2,107,382 firm-country-year observations that make up our final regression sample used in Table 3 to study the intensive margin. For the last two columns, the summary statistics are computed on the 454,805 firm-year dyads corresponding to our final regression sample. Source: authors' computations from BRN and French Customs.

3.2 Export Performance and Bilateral RER Volatility

Empirical strategy: The first main relationship we test is that both export values and volumes react negatively to RER volatility, the more so the higher the number of export destinations served. In general, we want to estimate a specification of the following form:

$$\ln \mathrm{X}_{ijt} = \alpha \ln \mathrm{Bil\_volat}_{jt} + \tau \left(\ln \mathrm{Bil\_volat}_{jt} \times \ln \mathrm{NbDest}_{it-1}\right) \tag{1}$$
$$+ \phi \mathbf{Z_{jt}} + \theta_j + \lambda_{it} + \epsilon_{ijt}$$

where X_{ijt} denotes either export values or volumes of firm i for export destination j in year t. This is a firm-level gravity equation like the one e.g. in Berman et al. (2012), adapted to fit the theoretical models presented above in two main ways. First, Bil_volat_{jt} is the standard bilateral RER volatility in destination j in year t, as defined in Section 3.1. Second, $NbDest_{it-1}$ denotes the number of destinations of firm i we lag one year. The conditioning set $\mathbf{Z_{jt}}$ includes standard destination-year gravity controls compatible with standard models of international trade, the destination country's market size (GDP) and price index (proxied by the real effective exchange rate).

Finally, all our estimations include firm-year fixed effects, λ_{it}, which capture time-varying firm characteristics that may affect export performance, such as, e.g., a productivity shock due to the implementation of a new production process. They allow us to examine variations in export allocations across destinations for a given year, i.e. to look at how volatility in one market, compared to total volatility in all markets, affects export behavior in that market (relative to total sales). Put differently, these firm-year fixed effects allow us to estimate the impact of RER volatility in a given destination relative to the multilateral RER volatility of all other destinations, in the spirit of Esposito (2016)'s framework. In this way, we investigate whether multi-destination firms favor countries with low volatility. Note that all unconditional firm-year variables, such as the number of destinations served, are by construction subsumed in the firm-year fixed effects. We complete this specification by adding a set of country dummies capturing the time-invariant heterogeneity that may affect export performance at the country level, e.g., distance from France or size of the importing country.

Our underlying theoretical frameworks leads us to expect a negative sign for τ, the coefficient on the interacted term, through Testable Relationship 1: the elasticity of both export volumes and values is increasingly negative with firm's number of destinations served. As for the α parameter, Testable Relationship 2 predicts it should be positive for low-performance firms:

following an RER volatility shock, a reallocation of market shares from the high- to low- performing firms occurs; in other words, export volumes and values should increase to a destination with increased volatility for firms serving only a few destinations.

We also estimate another specification including destination-year dummies γ_{jt} into equation 1:

$$\ln \mathrm{X}_{ijt} \quad = \quad \tau \left(\ln \mathrm{Bil\_volat}_{jt} \times \ln \mathrm{NbDest}_{it-1}\right) + \lambda_{it} + \gamma_{jt} + \epsilon_{ijt} \tag{2}$$

This specification notably makes sure that the τ parameter is not capturing any other factor that could be country-time varying and not fully controlled by the vector $\mathbf{Z_{jt}}$. Obviously, this wipes out all unconditional destination-year specific variables, including RER volatility and gravity controls $\mathbf{Z_{jt}}$. This will be our preferred specification for interpretation and additional tests of Testable Relationship 1, since it focuses on the allocation of exports between destinations. Nevertheless, for further robustness, we will also add estimations including firm-destination fixed effects, accounting for demand shocks or firm-destination-specific cost shocks, which will give us "true" within estimations. Including therefore a full set of country-year, firm-year and firm-country fixed effects, this very demanding specification will constitute an interesting test for the reliance of Testable Relationship 1.

Our third testable relationship is that firms divert their exports from high- to low-volatility markets, the more so the higher the number of destinations served. We estimate:

$$\begin{aligned} \ln \mathrm{X}_{i,-jt} \quad &= \quad \beta \ln \mathrm{Bil\_volat}_{jt} + \nu \left(\ln \mathrm{NbDest}_{it-1}\right) + \mu \left(\ln \mathrm{Bil\_volat}_{jt} \times \ln \mathrm{NbDest}_{it-1}\right) \\ &+ \quad \phi \mathbf{Z_{jt}} + \lambda_{ij} + \theta_t + \epsilon_{ijt} \end{aligned} \tag{3}$$

and, following the same line of reasoning as previously:

$$\ln \text{X}_{i,-jt} \quad = \quad \nu \left(\ln \text{NbDest}_{it-1}\right) + \mu \left(\ln \text{Bil\_volat}_{jt} \times \ln \text{NbDest}_{it-1}\right) + \lambda_{ij} + \gamma_{jt} + \epsilon_{ijt} \quad (4)$$

where $X_{i,-jt} = X_{it} - X_{ijt}$ is the sum of exports of firm i in year t to all destinations served but j. Note that this estimation requires some modifications of our baseline specification. The most important relates to the fixed-effects structure: the use of firm-year fixed effects is not in order anymore, since they would account for all variations in firm-level total exports and make identification impossible. Instead, we now include systematically firm-destination intercepts λ_{ij} in order to capture all time-invariant factors at the firm, country or firm-country level. A consequence is that unconditional firm-year controls can now be included, such as the number of destinations served. We expect the coefficient of the latter, ν, to be positive, consistently with international trade models based on heterogeneous firms predicting that the best performing firms export the most. More importantly, Testable Relationship 3 leads us to expect μ to be positive: following an RER volatility shock to a given destination, the elasticity of export values and volumes to all other destinations served by the firm is increasingly positive in the number of destinations served by the firm.

All regressions are performed with standard linear estimators. Finally, Moulton (1990) shows that regressions with more aggregate indicators on the right-hand side could induce a downward bias in the estimation of standard errors. Using the Froot (1989) correction, all estimations of equations are thus clustered at the destination-year level, which is the level of the most aggregated variables on the right-hand side. Note that this level of clustering still makes sense for equations 2 and 4, even though they include destination-year dummies; while the latter will control for part of the within-cluster correlation of the error, in general they will not completely control for within-cluster error correlation (see Cameron and Miller, 2015).[11]

[11] In any case, our results are also robust to other cluster structures, such as the country-only level, or the sectoral (HS2) level.

4 Firm-Level Results 1: Heterogeneous Reaction to RER Volatility

4.1 Baseline Results

Table 3 reports estimates of the impact of bilateral RER volatility on export values (in the upper panel) and export volumes (in the lower panel). Columns (1) and (2) present estimates of equation 1, first restricting τ to zero (col. (1)), then allowing the impact of volatility of export performance to vary along the number of destinations served (col. (2)). Columns (3) to (6) report results for different specifications of equation 2: column (3) corresponds to our preferred specification, and columns (4) and (6) checks how our results behave when another indicator of firm performance is included, namely the (ln of) firm's assets (with a one-year lag), as a proxy for size. Finally, columns (5) and (6) add firm-destination fixed effects. To begin with, note that, consistently with theoretical frameworks presented previously, values and quantities move in the same direction. Columns (2) to (6) also show that roughly two-thirds of the total effect on export values comes from the effect on export volumes.

Consistent with the literature on the micro-level effect of RER volatility on trade flows (Cheung and Sengupta, 2013; Héricourt and Poncet, 2015), column (1) confirms a negative average effect of bilateral RER volatility on export performance: a 10% increase in RER volatility generates lower export values and volumes, by around 0.3%. While qualitatively consistent with previous firm-level studies, this estimate seems quantitatively modest. In line with Testable Relationship 1, however, columns (2) to (6) support that this average effect hides strong heterogeneity across firms: the elasticity of export flows and quantities to RER volatility is increasingly negative with performance, as the interaction term between RER volatility and the number of destinations served (the τ parameter) is systematically negative and significant at the 1% level. This effect survives to the inclusion of the (ln of) assets (τ decreases by one-third, but remains negative and highly significant), and to various fixed-effect combinations. This is especially remarkable in columns (5) and (6) where firm-destination fixed effects are included, together with firm-year and country-year fixed effects. This very demanding specification does not leave much variance to explain. Yet, even if the size of the effect decreases, the interaction between the number of destinations served and RER volatility remains significant.[12]

[12] Tables D.1 to D.4 in the online appendix report estimates of the impact on RER volatility on export prices, as proxied by trade unit values. Equal to zero for the average firm, the elasticity is increasingly negative with the number of destinations served. We discuss possible interpretations in section D of the Online Appendix.

Table 3: Baseline Results

Dep. Variable	Ln Export Value					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln bil RER volatility	-0.025^{b}	0.357^{a}				
	(0.010)	(0.024)				
Ln country price index	0.016	0.005				
	(0.015)	(0.014)				
Ln GDP	0.571^{a}	0.582^{a}				
	(0.047)	(0.047)				
Ln bil RER volatility × Ln nb dest$_{t-1}$		-0.144^{a}	-0.145^{a}	-0.095^{a}	-0.028^{a}	-0.022^{a}
		(0.008)	(0.028)	(0.019)	(0.007)	(0.007)
Ln bil RER volatility × Ln assets$_{t-1}$				-0.062^{a}		-0.009^{a}
				(0.014)		(0.003)
R^2	0.540	0.542	0.543	0.545	0.885	0.885
Dep. Variable	Ln Export Volume					
Ln bil RER volatility	-0.031^{b}	0.223^{a}				
	(0.013)	(0.023)				
Ln country price index	0.023	-0.047^{a}				
	(0.025)	(0.016)				
Ln GDP	1.518^{a}	0.907^{a}				
	(0.087)	(0.068)				
Ln bil RER volatility × Ln nb dest$_{t-1}$		-0.084^{a}	-0.085^{a}	-0.018^{a}	-0.016^{a}	-0.010^{c}
		(0.008)	(0.008)	(0.006)	(0.005)	(0.005)
Ln bil RER volatility × Ln assets$_{t-1}$				-0.082^{a}		-0.009^{a}
				(0.006)		(0.003)
R^2	0.532	0.534	0.535	0.537	0.880	0.880
Observations	2107382	2107382	2107382	2107382	2107382	2107382
Firm-year dyads	454805	454805	454805	454805	454805	454805
Firm-year FE	X	X	X	X	X	X
Country-year FE			X	X	X	X
Firm-country FE					X	X
Country FE	X	X				

Note: Robust standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level.

Moreover, as expected from the theoretical discussion supporting Testable Relationship 2, the lower performing firms (i.e. the ones serving only a few destinations) actually increase their export performance following a hike in RER volatility. More precisely, the total impact of RER volatility (equal to $\alpha + \tau \times ln(NbDest)$) on export performance is positive for all firms serving at most 12 destinations. According to Table 2, this corresponds to half of firm-destination-years flows, or 90% of the firm-years pairs. This does mean that, for most firms in our sample, RER volatility actually boosts exports to the considered destination. Put differently, market shares are partly reallocated from the high- to low-performing firms following a RER volatility shock. Note however, that these low-performing firms represent only 9% of aggregate exports in our sample on average over the 1995-2009 period; the variations in aggregate exports coming from the top 10% (representing 91% of aggregate exports)[13] should, therefore, be quantitatively much more substantial.

We can illustrate these results more generally, by providing quantitative assessments of the differential impact of RER volatility on export performance for firms at the 10^{th} (bottom 10%) and 90^{th} (top 10%) percentiles of the distribution of the number of destinations served, still based on the summary statistics from Table 2. Based on coefficients from column (2) in Table 3, our results show that a 10% increase in bilateral volatility decreases export values by 1.7 % [$0.1\times 0.357 + 0.1 \times (-0.144) \times \ln(38)$] for firms above the 90^{th} percentile, but boosts export values for firms at the 10^{th} percentile by +2% [$0.1\times 0.357 + 0.1 \times (-0.144) \times \ln(3)$]. If we replicate the exercise for export volumes, we find the same 10% increase in RER volatility decreases quantities exported by 0.8 % for the top 10%, while pushing up those of the bottom 10% by 1.3%. This brings a net impact on the 90^{th} relative to 10^{th} percentile of -3.7% for values, and -2.1% for volumes. Similar computation for the differential effect between the 99^{th} and the 1^{st} percentile gives a decrease of 6.2% [$0.1 \times (-0.144) \times (\ln(72)-\ln(1))$] for values, and 3.6 % for volumes. These are economically significant figures.

Table 3 thus establishes that large firms decrease both export values and volumes when facing RER volatility in the destination country. This result is robust to the inclusion of an alternative performance measure and demanding combinations of fixed effects. However, many firms are exporting more than one product, and this may create biases in the estimations. Indeed, for

[13] Those figures are very similar to those found by earlier studies on French firm-level exports, see in particular Mayer and Ottaviano (2007).

those multi-product firms, variations in values and quantities may hide huge composition effects related to change in the product mix: for instance, the contraction in export volumes could actually hide a preservation of exported quantities of the best product, to the cost of other products that would bear most if not all the contraction following the volatility shock. This would be consistent with mechanisms uncovered, e.g., by Chatterjee et al. (2013), who find that, following an exchange-rate depreciation, firms increase their product range.

Therefore, we run our preferred estimation (based on equation 2) on several subsamples, neutralizing this composition issue, following the strategy implemented by Berman et al. (2012). Results are reported in Table 4. The left (columns (1) to (5)) and right (columns (6) to (10)) panels show results, respectively, for Export Values and Volumes. Both panels are strictly symmetric: columns (1) and (6) restrict the sample to firms exporting only one product (defined at the HS6 level) to a given destination; columns (2) and (7) focus on the top product exported by the firm worldwide in value; columns (3) and (8) also focus on the top product, but now defined as the one exported to the largest number of destinations; columns (4) and (9) only keep firms with a constant mix of products (i.e. the mix of products exported to a specific destination remains the same between *t* and *t-1*); finally, columns (5) and (10) again restrict the sample to single-product exporters, but defined at a more aggregate level (four-digit).[14]

[14]See Berman et al. (2012) for a detailed discussion on the merits and limitations of these various subsamples.

Table 4: Baseline Results: Product Composition

Dep. Variable	Ln Export Value					Ln Export Volume				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Single Prod.	Main prod. (value)	Main prod. (dest.)	Stable Mix	Single NC4	Single Prod.	Main prod. (value)	Main prod. (dest.)	Stable Mix	Single NC4
Ln bil RER volatility	-0.144^a	-0.091^a	-0.087^a	-0.103^a	-0.148^a	-0.083^a	-0.044^b	-0.050^b	-0.075^b	-0.087^a
$\times$ Ln nb dest$_{t-1}$	(0.025)	(0.022)	(0.027)	(0.039)	(0.026)	(0.023)	(0.020)	(0.023)	(0.038)	(0.024)
Observations	1176525	2096585	1547452	381215	1093837	1125429	2096585	1547452	381215	1052561
Firm-year dyads	174392	431757	431757	132204	155503	174392	431757	431757	132204	155503
R^2	0.513	0.521	0.592	0.666	0.510	0.650	0.669	0.737	0.758	0.635

Note: Robust standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All specifications include firm-year and country-year fixed effects.

The key conclusion arising from Table 4 is that our main result of a magnified, negative reaction to RER volatility by multi-destination firms holds on all the studied subsamples: the interaction term between RER volatility and the number of destinations served is negative and highly significant in all cases. Quantitatively speaking, elasticities for firms exporting one product per destination are identical to the ones presented in our baseline estimates (column (3) in Table 3). When focusing on the top product, elasticities tend to decrease by one third (values) to a half (volumes). This is consistent with the idea that firms tend to somewhat dampen the impact of RER volatility shock on their best product, by cutting or even stopping exports of other product lines - this intuition is confirmed by Table E.2. in the online appendix, showing that both the average export performance per product *and* the number of products exported are disproportionately reduced for multi-destination firms following a volatility shock. When the mix of products is constrained to be stable - i.e. when the adjustment through the number of exported products is shut down - the elasticity getes closer again to our baseline estimate.

4.2 Robustness Checks

We now proceed to different sets of robustness checks. We first check that our results are robust to the inclusion of potential omitted variables, that could directly bias the measured impact of RER volatility. Second, we test how experience on export markets can influence our results. Third, we summarize the results of various complementary robustness estimations reported in the online appendix.

Potential Omitted Variables: Table 5 checks the robustness of our results to the inclusion of the level of the real exchange rate. It could, indeed, be argued that our measure of RER volatility actually captures merely an (appreciation) trend. Including the level of RER controls explicitly for this trend. Because we rely on an indirect quotation, an increase in the level of the exchange rate, implying a depreciation, is expected to have a positive impact on export performance. Table 5 once again consists of two symmetric panels, the left one (columns (1) to (3)) for export values, the right one (columns (3) to (6)) for export volume. Columns (1) and (4) provide estimates of an augmented equation 1, including the (ln of) RER in level and constraining τ to be equal to zero; columns (2)/(5) and (3)/(6) report results for similarly modified equation

2, including both RER in level and its interaction with performance. Columns (3) and (6) also add firm-level fixed effects as an ultimate sensitivity test.

Table 5: Robustness: Level of Real Exchange Rate

Dep. Variable	Ln Export Value			Ln Export Volume		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln bil RER volatility	-0.007			0.003		
	(0.010)			(0.011)		
Ln country price index	-0.057^a			-0.075^a		
	(0.016)			(0.017)		
Ln GDP	0.482^a			0.862^a		
	(0.050)			(0.070)		
Ln RER level	0.218^a			0.125^a		
	(0.033)			(0.032)		
Ln bil RER volatility × Ln nb dest$_{t-1}$		-0.092^a	-0.019^a		-0.039^a	-0.009^a
		(0.007)	(0.004)		(0.007)	(0.003)
Ln RER level × Ln nb dest$_{t-1}$		0.062^a	0.019^a		0.060^a	0.016^a
		(0.003)	(0.002)		(0.003)	(0.002)
Observations	2107382	2107382	2107382	2107382	2107382	2107382
R^2	0.540	0.546	0.885	0.676	0.678	0.922
Firm-year FE	X	X	X	X	X	X
Country-year FE		X	X		X	X
Firm-country FE			X			X
Country FE	X			X		

Note: Robust clustered standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level.

On average, the impact of RER volatility on export performance is now insignificant, while, as expected, a depreciation of the RER leads to an increase in both export values and volumes. However, Testable Relationship 1 still holds in all cases: the reaction to RER volatility is disproportionately more negative for strongly multi-destination firms, while the latter tend also to react more to an RER depreciation. This is also true for the most demanding specifications in columns (3) and (6). Therefore, the inclusion of RER in level does not affect the main message: the trade-deterring effect of RER volatility remains present and is magnified by the number of destinations, even though elasticities are reduced by one-third (values) to a half (volumes).

Table 6 performs a similar exercise, by making sure that the impact of RER volatility on trade does not solely capture country-specific risks. Quality of institutions and governance is a strong determinant of trade at both the aggregate level and the firm level, insofar as trade is negatively associated with political and economic risks. We thus use the "Political Stability Estimate" variable from the Worldwide Governance Indicators dataset on institutional quality to control for country-specific risks in our specification (Kaufmann et al., 2010). This variable is an inverse measure of risks: an increase in the value of political stability is associated with a decrease in the risks associated with export activity in the country, and is therefore expected to positively affect firm-level bilateral export performance. Table 6 replicates the structure of Table 5, replacing RER level with the quality of governance.

Table 6: Robustness: Quality of Governance

Dep. Variable	Ln Export Value			Ln Export Volume		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln bil RER volatility	-0.011			0.004		
	(0.013)			(0.013)		
Ln country price index	0.007			-0.037[b]		
	(0.018)			(0.018)		
Ln GDP	0.489[a]			0.845[a]		
	(0.060)			(0.084)		
Ln QPG	0.036[b]			0.066[a]		
	(0.016)			(0.016)		
Ln bil RER volatility × Ln nb dest$_{t-1}$		-0.105[a]	-0.020[a]		-0.051[a]	-0.005[a]
		(0.012)	(0.005)		(0.011)	(0.002)
Ln QPG× Ln nb dest$_{t-1}$		0.090[a]	0.017[a]		0.076[a]	0.023[a]
		(0.010)	(0.007)		(0.010)	(0.005)
Observations	1577338	1577338	1577338	1577338	1577338	1577338
R^2	0.545	0.549	0.898	0.679	0.680	0.929
Firm-year FE	X	X	X	X	X	X
Country-year FE		X	X		X	X
Firm-country FE			X			X
Country FE	X			X		

Note: Robust clustered standard errors in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. QPG stands for Quality of Political Governance.

The quality of governance increases the average trade flows and volumes, and the effect is magnified for large and multi-destination firms. Both unconditional and conditional effects of quality of governance are thus consistent and perfectly in line with the impact of RER volatility. Crucially, these effects do not soak up each other: including quality of governance and conditioning this variable upon firm performance leaves our first testable relationship mainly unharmed. The elasticity of export values and volumes to RER volatility is still increasingly negative with firm performance, and the size of the effect remains close to our baseline specification.

Overall, these estimates support that the effect we are highlighting is truly related to exchange-rate volatility, rather than capturing an effect related either to a trend in the exchange rate, or to political uncertainty.

Experience: Albornoz et al. (2012) recently provided evidence that, in the short run, firms sequentially enter different markets to learn about their uncertain demand. This feature of exporters' behavior could interfere with the risk diversification behavior of exporters predicted by Esposito (2016) or De Sousa et al. (2017), and summarized in our testable relationships. Therefore, we implement a solution suggested by Esposito (2016), by running estimates on a sample restricted to exporters selling to a certain market for at least five years. By considering only these stable firm-destination pairs, the underlying intention is to capture only the diversification behavior, and not some short-run noise due to the firms' learning process. Table 7 reports the results of such estimates, replicating again the structure of Tables 5 and 6.

Table 7: Robustness: Experience

Dep. Variable	Ln Export Value			Ln Export Volume		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln bil RER volatility	-0.020			-0.011		
	(0.014)			(0.016)		
Ln country price index	0.033			-0.035		
	(0.025)			(0.027)		
Ln GDP	0.766[a]			1.035[a]		
	(0.089)			(0.091)		
Ln bil RER volatility × Ln nb dest$_{t-1}$		-0.160[a]	-0.027[a]		-0.106[a]	-0.016[a]
		(0.014)	(0.007)		(0.012)	(0.006)
Observations	867738	867738	867738	867738	867738	867738
R^2	0.576	0.580	0.908	0.700	0.702	0.932
Firm-year FE	X	X	X	X	X	X
Country-year FE		X	X		X	X
Firm-country FE			X			X
Country FE	X			X		

Note: Robust clustered standard errors in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level.

Testable Relationship 1 once again passes the test successfully: our results on both export values and volumes are qualitatively and quantitatively almost identical to our baseline specification. If anything, elasticities on the interaction term between RER volatility and the number of destinations served are slightly increased for our preferred specification (columns (2) and (5)), compared to our baseline results.

Hedging Behavior: Hedging strategies have been argued to be responsible for the muted response of trade flows following RER volatility. Previous results, however, suggest that RER volatility affects large firms more. In Table 8, we check whether the negative (micro-level) effect of RER volatility at the intensive margin resists the inclusion of variables embodying (or at least, indirectly related to) hedging or currency-invoicing behavior by firms. For clarity purposes and the sake of space, we report the results for export values only; the results on export volumes (available upon request) are very similar, and do not change anything in the conclusions reported below. Columns (1) to (6) are based on our preferred specification (equation 2). The test implemented in columns (7) and (8) (see below) makes the use of country-year fixed effects impossible, so that in this case we revert to equation 1.

Table 8: Robustness: Hedging Behavior

Dep. Variable	Ln Export Value							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln bil RER volatility × Ln nb dest$_{t-1}$	-0.135^a	-0.026^a	-0.144^a	-0.026^a	-0.149^a	-0.025^a	-0.140^a	-0.032^a
	(0.008)	(0.004)	(0.009)	(0.005)	(0.009)	(0.005)	(0.008)	(0.005)
D_{import}	0.729^a	0.255^a						
	(0.043)	(0.026)						
Ln bil RER volatility × D_{import}	0.038^a	0.017^a						
	(0.009)	(0.006)						
Ln bil RER volatility × Ln WCR$_{t-1}$			0.033^a	0.003				
			(0.003)	(0.002)				
Ln bil RER volatility × Ln STD$_{t-1}$					0.005^b	0.003		
					(0.002)	(0.003)		
Ln bil RER volatility							0.368^a	0.060^a
							(0.026)	(0.019)
Ln country price index							-0.008	0.054^b
							(0.014)	(0.026)
Ln GDP							0.561^a	1.258^a
							(0.049)	(0.072)
Ln bil RER volatility × D_{oecd}							-0.013	0.001
							(0.018)	(0.021)
D_{oecd}							-0.067	0.076
							(0.090)	(0.162)
Observations	2107382	2107382	1689494	1689494	1818755	1818755	2107382	2107382
R^2	0.549	0.885	0.538	0.891	0.540	0.890	0.542	0.884
Firm-year FE	X	X	X	X	X	X	X	X
Country FE							X	
Country-year FE	X	X	X	X	X	X		
Firm-country FE		X		X		X		X

Note: Robust clustered standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. WCR stands for Working Capital Ratio. STD stands for short-term debt.

In columns (1) and (2), we start by controlling for natural hedging strategy by accounting for firm-country imports. We compute a dummy variable (D_{import}) equal to 1 if the exporting firm i is simultaneously an importer from country j in year t.[15] Since this variable is defined at the firm-country level, the unconditional variable is not subsumed in the firm-year fixed effects. We can then estimate the conditional impact of RER volatility upon this dimension, by adding the relevant interaction in equation 2 (Column (1)). Column (2) repeats the exercise, making it even more demanding by including firm-country fixed effects in the estimation. Note, to begin with, that the estimated coefficient with respect to the interaction between the import dummy and RER volatility is significantly positive in both columns. This was expected: importing from the same country to which exports are directed creates a natural hedging, dampening the effect of RER volatility on export behavior. However, our main result remains unharmed: even taking into account this natural hedging behavior toward the same country, bilateral volatility still exerts a disproportionally negative impact on export performance for firms serving many destinations.

The inclusion of financial hedging in the picture is less straightforward. Exhaustive information regarding the use of hedging instruments is not available. Studies such as those by Lyonnet et al. (2016) and Ito et al. (2015) are based on survey data for a few thousand firms. However, we do know that, in a world of imperfect financial markets with information asymmetries, a larger firm will have easier access to external finance since it has more collateral (see Beck et al., 2005 for cross-country-evidence). The consequences are twofold: bigger firms have simultaneously better access to external finance and to hedging instruments; they have more finance to fund the use of hedging instruments, such as forward contracts or options. Since the latter are mostly short-term contracts, we can presume that they will weigh primarily on firms' short-term finance. Therefore, we focus on the effect of two ratios computed with BRN data to capture firm-level access to short-term finance and hedging instruments. First, we compute a working-capital ratio (WC ratio), defined as working capital requirement over stable resources. The results are presented in columns (3) and (4), which again only differ through the inclusion of firm-country fixed effects in column (4). We then compute a short-term debt ratio (STD ratio), equal to short-term debt over total debt. The results are presented in columns (5) and (6), the latter

[15] We chose to use a dummy rather than the continuous imports variable itself, because of the many zeros it contains - the log transformation would cause a drastic reduction in the sample. Using a dummy enables to keep the highest possible number of observations.

including again firm-country fixed-effects. Both firm-level measures (which are log-linearized and lagged one year) dampen the negative effect of RER volatility on trade flows, consistently with the idea that these two variables may correctly proxy financial coverage (columns (3) and (5)). These results do not survive the inclusion of firm-destination effects, however. In any case, our key result, of a negative impact of RER volatility magnified by the number of destinations served, holds almost identically.

Finally, the invoicing currency may also be a way of hedging again exchange-rate risk. As with the hedging instruments, this kind of information is unavailable for an exhaustive dataset such as ours. However, we know from the abovementioned studies based on survey data that firms mainly exporting to developing countries are expected to price in home currency while exports to the US or other large industrialized countries are more likely to be priced in destination countries' currency. We test this idea directly in columns (7) and (8) where a dummy variable is introduced that takes the value 1 if the destination country belongs to the OECD, as well as its interaction with bilateral volatility. This requires that country-year dummies not be included, so we move back to equation 1. Estimates are insignificant in all cases, and do not change the main result of a negative impact of bilateral volatility, growing with the number of destinations served.

Various Additional Checks: We provide in the online appendix additional robustness checks on various aspects of our baseline estimations. Section A provides estimates confirming that our results are not significantly altered if the volatility is based on: 1) the nominal exchange rate,[16] 2) a GARCH model, or 3/ a HP (Hodrick and Prescott, 1997) detrended version of our benchmark RER.

Section B of the online appendix presents various sensitivity checks regarding the definition of performance at the firm level. Tables B.1 (values) and B.2 (volumes) replicate our baseline estimations including alternative measures of firm performance: employment, apparent labor productivity, capital intensity. All firm size proxies amplify the negative effect of RER volatility, but the exacerbating impact of the number of destinations served is not altered even when the latter is included simultaneously with these other proxies of firm performance. This supports our

[16]In the last case, the sample is restricted to destinations outside the Euro Area. The latter exhibit zero nominal exchange-rate volatility after 1999, which may generate a bias in the estimation.

initial intuition that multi-destination firms have a specific behavior regarding volatility, which we will explore further in the next section. Other estimates based on TFP, as an alternative to the number of destinations served (Table B.4 in the online appendix) deliver more mixed results, either qualitatively similar to our main ones or insignificant. Note however that due to data constraints, these estimates are performed on a much smaller subsample. Besides, the underlying theoretical background clearly points to the number of destinations as the relevant measure of firm performance in our context.

Section C of the online appendix provides additional results regarding other potential omitted variables, such as the quality of economic governance and real market potential (Head and Mayer, 2004). Our baseline estimates are unaffected by the inclusion of these variables in the baseline estimation.

In Section F, we also tested the robustness to various alternative subsamples of the growing effect of RER volatility with the number of destinations served. First, a very substantial part of export flows in our sample is directed towards the Euro Area, for which nominal exchange-rate volatility is zero from 1999. For these observations, the sole source of RER volatility comes from a variation in relative price levels, which is known to be much smaller than the variation in the nominal exchange rate. Keeping these observations in the sample may generate a bias. Therefore, Table F.1 reports estimates based on a sample for which these observations are omitted. The results are qualitatively identical to the baseline ones, in line with Testable Relationships 1 and 2. However, quantitatively, elasticities are reduced by half, indicating that the extent of diversification is reduced in this subsample. This should not be surprising: Euro Area countries are major markets for French firms. Removing these destinations from the sample excludes significant reallocation options. We also check in Table F.3 that our results were unaffected by the exclusion from the estimations of firms affiliated to a business group or to a multinational corporation, identified with the LIFI ("Liaison Financières Internationales", provided by Bureau Van Dijk) dataset. Indeed, it could be argued that our results actually reflect strategies specific to those firms. Nevertheless, the results, reported in Table F.3 are again very close to our baseline estimates.

Other tables in this section support that self-selection into specific markets is not biasing our results. Table F.5 presents estimates from regressions we performed only on destinations belonging to the OECD. We then check that self-selection into fast-growing markets is not biasing our results, by first excluding BRICS countries (Table F.7), and then the top 25% of GDP growth distribution observations (Table F.9). Once again, this does not change our key conclusions.

4.3 Extensive Margin

The theoretical frameworks underlying our empirical result of a magnified, negative reaction of high-performing (multi-destination) firms to RER volatility also have implications for the extensive margin, i.e. the probability of exporting to a given destination market. Esposito (2016)'s approach predicts that entry should increase with the Sharpe ratio of the considered destination, the latter being an inverse measure of country risk, relative to all other countries. De Sousa et al. (2017) also show that entry should be reduced by higher volatility, with heterogeneous effects across firms; more specifically, it decreases the probability of exporting of the high-performing firms, since now the exporting zero-payoff cutoff condition can be non-positive because of the existence of a positive risk premium. Therefore, aggregate productivity in the considered destination decreases all other things equal, pushing up the probability of exporting of low-performing firms. On the whole, we are led to the following prediction: an increase in RER volatility should reduce the exporting probability to a considered country j, all the more so as the performance (the number of destinations served) increases. Conversely, we should observe increased entry for low-performing firms.

We bring this prediction to the data by estimating the effect of exchange-rate volatility on the decision for a firm i to start exporting to market j. This is constructed as a change of export status at the firm-country level: it takes the value 1 when a firm exports to country j in year t ($X_{ijt} > 0$) but did not in year $t-1$ ($X_{ijt-1} = 0$). As an alternative to pure entry behavior, we also estimate the impact of RER volatility on participation, which is defined as the unconditional probability to be exporting to destination j, $Pr(X_{ijt} > 0)$. Consistently with underlying theories, determinants of the probability of exporting should be the same as for the extensive margin, so we estimate replications of equations 1 and 2.

Table 9: Extensive Margin

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Variable			Entry $P(X_{ijt} > 0 \mid X_{ijt-1} = 0)$					Participation $P(X_{ijt} > 0)$		
Ln bil RER volatility	-0.012^a	0.025^a				-0.016^a	0.032^a			
	(0.004)	(0.007)				(0.005)	(0.008)			
Ln country price index	0.005^c	0.005^c				0.010^a	0.009^a			
	(0.003)	(0.003)				(0.003)	(0.003)			
Ln GDP	0.109^a	0.108^a				0.128^a	0.127^a			
	(0.013)	(0.013)				(0.015)	(0.015)			
Ln bil RER volatility × Ln nb dest$_{t-1}$		-0.012^a	-0.016^a	-0.004^a	-0.004^b		-0.016^a	-0.023^a	-0.004^a	-0.005^b
		(0.001)	(0.001)	(0.001)	(0.002)		(0.001)	(0.001)	(0.001)	(0.002)
Ln bil RER volatility × Ln assets$_{t-1}$			0.002^a		-0.000			0.007^a		0.000
			(0.000)		(0.000)			(0.000)		(0.001)
Observations	6996200	6996200	6996200	6996200	6996200	9392868	9392868	9392868	9392868	9392868
R^2	0.263	0.264	0.269	0.396	0.396	0.275	0.276	0.281	0.449	0.449
Firm-year FE	X	X	X	X	X	X	X	X	X	X
Country FE	X	X				X	X			
Country-year FE			X	X	X			X	X	X
Firm-country FE				X	X				X	X

Note: Robust clustered standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels.

Table 9 reports the results of these estimates, based on the Linear Probability Model (LPM). It is made of two symmetric panels, the left one (columns (1) to (5)) for the entry decision, the right one (columns (6) to (10)) for participation. Columns (1) and (5) report results with the interaction between RER volatility and performance constrained to be zero; conversely, all other columns allow the impact of RER volatility to move along the number of destinations served; columns (3) to (5) and (8) to (10) include country-year fixed effects, and columns (4), (5), (9) and (10) add further firm-country fixed effects. Finally, columns (3), (5), (8) and (10) also add the one-year lag ln of assets.

Both definitions of the extensive margin deliver virtually identical results (both quantitatively and qualitatively): as predicted by underlying theories, RER volatility has a negative impact on the probability of exporting, which is amplified by the number of destinations served. Low-performing firms actually benefit from increased volatility: for firms serving at most seven destinations, the total impact of RER volatility on entry and participation is positive. More generally, as we did previously for the intensive margin, we can compare the differential impact of RER volatility conditioning on the number of destinations served by contrasting effects for firms at the 10^{th} and 90^{th} percentile of the distribution of the number of destinations. Based on coefficients from column (2), this leads to a net differential effect on the 90^{th} percentile relative to the 10^{th} percentile of an additional 10 percent in RER volatility on the probability of entering being equal to -0.4% [0.1 × (-0.012) × (ln(72)-ln(3))]. For the 99^{th} percentile relative to the 1^{st}, the net differential impact amounts to -0.6% [0.1 × (-0.012) × (ln(72)-ln(1))]. Figures are in the same order of magnitude for participation. Therefore, if qualitative effects are undeniable, their extent remains modest compared to what we observed for the intensive margin.

In section E in the online appendix, we also report the results of robustness checks using an alternative, more restrictive definition of entry for the extensive margin. We follow Poncet and Mayneris (2013) when defining the dependent variable which is now the probability of starting to export to destination j, while not being an exporter to j at $t-1$ and still being an exporter at $t+1$. Formally, this variable is $\Pr(X_{ijt} > 0 \quad | X_{ijt-1} = 0, X_{ijt+1} > 0)$. This definition is more conservative than the previous one, insofar as it corresponds to a more definitive entry. Results reported in Table E.1 are qualitatively very similar to the ones presented previously. Quantitatively, they are smaller, elasticities decreasing by one-third to one-half. This constitutes further evidence that bilateral RER volatility does affect the decision of firms to enter a given market, but to a much more limited extent than the intensive margin. Note also that section A to F in the online appendix apply to the extensive margin all the robustness checks performed on the intensive margin, which have been detailed in section 4.2 above. Our main conclusions remain unchanged, and the few alterations encountered are similar to the one found on the intensive margin.

5 Firm-level Results 2: Investigating Reallocation Behavior

The previous section documented a robust magnified negative effect of RER volatility for multi-destination firms; results also showed that the low-performing firms (i.e., the ones serving only a few destinations) actually increase their export performance following a hike in RER volatility.

We now bring to the data the claim supporting the hypothesis that the reallocation behavior of multi-destination firms across destinations provides a plausible explanation for this result. We provide in this section some supporting evidence. More specifically, this section tests whether, facing the same RER volatility shock to a considered destination, sales toward other destinations also *increase*. To do so, we estimate equations 3 and 4 introduced in Section 3. The dependent variable is a measure of the total exports (values or volumes) of a given firm outside country j. Other variables are as previously defined. Consistent with Testable Relationship 3, we expect that, following an RER volatility shock to a given destination, the elasticity of export values and volumes toward all other destinations served by the firm is increasingly positive with firm performance. Put differently, we expect the interaction between RER volatility and the number of destinations served by the firm to be significantly positive.

Table 10: Reallocation Behavior: Exports outside j and RER Volatility in j

Dep. Variable	Ln Value				Ln Volume			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln bil RER volatility	-0.006	-0.097^a			-0.006	-0.128^a		
	(0.004)	(0.016)			(0.005)	(0.018)		
Ln country price index	0.015^c	0.017^b			0.009	0.013		
	(0.008)	(0.008)			(0.011)	(0.011)		
Ln GDP	0.032	0.023			0.130^a	0.117^a		
	(0.036)	(0.036)			(0.045)	(0.045)		
Ln nb dest$_{t-1}$	0.513^a	0.663^a	0.660^a	0.551^a	0.513^a	0.716^a	0.713^a	0.611^a
	(0.009)	(0.024)	(0.026)	(0.024)	(0.011)	(0.027)	(0.028)	(0.027)
Ln bil RER volatility × Ln nb dest$_{t-1}$		0.033^a	0.033^a	0.032^a		0.045^a	0.044^a	0.045^a
		(0.005)	(0.006)	(0.005)		(0.006)	(0.006)	(0.006)
Ln assets$_{t-1}$				0.598^a				0.581^a
				(0.008)				(0.012)
Ln bil RER volatility × Ln assets$_{t-1}$				-0.005^a				-0.007^a
				(0.001)				(0.002)
Observations	1958096	1958096	1958096	1958096	1949868	1949868	1949868	1949868
R^2	0.922	0.922	0.922	0.925	0.906	0.906	0.906	0.908
Firm-country FE	X	X	X	X	X	X	X	X
Country-year FE			X	X			X	X
Year FE	X	X			X	X		

Note: Robust standard errors in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level.

Table 10 provides the results of the estimation, and is made of two symmetric panels: columns (1) to (4) focus on export values, and columns (5) to (8) on exported quantities. Columns (1), (2) and (5), (6) report estimates equation 3. Columns (3) and (7) present results for equation 4, our preferred specification. Finally, columns (4) and (8) add to equation 4 the ln of assets (lagged one-year), as an ultimate check related to firm performance.

As previously, results are qualitatively identical in both panels, emphasizing that the effect on export values is driven by export volumes. Columns (1) and (5) suggest that exports outside j are not affected by RER volatility on average. However, columns (2) and (6) validate our third testable relationship: following a nRER volatility shock in country j, exports outside this destination increase with the number of destinations served by the firm. This is confirmed in columns (3)/(4) and (7)/(8). We note that the heterogeneous effect along the number of destinations seems to be specific to this dimension: the interacted term between RER volatility and assets is significantly negative, though quantitatively quite small. Consistently with underlying theories, the number of destinations served appears as the analytically consistent choice to capture the reallocation effect in presence of risk aversion leading to a preference for diversification of countries served.

Interestingly, Testable Relationship 2 appears also consistently reversed: low-performing firms (i.e. serving a few destinations) actually decrease their exports outside j when RER volatility increases in j. The effect turns positive on total exports to other destinations than j for firms serving at least 18 (volumes) or 19 destinations (values). As we said in Section 4.1, it is important to remember that these strongly multi-destination firms account for the bulk of aggregate exports. In the same vein, we can proceed as we did in Section 4 and provide quantitative assessments of the differential impact of RER volatility on this reallocation behavior for firms at the top 10% versus the bottom 10% of the distribution of the number of destinations served, still based on the summary statistics from Table 2. Based on coefficients from column (2) in Table 10, our results show that a 10% increase in bilateral volatility for destination j brings a net positive differential on exports to other destinations for the 90$^{\text{th}}$ relative to 10$^{\text{th}}$ percentile of 0.8% for values, and 1.1% for volumes. Similar computation for the differential effect between the 99$^{\text{th}}$ and the 1$^{\text{st}}$ percentile gives an increase of 1.4% for values, and almost 2% for volumes.

6 Aggregate Implications

The third layer of the empirical analysis consists of assessing the aggregate implications of the documented reallocation mechanism. We provided evidence that heterogeneity in the number of destinations served by firms is associated with heterogeneous trade response following RER volatility shocks. Firm-destination exports are all the more negatively affected by RER volatility if the firm is large, because of reallocation possibilities offered by a higher number of destinations served. Keeping in mind that these big firms account for the bulk of aggregate exports, this performance heterogeneity could also provide a new explanation for the weak reaction of destination-level aggregate exports to exchange rate movements in an uncertainty context, complementary to the one proposed by Berman et al. (2012) and others, relying on the markup behavior of big firms in a certainty context.

We now further investigate the aggregate implications of this heterogeneity. A first step is to check what happens to within-firm total exports: consistently with previous evidence, we expect that the latter should react less to RER volatility shocks for high-performing firms. We then move to the sectoral level: we start by checking that sectors for which destination-specific exports are concentrated on a few multi-destination firms are indeed those for which total sector-destination exports react the most to RER volatility. Finally, as we did at the firm level, we reaggregate over destinations to assess the reaction of total exports by sector: the latter should get weaker as the share of multi-destination firms in total exports increases.

6.1 Evidence at the Firm Level

We estimate whether total firm exports (that is, summed over all its destinations) performance are affected by RER volatilities in destination countries. To do so, we compute a firm-level effective RER volatility, consisting of a weighted sum of RER volatilities in all destinations served by the firm, with weights corresponding to the destination share of total firm exports. We then estimate the following equation :

$$X_{it} = \alpha \ln \text{ Eff. RER volat}_{it} + \phi_1 \ln \text{ Nb Dest}_{it-1} + \phi_2 (\ln \text{ Eff RER volat}_{it} \times (\ln \text{ Nb Dest}_{it-1}) + \lambda_i + \theta_t + \varepsilon_{it} \quad (5)$$

where export performance X_{it} (whether value or volume) is now aggregated at the firm level i at time t. $Eff.RERvolat_{it}$ is the average effective volatility faced by each firm on its portfolio of destinations. Our measure of firm performance, $Nb\ Dest_{it-1}$, is also included, as well as an interaction between the latter and the former. Finally, firm fixed effects and time dummies are also included.

Table 11 reports the estimation of equation 5, first for exported values (columns (1) and (2)), then for export volumes (columns (3) and (4)). As usual, results are consistent between the two measures of export performance, highlighting that the dynamics of export values are strongly driven by exported quantities. Columns (1) and (3) consistently show that that firm-level exports are on average deterred by the effective RER volatility faced by the firm. Quantitatively speaking, elasticities are much higher than previously: a 10% increase in the effective volatility faced by the firm reduces export values by almost 2%, and quantities by 4.3%. This was expected to the extent that, here, we are not considering an increase in the RER volatility of a single destination, holding all other volatilities constant; we are leaving open the possibility that volatility increases in all destinations simultaneously. This effect is fully consistent with the risk-aversion behavior framed in the production theory depicted in Section 2.

However, columns (2) and (4) suggest that this negative effect actually decreases with the number of destinations served. For high-performing firms, a large portfolio of destinations acts as a (partial) shield on total exports against a global shock in RER volatility, thanks to the diversification/reallocation mechanism pointed out previously. Put differently, multi-destination firms reallocate their exports toward the destinations with less volatility, decreasing the impact of a volatility shock hitting all the destinations in their portfolio.

6.2 Evidence at the Sectoral Level

We now estimate how sectoral exports to a given destination are affected by bilateral RER volatility and how the effect is shaped by the (sectoral) presence of multi-destination firms. We check that sectors exhibiting a large share of exports by multi-destination firms are those for which total sector exports to a given destination are the most sensitive to RER volatility in this destination: if an RER volatility shock leads multi-destination firms to decrease greatly

Table 11: Firm-level Exports

Dep. Variable	Ln Export Value Ln X_{it}		Ln Export Volume Ln Q_{it}	
	(1)	(2)	(3)	(4)
Ln effective RER volatility	-0.198[a]	-0.335[a]	-0.430[a]	-0.497[a]
	(0.008)	(0.012)	(0.009)	(0.014)
Ln nb dest$_{t-1}$	0.360[a]	0.503[a]	0.357[a]	0.590[a]
	(0.010)	(0.024)	(0.012)	(0.035)
Ln assets$_{t-1}$	0.645[a]	0.286[a]	0.697[a]	0.696[a]
	(0.010)	(0.018)	(0.014)	(0.013)
Ln effective RER volatility × Ln nb dest$_{t-1}$		0.032[a]		0.053[a]
		(0.005)		(0.007)
Observations	454805	454805	434046	434046
R^2	0.792	0.793	0.794	0.794

Note: All estimations include firm and year fixed effects. Robust standard errors clustered by sector-year in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels.

their exports to these destinations, the negative aggregate (sectoral) elasticity to RER volatility should be amplified by the presence of these firms.

To do this, we aggregate the value of exports by sector-destination, the sectoral level being defined at the HS-2 digits level. Following Berman et al. (2012), we focus exclusively on export values since this makes aggregate interpretation more straightforward; for symmetric reasons, interpreting aggregate quantities of heterogeneous products may be difficult. Also, since agricultural and mineral products are excluded, we are left with around 70 sectors.[17] The estimated equation is therefore:

$$X_{sjt} = \alpha \ln \text{Bil\_volat}_{jt} + \phi_1 \text{ShareExpMD}_{st} + \phi_2 (\ln \text{Bil\_volat}_{jt} \times \text{ShareMD}_{st}) + \phi \mathbf{Z_{jt}} + \lambda_{st} + \theta_j + \varepsilon_{sjt} \quad (6)$$

where X_{sjt} is the aggregated export value for sector s to destination j in year t. $\mathbf{Z_{jt}}$ is the same vector of country-specific controls used previously (GDP and effective real exchange rate), and ShareExpMD$_{st}$ is the share of sector-year exports made by multi-destination firms. We are specifically interested in the ϕ_2 coefficient on the interaction term between RER volatility and

[17] More precisely, our sample covers all sectors from HS 28 to HS 97.

the share of sector-year exports made by multi-destination firms: we expect this elasticity to be negative, reflecting the dominance of high-performing firms and their diversion from high-volatility destinations. Consistent with firm-level estimations, we also include sector-year fixed effects and country dummies; alternatively to the latter, we will include country-year dummies (skipping therefore country-year variables) for additional robustness.

Table 12 reports estimates of equation 6. Column (1) suggests that bilateral RER volatility deters trade at the sectoral level, and column (2) confirms a straightforward positive relationship between total sectoral exports to country j and the share of exports made by multi-destination firms. Column (3) reports a negative elasticity (ϕ_2) associated with the interaction between volatility and the share of exports made by multi-destination firms: consistently with our firm-level results, sectors in which the presence of multi-destination is the largest are also sectors in which exports to j are the most deterred. Column (4) reports the results from similar estimations, but considering the share of exports made by firms that serve a number of destination strictly larger than 2, which corresponds to the median number of destinations served by firms in our sample. Finally, column (5) presents the estimations when considering the share of exports made by firms serving more than 12 destinations, which corresponds to the 9^{th} decile of the number of destinations served by firms in the sample. As expected, all estimations conclude with a negative impact of RER volatility on sector-destination exports magnified by the presence of multi-destination firms.

Table 12: Aggregate Implications: Sector(HS2)-Country Level

Dep. Variable			Ln X_{sjt}		
	(1)	(2)	(3)	(4)	(5)
Ln bil RER volatility	-0.082^a	-0.075^a			
	(0.018)	(0.019)			
Ln country price index	0.055^b	0.056^b			
	(0.026)	(0.026)			
Ln GDP	1.095^a	1.166^a			
	(0.084)	(0.086)			
ShareExpMD		0.398^c	-1.570^a		
		(0.216)	(0.554)		
Ln bil RER volatility × ShareExpMD (ϕ_2)			-0.494^a		
			(0.133)		
Share ExpMD (above median)				-1.346^a	
				(0.392)	
Ln bil RER volatility × ShareExpMD (above median) (ϕ_2)				-0.429^a	
				(0.091)	
ShareExpMD (above top 10%)					-1.394^a
					(0.243)
Ln bil RER volatility × ShareExpMD (above top 10%) (ϕ_2)					-0.415^a
					(0.057)
Observations	76324	76324	76324	76324	76324
R^2	0.697	0.681	0.691	0.691	0.692
Sector-Year FE	X				
Sector FE		X	X	X	X
Country FE		X			
Year FE		X			
Country-year FE			X	X	X

Note: Robust standard errors clustered by destination-year in parentheses with ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels.

Table 12 reports a magnified elasticity of sectoral-destination export flows to RER volatility along the presence of multi-destination firms, as a counterpart for the amplified elasticity at the firm level that we documented above. We now perform a final set of estimates in which we reaggregate over all destinations total export value at the sectoral level (X_{st}), and assess its reaction to RER volatility. We estimate the following equation:

$$X_{st} = \alpha \text{ln Mean Bil\_volat}_t + \psi_1 \text{ShareExpMD}_{st} + \psi_2 (\text{ln Bil\_volat}_{jt} \times \text{ShareMD}_{st}) + \theta_s + \varepsilon_{st} \quad (7)$$

where *Mean Bil_volat*$_t$ is the weighted average of bilateral RER volatilities, in which the weights represent the share of each destination in the aggregate sectoral exports. *Mean Bil_volat*$_t$ thus measures the average RER volatility faced by French exporters, independently of their sector, to avoid potential endogeneity issues. As previously, *ShareExpMD*$_{st}$ is the share of sector-year exports by multi-destination firms, and the coefficient on the interacted term between the latter and average RER volatility will have again specific importance: ψ_2 is expected to be positive, indicating that the presence of multi-destination firms dampens the impact of RER volatility on aggregate sectoral exports. Finally, sector fixed-effects θ_s are also included, and standard errors are clustered by year.

The results are displayed in Table 13. Significance is in general not very strong: at the sector-year level, the number of observations is limited. Column (1) reports the results of a simple specification where the presence of non-linearities related to big firms is put aside (ψ_1 and ψ_2 are constrained to be zero). It appears that high average RER volatility for French exporters slightly deters trade at the aggregate level, but this result is insignificant at the 5% level. This is consistent with the puzzle highlighted by the macro literature: the reaction of aggregate exports to RER volatility is generally small and/or weakly significant. Columns (2) to (7) check how the within-sector importance of strongly multi-destination firms distorts this result - note that estimations reported in columns (2), (4) and (6) also include year dummies for robustness purposes. We follow the methodology implemented in Table 12, by testing interactions including either the share of sector-year exports made by all multi-destination firms (columns (2) and (3)), or the share of exports made by firms that serve a number of destinations strictly higher than the median number of destinations served (columns (4) and (5)), or the share of exports made by firms of the top 10% regarding the number of destinations served (columns (6) and (7)). Total exports consistently increase with the heterogeneity of the sector, i.e. with the share of high performing firms among total exports. More importantly, it appears that export concentration on multi-destination firms tends to *dampen* the trade-deterring effect of RER volatility: the elasticity on the interaction ψ_2 is positive in all cases. Quantitatively, it is worth noting that the effect almost dampens completely the negative effect of RER volatility. However, estimates are significant only in column (3), where the overall story remains supported.

Both Tables 12 and 13 confirm that export concentration on big, multi-destination firms tends to dampen the trade-deterring effect of RER volatility on aggregate exports, which is consistent with the micro-level diversification and reallocation behavior on which we provided evidence above. This set of results at the aggregate level is also additional evidence that supports the existence of reallocation behavior by multi-destination firms.

Table 13: Aggregate Implications: Sector (HS2) Level Estimations

Dep. Variable				Ln X_{st}			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln Mean bil RER volatility	-0.226[c]		-1.816[b]		-0.760		-0.359
	(0.124)		(0.897)		(0.707)		(0.294)
ShareExpMD		1.169[a]	1.247[a]				
		(0.398)	(0.414)				
Ln mean bil RER volatility × ShareExpMD		1.509	1.767[c]				
		(0.909)	(0.983)				
ShareExpMD (above median)				0.631[c]	0.655[c]		
				(0.330)	(0.334)		
Ln mean bil RER volatility × ShareExpMD (above median)				0.594	0.667		
				(0.782)	(0.833)		
ShareExpMD (above top 10%)						0.980[a]	0.970[a]
						(0.231)	(0.248)
Ln mean bil RER volatility × ShareExpMD (above top 10%)						0.323	0.422
						(0.548)	(0.544)
Observations	974	974	974	974	974	974	974
R^2	0.871	0.879	0.874	0.878	0.873	0.882	0.877
Sector FE	X	X	X	X	X	X	X
Year FE		X		X		X	

Note: Robust standard errors clustered by year in parentheses with [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels.

7 Conclusion

Relying on a large French firm-level database combining balance-sheet and export information over the period 1995-2009, we document a heterogeneous reaction of exporters to RER volatility. Consistently with various recent theoretical models generating diversification and reallocation behavior in a context of uncertainty by high-performing firms, we show that the elasticity of export flows and quantities to RER volatility is increasingly negative with the number of destinations served. In other words, strongly multi-destination firms divert their exports from high-volatility destinations to a greater extent, all other things being equal. This result is remarkably robust to a bunch of robustness checks, including potential omitted variables and country-specific risks. In particular, this diversion behavior appears unaffected by hedging strategies, and is not specific to multinational firms. At the other end of the spectrum, we also show that small firms, serving only a few destinations, actually increase their market share in a given destination following an RER volatility shock. Therefore, the latter reallocates market shares within a given market, from high- to low- performing firms.

In a second step, we find that this diversion behavior by strongly multi-destination firms is associated with a reallocation behavior. We show, that following an RER volatility shock in a given destination, exports (both values and volumes) outside this destination increase with the number of destinations served by the firm. Strongly multi-destination firms tend to reallocate exports away from destinations with unfavorable dynamics in terms of RER volatility, adopting efficient diversification behavior. Consequently, RER volatility drives some reallocation of exports within firms, between destination markets. This diversification behavior is consistent with various theoretical settings, and reminds of the portfolio theory: firms seek to hold constant the average risk level of their destinations portfolio, and this is easier to do as the scope of possible reallocations expands with the number of destinations served.

By providing this new evidence of a magnified reaction of multi-destination firms to RER volatility, this paper proposes a new, micro-founded explanation for the macro puzzle of the muted reaction of aggregate exports to RER volatility. If big multi-destination firms, which account for the bulk of aggregate exports, can react to an adverse shock of RER volatility somewhere by transferring trade to other, less volatile destinations, this leaves exports at the macro level mainly unchanged. This is the key mechanism we document at the intensive margin.

The same heterogeneity is also at work for the extensive margin, but with much more limited quantitative effects. The small aggregate trade response to RER volatility is thus explained by the diversification behavior of multi-destination firms and their prominent share in total exports.

This explanation of the weak reaction of aggregate exports to exchange rate movements in an uncertainty context appears, therefore, to complement a recent literature initiated by Berman et al. (2012), focusing on heterogeneous pricing-to-market in a certainty context. In the latter case, high-performing firm use their markup to absorb predictable (order one) movements in the exchange rate, such as a lasting trend of appreciation or depreciation. Our own results suggest that, when facing unpredictable (order two) movements in the exchange rate, such as multiple fluctuations around a trend, the same firms will tend to reallocate exported quantities (which are driving the dynamics of export values) elsewhere. Combining these two effects into a single theoretical framework, which would identify the conditions under which exchange-rate movements change in nature, and the different costs associated, constitutes an interesting area for future research.

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