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Export decision under risk☆

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ABSTRACT

We show that economic uncertainty in foreign markets affects firms' economic decisions, particularly those of the most productive firms. Using export data at both the industry and firm levels, we uncover two empirical regularities. First, demand uncertainty in foreign markets affects export entry/exit decisions (extensive margin) and export sales (intensive margin). If all destination countries exhibited the lowest volatility observed across destinations, then total French exports would rise by approximately 18% (an increase primarily driven by the extensive margin). Second, the most productive exporters are more affected by a higher industry-wide expenditure volatility than are the least productive exporters. The 25% most productive firms export, on average, 27% more in value than the 25% least productive firms in less volatile markets, while this difference decreases to 12% in the most volatile markets.

1. Introduction

According to recent surveys by Capgemini, demand uncertainty is a key factor in the decisions of international companies.[1] This view is consistent with the empirical evidence that uncertainty plays a crucial role in a wide range of economic outcomes, such as investment, output and price decisions (See Bloom, 2014, for a survey).[2] In this paper, we show that

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[1] See, for instance, the Capgemini surveys of leading companies that can be publicly accessed https://www.capgemini.com/wp-content/uploads/2017/07/The_2011_Global_Supply_Chain_Agenda.pdf here, https://www.capgemini.com/news/capgemini-consulting-study-reveals-impact-of-global-market-volatility-on-supply-chain-strategies here, and https://www.capgemini.com/consulting-nl/2013/02/the-2013-supply-chain-agenda/ here.

[2] Due to the practical difficulties of separating risky events from uncertain events, we follow Bloom (2014) in referring to a single concept of uncertainty, which captures a mixture of risk and uncertainty. The terms "risk" and "uncertainty" are thus used interchangeably.

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economic uncertainty in foreign markets affects not only export entry/exit decisions (extensive margin) but also the sales decisions of exporters (intensive margin), leading to the reallocation of market shares across firms.

Trade theory typically assumes that consumer expenditures in foreign markets are known with certainty. Accordingly, firms know their exact demand function but only the first central moment of the expenditure distribution, *i.e.,* market size, plays a role in export decisions and export sales. Although uncertainty has been introduced in the Melitz–Chaney- and Eaton–Kortum-type models of international trade, the uncertain parameter (productivity) is revealed before the firm supplies any destination. Recently, the trade literature has witnessed a revival of interest in studying the uncertainty realized after the firm enters any destination (Esposito 2017; Feng et al. 2017; Gervais 2018; Handley 2014; Handley and Limão 2017; Héricourt and Nedoncelle 2018; Lewis 2014; Nguyen 2012; Novy and Taylor 2019; Ramondo et al. 2013). In accordance with the theory of investment under uncertainty (Dixit and Pindyck, 1994), export entry decisions also depend on the variance of expenditures. Firms face uncertain destination-specific demands that are realized after they enter the market. However, this recent literature assumes that uncertainty is resolved before firms set their prices (or quantities) for each destination under certainty. Under these circumstances, export prices and quantities (thus, export sales) are not affected by demand uncertainty. However, exporters may not observe some random shocks before the time-strategic variables (prices or quantities) are chosen. Numerous factors are beyond the producer's control and influence the expenditure realization, including climatic conditions, changes in consumer tastes/incomes, opinion leader attitudes, competing product popularity, and industrial policy.

The objective of this paper is to estimate whether industry-wide expenditures affect not only entry/exit decisions but also export sales. Using French firm-level data, we observe the destination countries to which firms export and the products they sell over the 2000–2009 period. We match these firm-level export data with industry-wide measures of expenditure uncertainty in the destination countries, such as the variance (or volatility) and the skewness of expenditure.[3] A basic rationale for the role of skewness is that, for a given mean and variance, an increase in the skewness of the expenditure distribution involves a lower probability of low returns.[4] With these data, we uncover two main empirical regularities regarding the role of industry-wide expenditure uncertainty in firms' decisions in foreign markets.

First, the intensive and extensive margins of trade are significantly affected by uncertainty in destination markets. The expected value and skewness of expenditure positively affect both the probability of entry and export values while reducing the probability of exit. By contrast, the volatility – or variance – of expenditure produces the opposite effects, reducing both the probability of entry and export values while increasing the probability of exit. Hence, both second- and third-moment shocks must be considered to understand the patterns of trade at the extensive and intensive margins. We find that if all destination countries exhibited the lowest volatility observed across destinations, then total French exports would be expected to increase by approximately 18%. However, the increase in exports due to lower uncertainty is driven primarily by the extensive margin, i.e., the number of exporters in a destination-industry. Our counterfactual analysis at the industry level reveals that 30% of the average export increase is explained by the intensive margin, while 70% is explained by the extensive margin.

Second, the responses of firms to industry-wide expenditure uncertainty in foreign markets are *heterogeneous*. As firms differ in size and productivity, they appear to be affected differently by uncertainty. As expected, our estimations reveal that high-productivity firms export more on average than low-productivity firms to each destination-industry year. However, this export premium shrinks with expenditure volatility. In other words, the decrease in export sales due to volatility is greater for high-productivity firms than for low-productivity firms. Thus, the 25% most productive firms export, on average, 27% more in value than the 25% least productive firms in less volatile markets, while this difference *shrinks* to 12% percent in the most volatile markets. We also highlight that, for a given industry-year pair, the more productive firms favor destination countries with low volatility and high skewness.

Related literature. Although the impact of international trade on volatility has received considerable attention (Caselli et al., 2019; di Giovanni and Levchenko, 2009, 2012; Koren and Tenreyro, 2007), relatively little attention has been devoted to the reverse question. Recent contributions have studied the sources of export sales' volatility at the firm level (Kramarz et al., 2019; Vannoorenberghe et al., 2016). By contrast, in this paper, we do not consider firm-level volatility but analyze the effect of the volatility of industry-wide expenditure in foreign countries on the *level* of exports and the probability of exporting.

This paper also complements a recent body of the literature on the *heterogeneous* effects of uncertainty on individual firms (see Bloom, 2014; Bloom et al., 2018). First, Fillat and Garetto (2015) document that exporters and multinationals, which are typically the most productive firms, face higher risk exposure, which makes their profits *more sensitive* to the state of the global economy. Second, Bloom et al. (2007) highlight a "cautionary effect," such that higher uncertainty reduces the responsiveness of firms' R&D and investments to changes in productivity. We also capture a sort of cautionary effect of expenditure uncertainty on export behavior, such that greater volatility reduces the responsiveness of firms' exports to changes in productivity. This effect leads to the reallocation of market shares from the most to the least productive exporters in uncertain markets. As the reallocation of resources across heterogeneous firms is a key factor in explaining aggregate

[3] Expenditure in a destination is proxied by absorption or apparent consumption in that destination, calculated as total production plus imports minus exports.

[4] Indeed, decision makers can be more sensitive to downside losses than to upside gains (Menezes et al., 1980). Skewness can provide information about the asymmetry of the expenditure distribution and, thus, about downside risk exposure.

productivity growth (Foster et al., 2008; Melitz and Polanec, 2015), greater expenditure uncertainty can slow productivity growth.

This paper also contributes to the literature on international trade that emphasizes the role of demand in export performance (Fajgelbaum et al., 2011; Di Comite et al., 2014). Although firm heterogeneity in productivity is an important factor in explaining a firm's entry into export markets, demand factors also play a key role in explaining the variability in firm-level prices and sales across a range of export destinations (Eaton et al., 2011; Armenter and Koren, 2015). We view our paper as a complement to their approach. When the certain demand assumption is relaxed, demand fluctuations may also affect the intensive margin.

The remainder of the paper proceeds as follows. In Section 2, we present the data, the identification strategy, and descriptive statistics. Then, we provide evidence of a significant effect of foreign expenditure uncertainty on exports, first, at the industry level (Section 3) and, second, at the firm level (Section 4). For each level of the analysis, we explore the intensive and extensive margin effects. The economic meaningfulness of the estimates of volatility and skewness on trade, as well as an explanation of our findings, are discussed in Section 5. Section 6 concludes the paper.

2. Theory, data, and empirical strategy

2.1. From theory to empirical model

Our objective is to study whether uncertainty over industry-wide expenditures in destination markets affects firms' decisions on export values (intensive margin) and on market entry and exit (extensive margin).

Assume firm f producing a variety in industry k faces a downward-sloping demand curve in country j given by $p^k_{fj} = f[q^k_{fj}, R^k_j, .]$, where R^k_j denotes expenditure, and p^k_{fj} and q^k_{fj} are the price and the quantity of the variety supplied by firm f, respectively. Suppose the demand curve is not known for certain when the contracts are signed between exporters and importers. Expenditure, R^k_j, is subject to transitory shocks ω^k_j, which are independent and identically distributed with mean, variance, and skewness $\mathbb{E}(\omega^k_j)$, $\mathbb{V}(\omega^k_j)$, and $\mathbb{S}(\omega^k_j)$, respectively. Actual demand realization is therefore uncertain, i.e., $R^k_j(\omega^k_j)$ can be either high or low, when firms make their export and pricing decisions.

The theoretical literature highlights different mechanisms explaining why the variance and skewness of stochastic variables influence the choices of decision makers (Bloom, 2014). The impact of uncertainty on investment has been extensively studied since the 1970s (Dixit and Pindyck, 1994). Because of sunk costs, uncertainty over future returns reduces current investment through an option value to wait. Hence, due to fixed export costs, higher uncertainty reduces the probability of exporting.

Another strand of literature, related to industrial organization, shows that the variance of shocks affects the expected profit when the relationship between profits and the stochastic variable is nonlinear, even though decision makers are risk neutral and in the absence of sunk costs. In equilibrium, the quantity q_{ij} or price p_{ij} maximizing the expected profit depends on $\mathbb{E}(f[R^k_j(\omega^k_j), .])$ so that the variance of shocks influences prices and quantities when uncertainty is revealed after the firm sets the output size or price (Klemperer and Meyer, 1986).[5]

In a different setting, production theory shows that when decision makers are risk averse, an increase in risk (as measured by a higher variance) has a negative effect on the output size (see Section 5). In addition, as macroeconomic fluctuations are skewed rather than symmetric (see, e.g., Popov 2011), decision makers can be sensitive to downside losses, relative to upside gains. *Ceteris paribus*, decision makers might prefer to serve a country exhibiting a high probability of an extreme event associated with a high level of demand rather than a country with a high probability of an extreme event associated with a very low demand. The variance, however, does not distinguish between upside and downside risks. In this context, skewness provides information on the asymmetry of the demand distribution, thus on downside risk exposure. For the same mean and variance, countries with a demand distribution more skewed to the right can be viewed as providing better downside protection or a smaller downside risk. An increase in skewness would involve a smaller probability of large negative returns. In other words, for the same mean and variance, a decision maker therefore prefers the distribution with the highest skewness.[6]

As a consequence, if firms have to make their choice (entry/exit, quantity or price) before the resolution of uncertainty, the different moments of the expenditure distribution such as its variance and skewness could affect their decision to export and their export sales. In other words, firms' export decisions could depend not only on $\mathbb{E}(R^k_j)$ but also on $\mathbb{V}(\omega^k_j)$ and $\mathbb{S}(\omega^k_j)$.

[5] For example, if $f[R^k_j(\omega^k_j), .]) = \alpha + \beta\omega^k_j + \gamma(\omega^k_j)^2$ where α, β, and γ are known by the decision maker, then $\mathbb{E}(f[R^k_j(\omega^k_j), .]) = \alpha + \beta\mathbb{E}(\omega^k_j) + \gamma[\mathbb{E}(\omega^k_j)]^2 + \gamma(\mathbb{V}(\omega^k_j))$, so the variance of the random variable influences prices and quantities when uncertainty is revealed after the firm sets the output size or price. This literature is discussed in greater detail in Section 5.

[6] To illustrate our point, consider the demand pattern of two hypothetical countries *A* and *B*. Each country exhibits a demand distribution with the same mean (60 k€) and the same variance (1,200k€). Assume that, in country *A*, the level of demand is either 40 k€ with probability 3/4 or 120 k€ with probability 1/4, while in country *B*, the level of demand is either 0 k€ with probability 1/4 or 80 k€ with probability 3/4. Despite the equal demand variance in the two countries, the manager may prefer to serve the country with a higher skewness (country *A*) because of its lower exposure to downside risk. In this case, the decision maker is averse to downside risk. As a result, a decision maker prefers to serve a country with a large mean demand, a small variance and a large (unweighted) skewness.

The objective of our estimations is not to disentangle the mechanisms at work. Rather, we estimate whether expenditure fluctuations play a significant role in exports and whether their effects vary with respect to the types of decisions (entry/exit and sales) and the types of firms. Hence, we postulate a simple specification:

$$y_{fj}^k = \mu_1 \ln \mathbb{E}(R_j^k(\omega_j^k)) + \mu_2 \ln \mathbb{V}(\omega_j^k) + \mu_3 \mathbb{S}(\omega_j^k) + \varepsilon_{fj}^k, \tag{1}$$

where y_{fj}^k is the strategic variable (entry decision, exit decision, or export value) of firm f associated with destination j and industry k, ε_{fj}^k represents the usual error term, and $\mu_{i_{|i=1,2,3}}$ are the parameters to be estimated.

Uncertainty is difficult to measure because it is not directly observed. We have information on *actual* expenditure R_j^k, whereas the shock ω_j^k is unknown. To circumvent this issue, we show that $\mathbb{V}(\omega_j^k)$ and $\mathbb{S}(\omega_j^k)$, in Eq. (1), can be approximated by $\mathbb{V}(\dot{R}_j^k)$ and $\mathbb{S}(\dot{R}_j^k)$, respectively, where $\dot{R}_j^k$ is the growth rate of expenditure for industry k in country j. We assume that ω_j^k may influence realized expenditures such that it deviates from its expected level $\mathbb{E}(R_j^k)$. Hence, R_j^k is subject to multiplicative shocks, with $R_j^k = \omega_j^k \times \mathbb{E}(R_j^k)$, $\mathbb{E}(\omega_j^k) = 1$ and $\omega_j^k > 0$ (positive realizations). Consider, as in di Giovanni and Levchenko (2012), that actual expenditure can be approximated as follows:

$$R_j^k(\omega_j^k) = \mathbb{E}(R_j^k) + \left.\frac{\partial R_j^k}{\partial \omega_j^k}\right|_{\omega_j^k=\mathbb{E}(\omega_j^k)} \left[\omega_j^k - \mathbb{E}(\omega_j^k)\right] = \mathbb{E}(R_j^k) + \mathbb{E}(R_j^k)\left[\omega_j^k - \mathbb{E}(\omega_j^k)\right]. \tag{2}$$

Denoting by $\dot{R}_j^k$ the change in expenditure relative to the nonstochastic steady state (e.g., the growth rate) and using (2), we obtain:

$$\dot{R}_j^k \equiv \frac{R_j^k - \mathbb{E}(R_j^k)}{\mathbb{E}(R_j^k)} = \frac{\omega_j^k - \mathbb{E}(\omega_j^k)}{\mathbb{E}(\omega_j^k)}. \tag{3}$$

Therefore, it follows that $\mathbb{V}(\omega_j^k) = \mathbb{V}(\dot{R}_j^k)$ and $\mathbb{S}(\omega_j^k) = \mathbb{S}(\dot{R}_j^k)$. In addition, we have $\mathbb{E}(R_j^k(\omega_j^k)) = \mathbb{E}(R_{jt}^K)$ as $\mathbb{E}(\omega_j^k) = 1$. Hence, the empirical model (1) becomes

$$y_{fj}^k = \mu_1 \ln \mathbb{E}(R_j^k) + \mu_2 \ln \mathbb{V}(\dot{R}_j^k) + \mu_3 \mathbb{S}(\dot{R}_{j^k}) + \varepsilon_{fj}^k. \tag{4}$$

Hence, our measure of uncertainty at the industry-country level is based on the deviation of the growth rate of expenditures. This type of measure is widely used in the literature (see for example Acemoglu et al., 2003; di Giovanni and Levchenko, 2009).[7]

2.2. Data and identification strategy

Data. We combine two types of data. First, French customs provides export data by firm, product and destination over the 2000–2009 period. For each firm located on French metropolitan territory, we observe the quantity (in tons) and value (in thousands of euros) of exports for each destination-product-year triplet. To match these data with other sources, we aggregate them at the industry level (4-digit ISIC code).[8] We thus obtain the exports of each firm for each destination-industry-year triplet. Prices, proxied by unit values, are computed as the ratio of export values to export quantities. Using the official firm identifier, we merge the customs data with the BRN (Bénéfices réels normaux) dataset from the French Statistical Institute, which provides firm balance-sheet data, e.g., value added, total sales, and employment.

Our sample contains 106,267 different firms located in France, serving 90 destination countries and producing in 119 manufacturing industries. In an average year, 43,798 firms export to 75 countries in 117 industries, amounting to 189.8 billion euros and 71.7 million tons. The firm turnover in industries and destinations is rather high over the 2000–2009 period. On average, a firm is present for 2.73 years in a given destination-industry and serves 1.99 industries per destination-year and 3.22 destinations per industry-year.[9]

In addition to the firm-industry level data, we use annual destination country-industry-year information on manufacturing production, exports and imports. These data come from COMTRADE and UNIDO and cover 119 4-digit ISIC manufacturing industries over the period from 1995 to 2009. Such destination-industry-year data allow us to define consumption expenditure variable R, which is also known as apparent consumption or absorption, computed as domestic production minus net exports:

$$R_{jt}^k = \text{Production}_{jt}^k + \text{Imports}_{jt}^k - \text{Exports}_{jt}^k, \tag{5}$$

[7] Two comments are in order. First, our analysis is grounded in the assumption that part of the fluctuations in demand cannot be known by decision makers when strategic variables (prices or quantities) are chosen. Second, expenditure is seen here as the main source of residual demand uncertainty. We abstract from analyzing the roles of other sources of demand uncertainty such as the number of competitors within an industry in the destination country.

[8] See Table A1 in Appendix A for the detailed classification.

[9] The turnover is also high for firms that do not exhibit any extensive margin change in a destination-industry during the whole study period. This subsample includes 6009 different “continuing” firms present in 41 destinations and 102 industries. On average, these firms export to 1.55 industries per destination-year and to 3.37 destinations per industry-year.

where Production, Imports, and Exports are defined as total production, total imports, and total exports, respectively, for each triplet destination *j*, 4-digit industry *k*, and year *t*. The intention here is to capture the industry consumption expenditure that is used in a destination for any purpose.[10]

Identification strategy. We are interested in the causal estimates of coefficients $\mu_{i_{|i=1,2,3}}$. The identification of these parameters poses several challenges. The estimations may be plagued by reverse causality running from trade to uncertainty. To address this concern, we use the following identification strategy. Our strategic variable, y^k_{fj}, representing a firm's decision in a destination *j*, i.e., exit, entry, and the value of exports, is considered at the 4-digit *k* industry level, while the three central moments of the expenditure distribution are calculated at the 3-digit *K* industry level. We expect that these moments of aggregated expenditure affect individual trade decisions but not necessarily the reverse. The identifying assumption is that the 4-digit export flow of an individual firm to a destination does not affect the 3-digit industry expenditure distribution in that destination. This assumption is supported by two key features of the data. First, the 3-digit industry is composed of various 4-digit subindustries. Thus, it is reasonable to assume, for example, that an individual export shipment of soft drinks (k=1554) to the United Kingdom (UK) only marginally affects the volatility of UK beverages (K=155). However, some 3-digit industries are composed of only one 4-digit subindustry (see Table A1 in Appendix A). Despite this concern, a second feature of the data supports our assumption: substantial evidence exists of large border effects in trade patterns (see De Sousa et al., 2012). Consumer spending is thus domestically oriented, and net exports account for a small share of domestic expenditure, reinforcing the idea that an individual export shipment only marginally affects the expenditure moments. Nevertheless, to address the concern that an individual French firm's export flow may affect expenditure shifters in a destination, we remove French export and import flows from the destination's expenditure computation.[11]

Our intensive margin estimations focus on export values rather than on quantities and prices. The first reason for doing so is that we assume that a firm mostly cares about its sales or profits rather than about the tonnage of its exports. The second reason is that the unit values at the 4-digit level cannot be accurately interpreted as prices due to the potential composition effects at this level of aggregation.[12]

Further, to address the problem of omitted variables and to exploit the time variation of our data, we estimate

$$y^k_{fjt} = \mu_1 \ln \mathbb{E}_t(R^K_{jt}) + \mu_2 \ln \mathbb{V}_t(\dot{R}^K_{jt}) + \mu_3 \mathbb{S}_t(\dot{R}^K_{jt}) + \mathbf{X}'\gamma + \varepsilon^k_{fjt}, \tag{6}$$

where $\mathbf{X}$ represents a vector of control variables and fixed effects discussed in the next section. We have added time subscripts to stress the point that we use panel data where all of the variables, including the uncertainty variables, are time varying. Building on the fact that uncertainty also fluctuates over time (see the next subsection), our identification strategy exploits fluctuations in uncertainty and absorbs cross-country and industry-specific differences in uncertainty by using fixed effects.[13]

To be more precise, the volatility $\mathbb{V}_t(\dot{R}^K_{jt})$ in 3-digit industry *K* and year *t* is computed in two steps. First, we compute the yearly growth rates of *R* (Eq. (5)) over 6-year rolling periods at each 4-digit subindustry *k* of industry *K*. Then, volatility is simply the standard deviation of these yearly growth rates.[14] For example, consider the manufacture of beverages (K=155) in the UK in 2000. This industry is disaggregated into 4 subindustries (k=1551, 1552, 1553, and 1554).[15] First, for each subindustry *k*, we compute the yearly growth rates of apparent consumption from 1995 to 2000. Then, we calculate $\mathbb{V}_{2000}(\dot{R}^{155}_{UK,2000})$ as the standard deviation of all computed growth rates for the 4 subindustries.

The third moment of the expenditure distribution, $\mathbb{S}_t(\dot{R}^K_{jt})$, corresponds to the unbiased skewness. Instead of the standard parametric skewness index, measured as the gap between the mean and the median, $\mathbb{S}_{\approx}(\dot{R}^K_{jt})$ is computed using the same strategy as volatility, i.e., as the skewness of the yearly growth rates of *R* for 6 years and subindustries *k*. This latter index is easily interpreted. When $\mathbb{S}_t(\dot{R}^K_{jt})$ is positive (negative), the expenditure distribution is right skewed (left skewed). Using the growth measures of volatility and skewness allows us to exploit the fact that uncertainty fluctuates over time (Bloom, 2014) to identify the role of uncertainty on the intensive and extensive margins of trade.

Finally, the expected value $\mathbb{E}_t(R^K_{jt})$ is computed in year *t* as the mean of expenditure *R* over the 5 previous years. In this way, we capture the market size effect on trade. To keep matters simple, we assume that agents use a subset of all the information they can acquire to make decisions (because information acquisition is costly).

2.3. Descriptive statistics

We present some descriptive statistics on the variation in the expenditure moments across (i) destination markets and (ii) industries and (iii) over time. Specifically, we show that these moments match different facts advanced in the literature

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[10] Eaton et al. (2011) use this absorption measure to capture market size.

[11] As a robustness check, we exclude industry-destination pairs in which France accounts for a high share of the market.

[12] We thank the referee for highlighting this issue. The online Appendix reports the estimation results obtained with quantities and prices. The main conclusions remain unchanged.

[13] Ramondo et al. (2013), for instance, follow a different approach. They compute the volatility of a country's GDP over a 35-year period and study the effects of cross-country differences in uncertainty on the firm's choice to serve a foreign market through exports or foreign affiliate sales.

[14] As a robustness check, we also use 5- and 7-year rolling periods.

[15] The 4 subindustries of K=155 are 1551 - distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials; 1552 - manufacture of wines; 1553 - manufacture of malt liquors and malt; 1554 - manufacture of soft drinks and production of mineral waters.

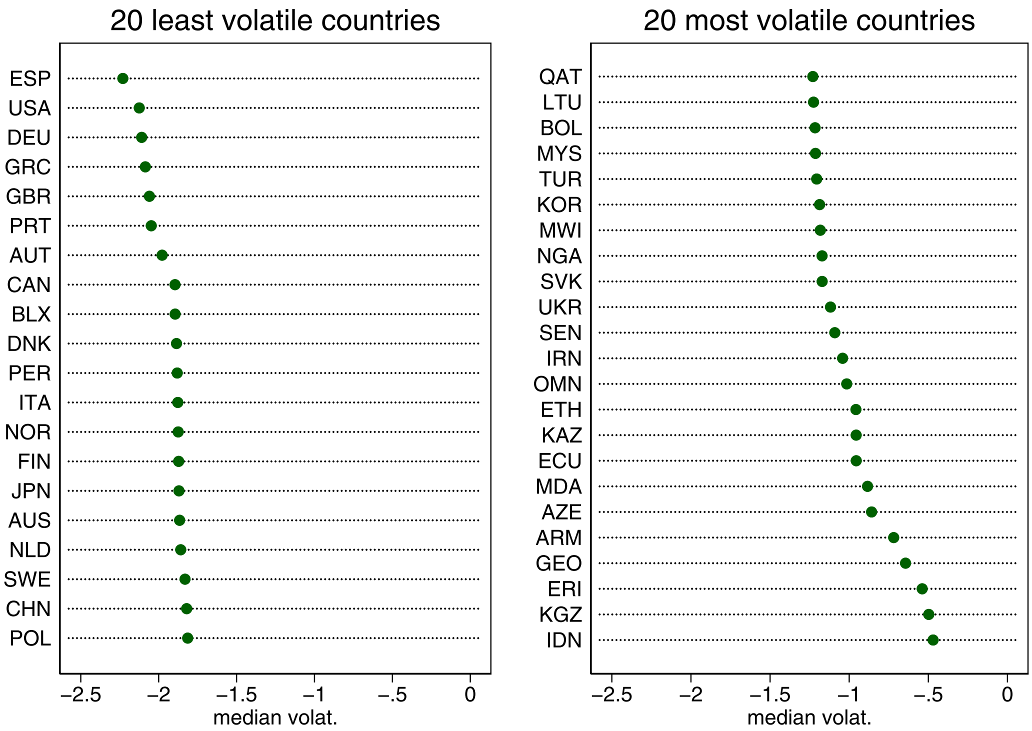


Fig. 1. Least and most volatile countries. *Note:* This figure reports the median expenditure volatility (in logs) over the period 2000–2009 for the 20 least (left panel) and most (right panel) volatile countries.

on uncertainty, which supports the way we have calculated our uncertainty measurements. In Table B1 in Appendix B, we provide additional descriptive statistics on expenditure mean, variance and skewness along different dimensions: firm-destination-industry (4-digit)-year, destination-industry (3-digit)-year, and firm-year level.

Variation across destination markets, industries, and years. In Fig. 1, we depict the median of expenditure volatility (in logs) across destination markets for the 20 least and most volatile countries over the 2000–2009 period.[16] Spain has very low volatility, as do the US and Germany (in the left panel). By contrast, the most volatile countries (in the right panel) tend to be developing countries. Our volatility measure confirms that, on average, developed countries are less volatile than developing countries, as documented in World Bank (2013) and Bloom (2014).

Similarly, Fig. 2 reports the median skewness over the 2000–2009 period for the 20 least and most skewed countries. Developed countries tend to be less skewed than developing countries, as reported in Bekaert and Popov (2012). The difference between developed and developing countries in terms of skewness seems, however, less pronounced than the difference in volatility.[17] One country in our sample has negative median skewness: Russia.

Expenditure volatility and skewness also vary across 2-digit industries and the ranking of industries differs somewhat for the two moments. For example, as shown in Fig. 3, the food and beverages category is among the most volatile industries, while its skewness is in the middle of the distribution.

A simple analysis of the variance of our volatility measure suggests that variations occur primarily across countries and industries. Nevertheless, in accordance with the literature (Bloom, 2014), we also observe fluctuations in uncertainty over time. In particular, Fig. 4 shows that the median volatility of food and beverage expenditures in the US increased between 2000 and 2008 (plain line). This finding confirms a trend that has been documented in the literature on US food consumption (Gorbachev, 2011).[18] We also observe variation in the skewness distribution, which is used for identification (dotted line).

[16] The distribution is computed for each destination using all of the 3-digit industries and years for which we can compute apparent consumption (we have, at most, 10 years * 57 3-digit industries = 570 observations per destination). We retain only countries for which we have at least 10% of the 570 possible observations. Furthermore, we drop outliers based on the annual growth rates of absorption below the 0.5 percentile or above the 99.5 percentile.

[17] One limitation of our approach is that the number of industry-years for which we can compute volatility and skewness figures is smaller for developing countries than for developed countries, and this restriction may affect the median values.

[18] Gorbachev (2011) shows that the mean volatility of household food consumption in the US increased between 1970 and 2004. As in Figs. 1–3, we report median numbers in Fig. 4 but the same variation is observed with averages (see the online Appendix).

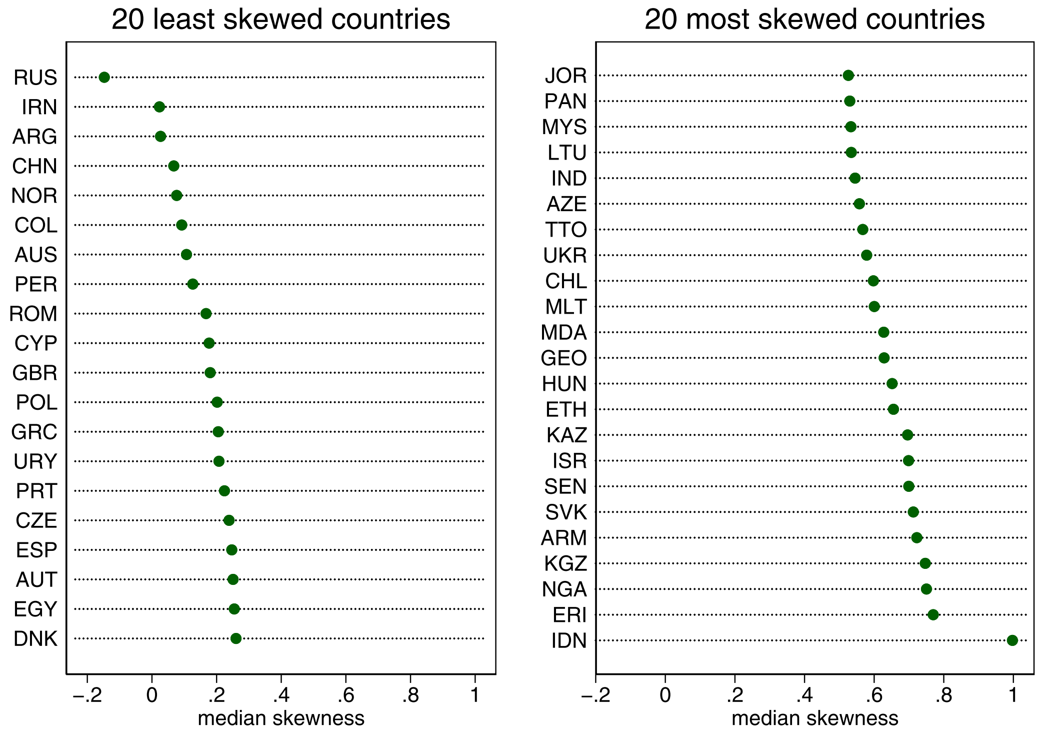


Fig. 2. Least and most skewed countries. *Note:* This figure reports the median skewness of expenditure over the period 2000–2009 for the 20 least (left panel) and the 20 most (right panel) skewed countries.

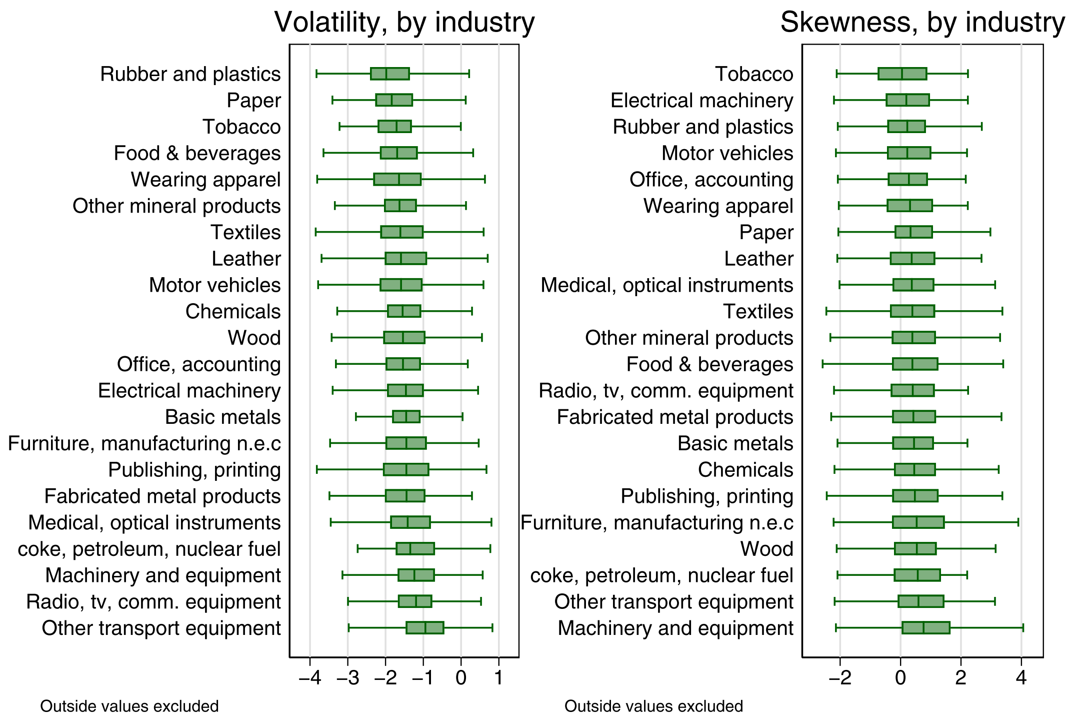


Fig. 3. Distribution of volatility and skewness by industry. *Note:* This figure reports the distribution of expenditure volatility (in logs) and skewness across 2-digit industries over the period 2000–2009.

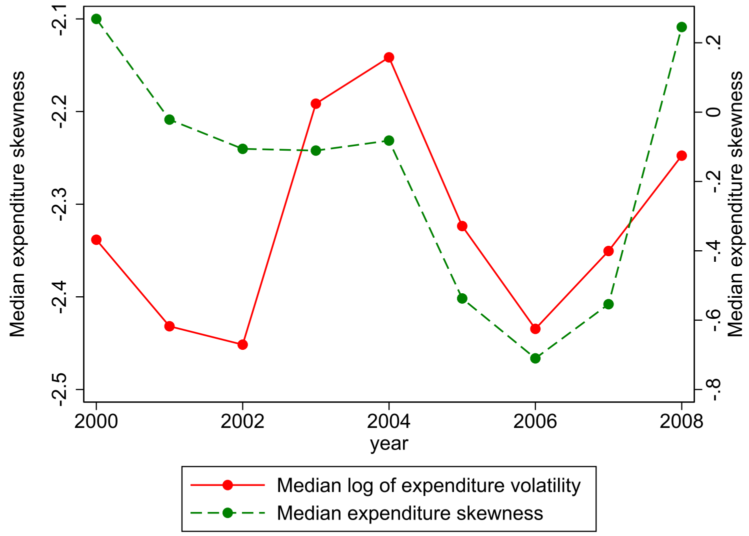


Fig. 4. Volatility and skewness of US expenditures on food and beverages, 2000–2008. *Note:* This figure reports the variation in median expenditure volatility (in logs) and median skewness in the US food and beverages industry over the period 2000–2008. The same figure with averages instead of medians is reported in the online Appendix.

3. Industry-level evidence

This section presents our industry-level estimations of the intensive (export values by destination-industry-year) and extensive margins (number of firms per destination-industry-year) of trade.

3.1. Intensive margin of trade

Starting from Eq. (6), we first estimate the following intensive margin specification at the industry level:

$$\ln y_{jt}^{k} = \beta_1 \ln \mathbb{E}_t(R_{jt}^{K}) + \beta_2 \ln \mathbb{V}_t(\dot{R}_{jt}^{K}) + \beta_3 \mathbb{S}_t(\dot{R}_{jt}^{K}) + \mathbf{X}'\gamma + \varepsilon_{jt}^{k}, \tag{7}$$

where y_{jt}^{k} is the French exports in value to destination j aggregated at the 4-digit manufacturing level k (ISIC classification) in year t. The sample covers the period from 2000 to 2009. Exports are related to the first three moments of the expenditure distribution of the destination and defined at the 3-digit level K: expected value $\mathbb{E}_t(R_{jt}^{K})$, volatility $\mathbb{V}_t(\dot{R}_{jt}^{K})$, and skewness $\mathbb{S}_t(\dot{R}_{jt}^{K})$. ε_{jt}^{k} represents the error term. The standard errors are clustered at the destination-(4-digit)-industry level. $\mathbf{X}$ is a vector of the different combinations of fixed effects.

The results are presented in Table 1 (columns 1 and 2). We consider two combinations of fixed effects, $\mathbf{X}$, based on the fact that most of the variation in the volatility measure arises across industries and destinations. The first combination considers industry and destination-by-year fixed effects (column 1), while the second combination considers industry-by-year and destination fixed effects (column 2). The fixed effects control for unobserved heterogeneity in industries (e.g., market structure) and destination markets (e.g., exchange rate fluctuations).

The results in Table 1 document that the values of exports at the industry level are positively affected by the first and third central moments of the foreign expenditure distribution, i.e., the expected expenditure and its skewness. The third-moment effect suggests that exporters are sensitive to downside risk exposure. Holding other features constant, a higher skewness of expenditure in an industry-destination means a lower exposure to downside risk because the chance of extremely negative outcomes is lower. This lower exposure to downside risk increases exports to this industry-destination. In contrast, exports are negatively affected by the second central moment of expenditure. Let us consider an example based on the fact that volatility in the grain mill products and feeds industry (ISIC rev. 3 code 153) is twice as high in Mexico as in Canada. Given an export elasticity to expenditure volatility of -0.133 (column 1), French exports to Canada in the grain mill industry would decrease by 13.3% if, *ceteris paribus*, its expenditure were as volatile as that of Mexico.[19]

In the last four columns of Table 1, we investigate whether the negative effect of expenditure volatility on export values varies with trade costs and trade policy in general. We know from Bloom et al. (2007) that the responsiveness of investment

[19] We also explored the variation in the volatility estimates across the 2-digit industries by regressing industry-level export values on the volatility of expenditure interacted with the 2-digit industry dummies, conditioned on mean and skewness expenditure, as well as on industry and destination-year fixed effects (as in column 1 of Table 1). The results show a negative and significant influence of volatility in almost all industries. The negative impact of volatility is particularly strong for basic metals, wood products and leather (see the online Appendix).

Table 1
Intensive margin of industry exports: Uncertainty, distance and the EU.

Dependent variable:	Industry export values: $\ln y_{jt}^k$					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln Mean Expenditure$_{j,t-1}^K$	0.267^a	0.283^a	0.266^a	0.268^a	0.282^a	0.284^a
	(0.028)	(0.028)	(0.029)	(0.029)	(0.027)	(0.027)
Ln Expenditure Volatility$_{jt}^K$	-0.133^a	-0.134^a	-0.086^a		-0.095^a	
	(0.023)	(0.022)	(0.027)		(0.024)	
Ln Expenditure Volatility$_{jt}^K$			0.084^a		0.076^a	
$\times$ Ln Distance$_j$			(0.018)		(0.017)	
Ln Expenditure Volatility$_{jt}^K$				-0.225^a		-0.226^a
$\times$ EU15$_j$				(0.034)		(0.033)
Ln Expenditure Volatility$_{jt}^K$				-0.094^a		-0.099^a
$\times$ non EU15$_j$				(0.027)		(0.025)
Expenditure Skewness$_{jt}^K$	0.037^a	0.035^a	0.037^a	0.037^a	0.035^a	0.035^a
	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)	(0.009)
Observations	49,773	49,787	49,773	49,773	49,787	49,787
R^2	0.787	0.797	0.787	0.787	0.798	0.798
Sets of Fixed Effects:						
(4-digit-)Industry$_k$	yes	–	yes	yes	–	–
Destination-by-Year$_{jt}$	yes	–	yes	yes	–	–
(4-digit-)Industry-by-Year$_{kt}$	–	yes	–	–	yes	yes
Destination$_j$	–	yes	–	–	yes	yes

Notes: Dependent variable is aggregated export values in logs. Number of years: 10; Number of destinations: 88; Number of 4-digit industries: 119. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. Distance is the geographical distance between France and the destination country. EU is a dummy variable that equals one for relationships between France and its EU partners. Robust standard errors are in parentheses, clustered by destination-(4-digit-)industry level, with ^{a} denoting significance at the 1% level.

to policy stimulus may be weaker in periods of high uncertainty. We wonder whether the effects of trade costs and trade policy on exports are weaker when expenditure uncertainty increases. The basic intuition is that the marginal negative impact of volatility could be magnified when trade costs are lower and market potential is higher. Thus, the lower the trade costs in a destination market are, the greater the exports and, therefore, the higher the risk at the margin.

To check this idea we use the following proxy measures of trade costs, which differ across destinations with respect to (i) the geographical distance between France and each destination country and (ii) the European Union (EU) relationships between France and its trade partners. We thus interact the volatility variable with distance and with an EU dummy variable.[20] Beyond the fact that EU members are geographically closer to France than they are to other destinations, EU partners also share lower trade barriers. We thus expect higher marginal effects for the EU interaction terms.

Before commenting on the results, note that the separate effects of distance and the EU on French exports are captured by the destination(-by-year) fixed effects, which also absorb other destination covariates, such as a common language and contiguity. The estimated coefficient associated with the interaction term between volatility and distance are positive and statistically significant (columns 3 and 5). These estimates suggest that the negative effect of volatility on exports is relatively higher for closer markets, where the impact of a trade cost reduction is magnified by the size of the shipment. The risks appear higher at the margin in closer markets where exports are greater. The EU interaction effects confirm these results with higher expected magnitudes (columns 4 and 6). Exports to EU members appear to significantly magnify the negative effect of expenditure volatility. In other words, higher expenditure uncertainty tends to shrink the positive impact of trade policy (lower trade barriers) on exports.

3.2. Extensive margin of trade

We now investigate the extensive margin of trade at the industry level and run the following estimation:

$$\ln(\text{nb firms})_{jt}^k = \lambda_1 \ln \mathbb{E}_t(R_{jt}^K) + \lambda_2 \ln \mathbb{V}_t(\dot{R}_{jt}^K) + \lambda_3 \mathbb{S}_t(\dot{R}_{jt}^K) + \mathbf{X}'\gamma + \varepsilon_{jt}^k, \tag{8}$$

where $(\text{nb firms})_{jt}^k$ denotes the number (in logs) of French exporting firms in a destination-(4-digit)-industry-year triplet. The number of French exporters is regressed on the first three moments of the expenditure distribution of the destination at the 3-digit level K, $\mathbb{E}_t(R_{jt}^K)$, $\mathbb{V}_t(\dot{R}_{jt}^K)$, and $\mathbb{S}_t(\dot{R}_{jt}^K)$. As previously, ε_{jt}^k represents the error term, and the standard errors are clustered at the destination-(4-digit)-industry level. The results reported in Table 2 control for unobserved heterogeneity in

[20] The distance to the destination country is obtained from CEPII and computed as the distance between the major cities of each country weighted by the share of the population living in each city. The EU dummy variable indicates whether at least one EU agreement with destination j has been in force since 2000.

Table 2
Extensive margin: Number of exporting firms per industry and uncertainty.

Dependent variable:	$\ln(\text{nb firms})^k_{jt}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln Mean Expenditure$^K_{j,t-1}$	0.117^a	0.116^a	0.117^a	0.139^a	0.139^a	0.140^a
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Ln Expenditure Volatility$^K_{jt}$	-0.094^a	-0.076^a		-0.088^a	-0.071^a	
	(0.010)	(0.012)		(0.010)	(0.011)	
Ln Expenditure Volatility$^K_{jt}$ × Ln Distance$_j$		0.033^a			0.033^a	
		(0.008)			(0.008)	
Ln Expenditure Volatility$^K_{jt}$ × EU15$_j$			-0.169^a			-0.157^a
			(0.015)			(0.014)
Ln Expenditure Volatility$^K_{jt}$ × non EU15$_j$			-0.062^a			-0.061^a
			(0.012)			(0.011)
Expenditure Skewness$^K_{jt}$	0.020^a	0.020^a	0.020^a	0.016^a	0.017^a	0.017^a
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Observations	49,773	49,773	49,773	49,787	49,787	49,787
R^2	0.891	0.891	0.892	0.898	0.898	0.898
Sets of Fixed Effects:						
(4-digit-)Industry$_k$	yes	yes	yes	–	–	–
Destination-by-Year$_{jt}$	yes	yes	yes	–	–	–
(4-digit-)Industry-by-Year$_{kt}$	–	–	–	yes	yes	yes
Destination$_j$	–	–	–	yes	yes	yes

Notes: dependent variable is the logged number of firms per destination-(4-digit-)industry-year triplet. Number of years: 10; Number of destinations: 90; Number of 4-digit industries: 119. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. Distance is the geographical distance between France and the destination country. EU is a dummy variable that equals one for relationships between France and its EU partners. Robust standard errors are in parentheses, clustered by destination-(4-digit-)industry level, with ^{a} denoting significance at the 1% level.

industries and destination markets by including the same two sets of fixed effects as in the intensive margin regressions: industry and destination-by-year fixed effects (columns 1 to 3), and industry-by-year and destination fixed effects (columns 4 to 6). As in the intensive margin case, the number of French exporters in a destination-industry-year triplet is positively influenced by the expected demand and the skewness and negatively impacted by the volatility. We also document the same trade costs and trade policy effects. The extensive margin of trade is more sensitive to volatility effects in the closest markets and where the trade barriers are the lowest.

3.3. Robustness of industry-level evidence

This section investigates the robustness of the industry-level evidence presented above. Fourth sensitivity tests are performed: (i) Estimations without skewness, (ii) estimations including the average growth of expenditures (in addition to mean expenditure in logs), (iii) estimations using alternative measures for expenditure moments based on log differences, and (iv) estimations controlling for spatial and serial correlations. Regarding the last robustness check, we use the method developed by Conley (1999) and Berman et al. (2017). Standard errors are estimated with a spatial heteroskedasticity- and autocorrelation-consistent correction allowing for both spatial and serial correlations. As in Berman et al. (2017), we assume that the horizon at which serial correlation vanishes can be infinite (e.g., 100,000 years). For the spatial correlation, we select a radius of 4,300 km, which is the median distance between France and all the destination countries included in our sample.

For each robustness check, reported in the online Appendix, the intensive and extensive margin results hold. The magnitude of the volatility estimate is marginally smaller when skewness is omitted, but remains highly significant. By contrast, the magnitude of the volatility estimate is somewhat larger when the average growth of expenditure is added, while the estimates of mean and skewness expenditure are not impacted. Note that the average growth of expenditure has a positive impact on industry exports and on the number of exporting firms per industry. Moreover, the results are valid if expenditure volatility and skewness are computed using log differences in R instead of growth rates as explained in Section 2.2.

4. Firm-level evidence

The intensive and extensive margins of trade are now estimated at the firm level (Sections 4.1 and 4.3), while we explore the heterogeneous intensive responses of firms to expenditure volatility in Section 4.2.[21] The economic meaningfulness of the estimates of volatility and skewness on trade, as well as the rationalization of our findings, are discussed in Section 5.

[21] As in Section 3, we focus our analysis on export values and present the analyses on quantities and prices in the online Appendix.

Table 3
Intensive margin: Firm export values.

Dependent variable:	Firm export values: $\ln y^k_{fjt}$		
	(1)	(2)	(3)
Ln Mean Expenditure$^K_{j,t-1}$	0.060^a	0.077^a	0.186^a
	(0.016)	(0.020)	(0.024)
Ln Expenditure Volatility$^K_{jt}$	-0.034^a	-0.049^a	-0.015^a
	(0.010)	(0.013)	(0.005)
Expenditure Skewness$^K_{jt}$	0.012^a	0.013^a	0.007^a
	(0.004)	(0.005)	(0.002)
Ln Productivity$_{ft}$			0.147^a
			(0.003)
Observations	3,975,771	3,180,244	3,945,943
R^2	0.644	0.469	0.845
Sets of Fixed Effects:			
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes	–	–
Destination$_j$	yes	–	–
Firm-by-Destination-by-Year$_{fjt}$	–	yes	–
(4-digit-)Industry$_k$	–	yes	–
Firm-by-Destination-by-(4-digit-)Industry$_{fjk}$	–	–	yes
Year$_t$	–	–	yes

Notes: dependent variable is firm-level export values in logs aggregated at the 4-digit k level. Number of years: 10; Number of destinations: 90; Number of 4-digit industries: 119; Number of firms: 105,724. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. Robust standard errors are in parentheses and clustered by destination-(4-digit-)industry level, with ^{a} denoting significance at the 1% level.

4.1. Intensive margin of trade

We estimate the following specification of firm-level exports at the destination-(4-digit)-industry-year triplet:

$$\ln y^k_{fjt} = \beta_1 \ln \mathbb{E}_t(R^K_{jt}) + \beta_2 \ln \mathbb{V}_t(\dot{R}^K_{jt}) + \beta_3 \mathbb{S}_t(\dot{R}^K_{jt}) + \mathbf{X}'\gamma + \varepsilon^k_{fjt}, \tag{9}$$

where y^k_{fjt} is now the export value of French firm f to destination j at the 4-digit manufacturing level k in year t. As previously described, $\mathbb{E}_t(R^K_{jt})$, $\mathbb{V}_t(\dot{R}^K_{jt})$, and $\mathbb{S}_t(\dot{R}^K_{jt})$ are the first three central moments of the expenditure distribution, and ε^k_{fjt} represents the usual error term. Compared with the industry-level estimations, firm-level data offer considerably more observations and mitigate concerns about the inefficiency of the panel estimator when introducing various combinations of fixed effects. Consequently, we use fairly demanding specifications with a vector $\mathbf{X}$ of different combinations of fixed effects. The standard errors are clustered at the destination-(4-digit)-industry level.[22]

The main results are reported in Table 3 and presented according to the main source of variation in expenditure: across destination markets (column 1), industries (column 2), and years (column 3). Before discussing the differences across columns, note that in every specification, all coefficients are statistically significant (at the 1 percent confidence level) and exhibit the expected signs. The results clearly show that expenditure volatility is negatively correlated with firm export values. This finding confirms the industry evidence presented above. Moreover, as expected, average expenditures, skewness, and firm productivity are positively correlated with the export values.

In column 1, we introduce firm-by-industry-by-year fixed effects (α_{fkt}), which capture all time-varying firm-specific determinants, such as productivity and debt, as well as any firm-industry heterogeneity. The coefficients of interest on volatility and skewness are identified in the destination dimension. In other words, the estimation relies on firm-industry-year triplets with multiple destinations. We add a separate destination country fixed effect (α_j) to control for destination-specific factors. In this way, we investigate whether multi-destination firms favor countries with low volatility and high skewness. This estimation neutralizes the ability of firms to manage their risk exposure by adjusting their (4-digit) industry lines.

In this fixed effects setting, we find a negative effect of expenditure volatility and a positive effect of expenditure skewness on firm-level exports. Hence, multi-destination firms manage their risk exposure by favoring countries with low expenditure variance and high skewness. In other words, firms avoid a high-risk market j by diverting exports to other markets with lower risks.

In column 2, we introduce firm-by-destination-by-year fixed effects (α_{fjt}). With this specification, we still absorb productivity differences across firms, but we also control for any time-varying firm-destination-specific factors. Our coefficients of interest are now identified in the industry dimension. In other words, the estimation relies on firm-destination-year triplets

[22] We use the Stata package REGHDFE developed by Correia (2014). Because maintaining singleton groups in linear regressions where fixed effects are nested within clusters might lead to incorrect inferences, we exclude groups containing only one observation (Correia, 2015). Therefore, the numbers of observations differ across estimations. The results are similar when retaining singleton groups.

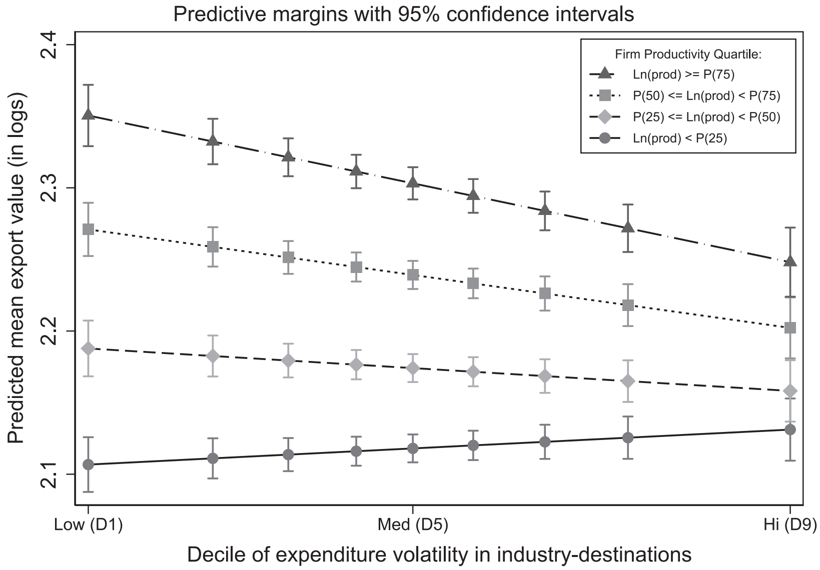


Fig. 5. Volatility, productivity and export values. *Note:* The figure compares exporters across categories of productivity (prod) and expenditure volatility in terms of predicted export values between 2000 and 2009. The x-axis displays the deciles of expenditure volatility in 3-digit industry-destination-year triplets. The y-axis displays the predicted mean export value in 4-digit industry-destination-year triplets. See the text for estimation details.

with multiple 4-digit industries. We add a separate 4-digit industry fixed effect (α_k) to control for industry-specific factors. Hence, we estimate whether firms favor the exports of industries with low volatility and high skewness for a given firm-destination-year triplet. In this setting, by controlling for firm-by-destination-by-year fixed effects, we eliminate the possibility that firms diversify across destinations. Unsurprisingly, the magnitude of the volatility estimate *increases* from 0.034 in column 1 to 0.049 in column 2. Firms are more affected because it is intuitively more difficult to diversify across industries than it is across destinations when uncertainty increases. The magnitude of the skewness effect is also somewhat larger.

In column 3, we use firm-by-destination-by-industry fixed effects (α_{fjk}) and add a separate year fixed effect (α_t). We capture any differences that are maintained across our observation period at the firm-destination-industry level. However, this set does not control for time-varying firm characteristics such as productivity, which is now introduced as an additional control and defined as the ratio of value added to the number of employees. The estimates in the third column have a very natural interpretation with a set of fixed effects corresponding to a within-panel estimator. The identification lies in the variation of expenditure moments over time. The within estimates suggest that, for a given firm-destination-industry triplet, an increase in volatility over time reduces the firm's export values, while an increase in skewness increases exports.

4.2. Heterogeneous intensive responses of firms to expenditure volatility

We now assess the potential for heterogeneity in firm responses to volatility on the intensive margin of trade. Specifically, we evaluate whether expenditure uncertainty reduces the difference in export values between the least and the most productive firms. To this end, we first construct Fig. 5, which depicts a parametric version of the reallocation effect.[23]

To construct Fig. 5, we first divide firm productivity into quartiles and industry expenditure volatility into deciles. Then, we create new variables by interacting each productivity quartile with the volatility deciles. Finally, we use an estimator that allows us to identify these interactions and to overcome the computational cost of calculating the marginal effects. We run the regression by conditioning firm responses on destination-by-year (α_{jt}) and firm-by-(4-digit)-industry (α_{fk}) fixed effects. Based on the estimated parameters, we compute the predicted mean of export value (in logs) for each decile of volatility and quartile of productivity. The different predictions for trade are plotted in Fig. 5. This plot shows three interesting results: (i) The most productive firms export more than the others at any level of volatility; (ii) the greater the expenditure volatility is, the smaller the export values for all levels of productivity, except for the least productive firms; and (iii) the marginal decrease in exports increases for the most productive firms as volatility increases. These results imply that the export difference between the least and the most productive firms decreases with volatility. We find that the 25% most productive firms export, on average, 27% more in value than the 25% least productive firms do in less volatile markets, while this difference decreases to 12% percent in the most volatile markets.

[23] Appendix C provides a nonparametric version of this figure, which also documents the reallocation effect.

Table 4
Intensive margin: Reallocation of exports across firms.

Dependent variable:	Firm export values: $\ln y^k_{fjt}$		
	(1)	(2)	(3)
Ln Mean Expenditure$^K_{jt}$	0.059[a]	0.077[a]	0.186[a]
	(0.016)	(0.020)	(0.024)
Ln Expenditure Volatility$^K_{jt}$	-0.007	-0.046[a]	-0.012[b]
	(0.010)	(0.013)	(0.005)
Ln Volatility$^K_{jt}$ × Ln Productivity$_{ft}$	-0.008[a]	-0.001	-0.001[b]
	(0.001)	(0.001)	(0.000)
Expenditure Skewness$^K_{jt}$	0.011[a]	0.012[a]	0.007[a]
	(0.004)	(0.005)	(0.002)
Ln Productivity$_{ft}$			0.146[a]
			(0.003)
Observations	3,975,771	3,180,244	3,945,943
R^2	0.644	0.469	0.845
Sets of Fixed Effects:			
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes	–	–
Destination$_j$	yes	–	–
Firm-by-Destination-by-Year$_{fjt}$	–	yes	–
(4-digit-)Industry$_k$	–	yes	–
Firm-by-Destination-by-(4-digit-)Industry$_{fjk}$	–	–	yes
Year$_t$	–	–	yes

Notes: dependent variable is firm-level export values, in logs and aggregated at the 4-digit k level. Number of years: 10; Number of destinations: 90; Number of 4-digit industries: 119; Number of firms: 105,777. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. The productivity of firm f in year t is measured using the value-added per employee. Robust standard errors are in parentheses, clustered by destination-(4-digit-)industry level, with [a] and [b] denoting significance at the 1% and 5% level respectively.

We now pursue our investigation of the heterogeneous responses of firms to expenditure volatility using the same firm specifications as in Table 3. The only difference is that we add a new covariate to the specifications: the interaction between volatility and firm productivity. The estimates are reported in Table 4. The results confirm that the most productive firms are more sensitive to variation in expenditure volatility (across destinations, industries, and years). High productivity firms export less in the most volatile markets.

4.3. Extensive margin of trade

We now investigate the impact of uncertainty on the extensive margin of trade. We follow the same identification strategy as above, with a disaggregated left-hand side variable regressed on the aggregated right-hand side expenditure moments. We distinguish between the entry of new French firms into the international market and the exit of incumbents from that market over the 2000–2009 period. Regarding entry, our dependent variable (y^k_{fjt}) is the probability that firm f begins exporting to destination j in 4-digit industry k and year t. Our counterfactual scenario considers the firms that do not enter in the same triplet jkt. This choice model can be written as a latent variable representation, with y^{*k}_{fjt} being the latent variable determining whether a strictly positive export flow is observed for firm f in a destination-industry-year triplet. Our estimated equation is therefore:

$$Pr(y^k_{fjt} | y^k_{fj,t-1} = 0) = \begin{cases} 1 & \text{if} \quad y^{*k}_{fjt} > 0, \\ 0 & \text{if} \quad y^{*k}_{fjt} \leq 0, \end{cases} \tag{10}$$

with

$$y^{*k}_{fjt} = \lambda_1 \ln \mathbb{E}_t(R^K_{j,t}) + \lambda_2 \ln \mathbb{V}_t(\dot{R}^K_{jt}) + \lambda_3 \mathbb{S}_t(\dot{R}^K_{jt}) + \mathbf{X}'\gamma + \varepsilon^k_{fjt},$$

where, as previously described, $\mathbb{E}_t(R^K_{jt})$, $\mathbb{V}_t(\dot{R}^K_{jt})$, and $\mathbb{S}_t(\dot{R}^K_{jt})$ are the first three central moments of the expenditure distribution; $\mathbf{X}$ represents various combinations of fixed effects; and ε^k_{fjt} is the error term. In addition to the probability of entry, one can study the exit transition. Higher volatility or lower upside gains may increase the exit of firms from the export market. In the exit case, our dependent variable is the probability that firm f in destination j, industry k and year $t-1$ stops exporting products from industry k to this destination in year t. Our counterfactual scenario now considers the firms that continue to serve the same triplet jkt. The explanatory variables are the same as in the entry estimations.

We estimate the entry and exit equations using a linear probability model (LPM). The inclusion of fixed effects in a probit model would give rise to the incidental parameter problem. The LPM avoids this issue. Furthermore, the use of an LPM

Table 5
Extensive margin: Firm entry and exit probabilities.

Dependent variable:	Proba. of entry		Proba. of exit	
	$Prob(y_{fjk,t}=1)\|Prob(y_{fjk,t-1}=0)$		$Prob(y_{fjk,t}=0)\|Prob(y_{fjk,t-1}=1)$	
	(1)	(2)	(3)	(4)
Ln Mean Expenditure$^K_{jt}$	0.002^a	0.002^a	-0.013^a	-0.008^a
	(0.0002)	(0.0002)	(0.002)	(0.002)
Ln Expenditure Volatility$^K_{jt}$	-0.001^a	-0.001^a	0.006^a	0.005^a
	(0.0002)	(0.0001)	(0.001)	(0.001)
Expenditure Skewness$^K_{jt}$	0.0003^a	0.0002^a	-0.001^b	-0.001^c
	(0.0001)	(0.0001)	(0.0005)	(0.0005)
Observations	48,145,780	38,954,820	3,388,796	2,464,377
R^2	0.086	0.343	0.374	0.423
Sets of Fixed Effects:				
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes	–	yes	–
Destination$_j$	yes	–	yes	–
Firm-by-Destination-by-Year$_{fjt}$	–	yes	–	yes
(4-digit-)Industry$_k$	–	yes	–	yes

Notes: dependent variable is probability for a firm to enter the export market (columns 1–2) and probability for a firm to exit the export market (columns 3–4). Entry sample: 9 years, 89 destinations, 119 4-digit industries, and 75,791 firms. Exit sample: 9 years, 89 destinations, 119 4-digit industries, and 73,270 firms. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. Robust standard errors are in parentheses, clustered by destination-4-digit industry level, with ^{a}, ^{b}, and ^{c} denoting significance at the 1%, 5%, and 10% level respectively.

allows us to directly interpret the coefficients. As for the intensive margin, in all regressions, we account for the correlation of errors by clustering at the destination-(4-digit-)industry level. The results are reported in Table 5.

In accordance with the definition of our counterfactual scenarios, we investigate the effects of uncertainty across industries and destinations. In columns 1 and 3, we introduce destination (α_j) and firm-by-industry-by-year (α_{fkt}) fixed effects. Here, our coefficients of interest on volatility and skewness are identified in the destination dimension. In other words, regarding the probability of firm entry (column 1), we compare firms in a given industry k and year t entering an export market j versus those not entering that market. In columns 2 and 4, we introduce industry (α_k) and firm-by-destination-by-year fixed effects (α_{fjt}). Our coefficients of interest on volatility and skewness are now identified in the industry dimension. Regarding the probability of firm entry (column 2), we compare firms in a given destination j and year t entering industry k versus those not entering that industry.[24]

Table 5 presents quite intuitive results. Mean expenditure significantly increases the probability that a firm enters a destination j or an industry k (columns 1–2), while reducing the probability of exit (columns 3–4). As expected, the within firm-industry-year (columns 1 and 3) and firm-destination-year (columns 2 and 4) dimensions react to the second- and third-order moment changes in expenditures. Expenditure volatility significantly decreases the probability of entry and increases the probability of exit. These results depict the reallocation effects across destinations and industries in terms of export decisions. Interestingly, destination reallocation appears to be stronger (see columns 1 and 3 versus columns 2 and 4). As noted for the intensive margin of trade, diversification and reallocation across destinations is easier than diversification across industries, which may explain the difference in the magnitudes of the coefficients. Thus, a smaller volatility effect on the intensive margin is consistent with a larger effect on the extensive margin. Note that skewness has a positive and significant effect on the probability of entry and a negative and significant impact on the probability of exit.

4.4. Robustness of firm-level evidence

In this section, we check the robustness of the intensive and extensive firm-level results. First, Appendix D shows that our results are robust to the consideration of mono- and multi-destination firms as well as mono- and multi-industry firms.

Second, we test whether our estimates are impacted when (i) omitting the skewness, (ii) including the average growth of expenditures (in addition to logged-mean expenditure), (iii) using alternative measures of expenditure moments based on log differences, and (iv) considering the export quantities or the export prices as the dependent variables instead of the export values.[25] These robustness checks, reported in the online Appendix, do not alter our main conclusions.

[24] Given the definitions of entry and exit, which are based on yearly firm behaviors in each destination-industry, the investigation of the variation across years at the firm-destination-industry level is not as relevant as on the intensive margin. Therefore, we do not consider for the extensive margin a specification with firm-by-destination-by-industry fixed effects (α_{fjk}) or a separate year fixed effect (α_t).

[25] Unfortunately, serial correlation cannot be tested at the firm level because the firm sample size is far too large relative to the computing power required to run the programs. However, as previously shown at the industry level, our results do not appear to be significantly affected by spatial and temporal correlations.

We also study the sensitivity of our results to alternative definitions of entry and exit. The definitions used in Section 4.3 may capture small exporters that enter and exit the international market several times over the sample period (2000–2009). Requiring that a firm entering the export market in year t remains in $t+1$ and, similarly, that a firm exiting the export market in year t remains a nonexporter in $t+1$ does not affect the estimation results.

In addition, we show that our results are not driven by the time span chosen for the construction of the expenditure moments, e.g. 5- and 7-year rolling periods instead of a 6-year time window (see the online Appendix).

Finally, in addition to removing French export and import flows from the destination's expenditure computation (see Section 2.2), we exclude industry-destination pairs where France has a significant market share. In particular, we drop from each regression, reported in the online Appendix, the industry-destination pairs belonging to the top 10% of the destination's expenditure distribution. In this top decile, French exports represent at least 4% of the destination's total expenditure. The results remain nearly unchanged from the baseline results displayed in Table 3.

5. Discussion and simulations

Our estimations reveal that expenditure volatility negatively affects both the intensive and extensive margins of trade. The estimations also highlight the heterogeneous effects of uncertainty. The more-productive exporters seem to favor destinations or industries with low volatility. By contrast, the less-productive exporters can increase their exports in the countries and industries with high volatility due to the reallocation of market shares among firms. Our results on expenditure skewness also suggest that downside risk matters to exporters.

5.1. How economically meaningful are the estimates of volatility and skewness?

To answer this question we evaluate the expected change in export value at the industry level if all countries exhibit the lowest level of volatility observed across destinations $V^k_{\min} \equiv \min V^k_{jt}$ for a given industry k. We also decompose the expected change into extensive and intensive margin changes. To implement this counterfactual analysis, we use the results associated with the estimation of two equations: first the number of exporters in a destination-industry-year triplet (Eq. (8)) and, second, firm-level export values at a destination-industry-year triplet (Eq. (9)).

Assuming for simplicity that $S^k_{jt} = 0$, the expected change in the value of exports in a destination-industry-year triplet, Δv^k_{jt}, can be written as follows

$$\Delta v^k_{jt} \equiv \tilde{n}^k_t \tilde{\bar{v}}^k_t - n^k_{jt}\bar{v}^k_{jt}$$

where n^k_{jt} and $\bar{v}^k_{jt}$ represent the observed number of exporters and average exports, respectively, and $\tilde{n}^k_t$ and $\tilde{\bar{v}}^k_t$ represent the expected number of exporters and average exports, respectively, when the level of volatility prevailing in destination country j and industry k reaches $V^k_{\min}$ (with $S^k_{jt} = 0$).

As industry-level French trade $v^k_{jt} = n^k_{jt}\bar{v}^k_{jt}$ can be decomposed into an extensive margin, n^k_{jt}, and an intensive margin, $\bar{v}^k_{jt}$, the expected change Δv^k_{jt} is also given by

$$\Delta v^k_{jt} = n^k_{jt}\Delta\bar{v}^k_{jt} + \bar{v}^k_{jt}\Delta n^k_{jt} \tag{11}$$

with $\Delta\bar{v}^k_{jt} \equiv \tilde{\bar{v}}^k_t - \bar{v}^k_{jt}$ and $\Delta n^k_{jt} \equiv \tilde{n}^k_t - n^k_{jt}$. Dividing each side of (11) by v^k_{jt} implies

$$\begin{aligned}\frac{\Delta v^k_{jt}}{\tilde{v}^k_t} &= \frac{\Delta\bar{v}^k_{jt}}{\bar{v}^k_{jt}} + \frac{\bar{v}^k_{jt}}{\bar{v}^k_{jt}}\frac{\Delta n^k_{jt}}{n^k_{jt}} = \frac{\Delta\bar{v}^k_{jt}}{\bar{v}^k_{jt}} + \frac{\mathbf{E}(\tilde{v}^k_{ft})}{\mathbf{E}(v^k_{fjt})}\frac{\Delta n^k_{jt}}{n^k_{jt}} \\ &= \underbrace{\left[\left(\frac{V^k_{\min}}{V^k_{jt}}\right)^{\widehat{\delta}_2} e^{-\widehat{\delta}_3 S^k_{jt}} - 1\right]}_{\text{Intensive margin}} + \underbrace{\left(\frac{V^k_{\min}}{V^k_{jt}}\right)^{\widehat{\delta}_2} e^{-\widehat{\delta}_3 S^k_{jt}}\left[\left(\frac{V^k_{\min}}{V^k_{jt}}\right)^{\widehat{\beta}_2} e^{-\widehat{\beta}_3 S^k_{jt}} - 1\right]}_{\text{Extensive margin}}\end{aligned} \tag{12}$$

According to Eq. (12), a lower volatility affects trade through the intensive margin (first term on the right-hand side of 12) and the extensive margin (second term). Our counterfactual analysis uses the estimates reported in column 4 of Table 2 ($\widehat{\beta}_2 = -0.088$, and $\widehat{\beta}_3 = 0.016$) and column 1 of Table 3 ($\widehat{\delta}_2 = -0.036$ and $\widehat{\delta}_3 = 0.012$). If all destination countries exhibited the lowest level of volatility observed across destinations in a given industry for the year 2005, then the variation of French exports by industry would follow the pattern depicted in Fig. 6.[26] This figure shows the variation of exports by

[26] *Note* that our analysis neglects the feedback effects on price and demand.

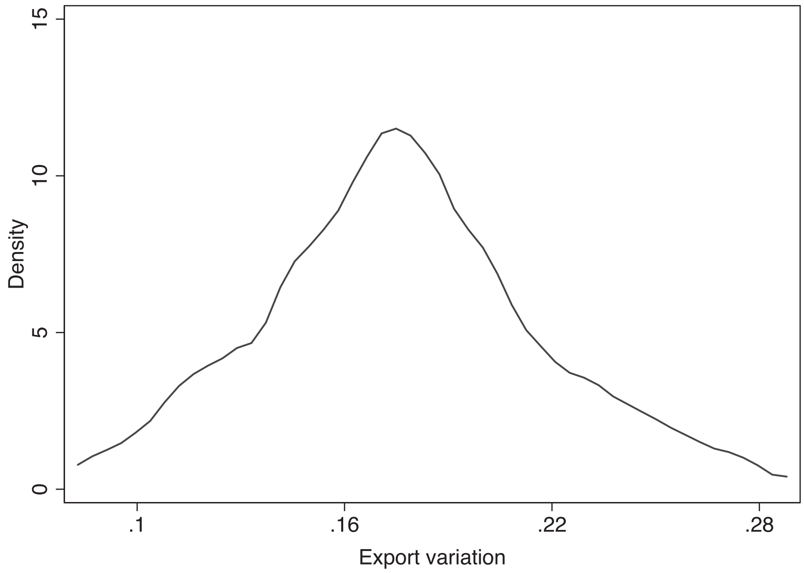


Fig. 6. Volatility decrease and export variation for each industry. *Note:* The figure reports the distribution of the export variation for each industry when all destination countries exhibit the lowest level of volatility observed across destinations for the year 2005. For exposition purpose, we drop here the bottom and top 5% of industry observations. The online appendix reports a figure using all industry observations.

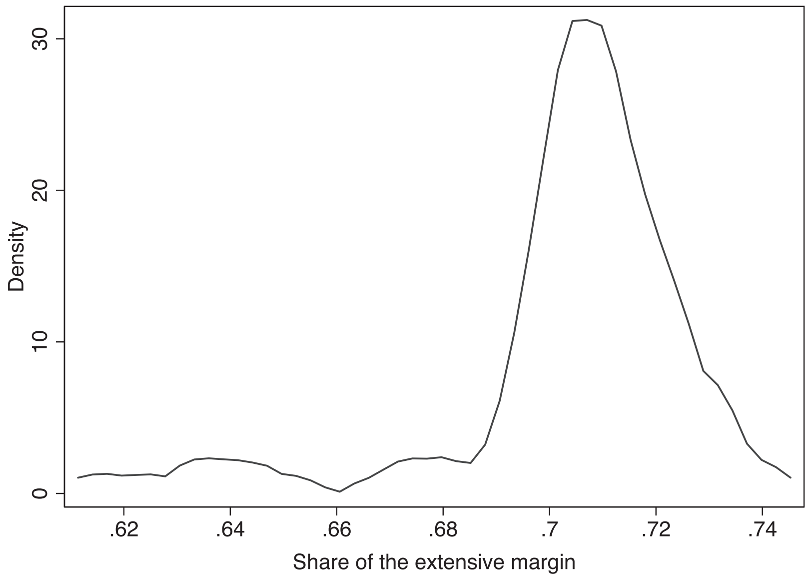


Fig. 7. Share of the extensive margin in export variation for each industry. *Note:* The figure reports the distribution of the share of the extensive margin in export variation for each industry when all destination countries exhibit the lowest level of volatility observed across destinations for the year 2005. For clarity, we drop the bottom and top 5% of industry observations. The online appendix reports a figure using all industry observations.

3-digit industry. The average increase in exports is approximately 18% and moves from 8.6% in the manufacture of articles of fur (industry 182) to 40.7% in the manufacture of dairy products (industry 152).

Our counterfactual analysis also suggests that the effect of lower volatility on exports is primarily driven by the extensive margin. Indeed, the average increase in French exports can be decomposed into a 70% increase at the extensive margin and a 30% increase at the intensive margin. Heterogeneity is depicted in Fig. 7, where most of the industries experience an increase at the extensive margin between 62 and 74%. The manufacture of railway and tramway locomotives and rolling stock (industry 352) has the lowest extensive margin share (32%), while the manufacture of rubber products (industry 251) has the highest share (94%). Hence, even if the adjustment goes through the intensive margin, reducing demand uncertainty would mainly boost the number of exporters per industry and destination.

5.2. How can we rationalize our empirical results on the role of uncertainty on export performance?

Explaining the effects of uncertainty on both the intensive and extensive margins of trade is theoretically challenging. The theoretical literature emphasizes three main channels through which uncertainty may affect export decisions: (*i*) Real-option effects, (ii) Oi-Hartman-Abel effects, and (iii) risk premium effects.

In the real-option effects approach, the decision whether and when to export may be similar to an investment decision under uncertainty Ã la Dixit–Pindyck. This approach has offered fruitful contributions on the role of uncertainty on the extensive margin of trade and on the entry decisions of multinational firms (Nguyen, 2012; Impullitti et al., 2013; Handley, 2014; Feng et al., 2017; Handley and Limão, 2017). Given the sunk costs of accessing foreign markets, uncertainty makes firms more cautious about serving a new market and delays the entry of exporters into new markets. However, this literature assumes that uncertainty is revealed before the firm sets the output price, so sales are not affected by demand uncertainty. Our empirical analysis shows that expenditure uncertainty also affects export sales. The question is to determine whether the export value is easily reversible. For instance, if production factors cannot be considered as a perfectly flexible input at the firm level, they can be flexibly allocated within a firm from one destination-product to another. As a result, the real-option approach requires further development to explain the role of uncertainty in pricing/production decisions.

In the Oi–Hartman–Abel approach (Oi, 1961; Hartman, 1972; Abel, 1983), uncertainty can decrease the expected profit when the relationship between profits and the stochastic variable is concave (Klemperer and Meyer, 1986). Nevertheless, under imperfect competition with constant marginal cost, the relationships between profits and uncertain parameters associated with demand or productivity are convex. As in Ramondo et al. (2013) and Lewis (2014), the convexity of the profit function implies that an increase in volatility leads to an increase in expected profit. To account for a negative effect of uncertainty on expected profits and sales, strong diseconomies of scale in production must be assumed. Such an assumption clashes with the empirical evidence, as exporters are typically large companies.

In the third approach, decision makers want to be compensated for higher risk due to risk/loss aversion. As shown in the literature on production decisions under risk and imperfect competition, an increase in risk raises the risk premium and decreases the output when the decision maker is risk averse (Klemperer and Meyer, 1986). This situation occurs when prices or quantities are set before demand shocks are realized. In addition, the variance in firm profits is shown to be proportional to the square of the expected output; hence, the risk premium increases with the firm's output. This phenomenon may explain why more-productive firms are more affected by expenditure uncertainty. It may also rationalize the negative effect of expenditure uncertainty on exports, which is magnified by lower trade costs. Indeed, lower trade costs yield a greater demand and, thus a higher risk premium at the margin. As in Turnovsky (1974), Helpman and Razin (1978), Esposito (2017), and Gervais (2018), we consider that risk-aversion effects offer a promising framework through which the impact of uncertainty on trade can be studied. In the working paper version of this paper (De Sousa et al., 2017), we propose a model rationalizing our main empirical findings wherein managers are risk averse. However, we lack empirical evidence to support that managers and shareholders of exporting firms might be risk averse.[27]

6. Conclusion

In firm-based theoretical and empirical studies on trade, expenditures for foreign markets are typically assumed to be known with certainty. Firm surveys suggest, however, that expenditure uncertainty is a crucial business driver, and little is known about how firms cope with this uncertainty in foreign markets. Foreign expenditure uncertainty provides incentives for firms to reduce their risk exposure by adjusting not only their extensive but also their intensive margins of trade. Thus, the responsiveness of firms to trade policy (lower trade costs) and R&D policy (higher productivity) can be altered in the context of uncertainty.

Using French firm-level data, we establish three key features of trade and demand uncertainty: (i) Greater expenditure uncertainty not only reduces export sales and exporting probabilities but also makes exports less sensitive to trade policy; (ii) the most productive exporters are more likely to be affected by higher volatility than are the least productive firms; and (iii) the increase in exports due to lower demand uncertainty is mainly driven by the extensive margin. Our results are robust to different-sized panels and to the inclusion of a plethora of fixed effects and controls.

Even if the largest firms have access to better risk management strategies, they can only partially diversify against risk. In addition, according to the production theory under uncertainty, the variance of firm profit is proportional to the square of the expected output, meaning that the average risk premium increases with firm size. Hence, our results suggest that risk exposure is a disadvantage for the largest firms.

[27] The manager of an exporting firm might be risk averse for various reasons (even if shareholders are risk neutral): (i) bankruptcy costs might be high (Greenwald and Stiglitz, 1993), (ii) risk is not adequately hedged (Wei, 1999), (iii) open-account terms are common in trade finance and allow importers to delay payment for a certain time following the receipt of goods (Antràs and Foley, 2015), or (iv) a manager's human and financial capital (through their equity shares) is disproportionately vested in the firms they manage (Bloom, 2014).

Appendix A. Industry classification

The International Standard Industrial Classification (ISIC) rev. 3 of manufacturing activities is the United Nations' system for classifying economic data into 22 2-digit, 59 3-digit and 125 4-digit industries, as depicted in Table A1.[28] We use this classification to distinguish between 3-digit K industries and 4-digit k sub-industries.

Table A1
Industry classification of manufacturing (ISIC classification).

2-digit	Industries	3-digit	4-digit
15	Food products and beverages	151	1511-4
		152	1520
		153	1531-3
		154	1541-4; 1549
		155	1551-4
16	Tobacco products	160	1600
17	Textiles	171	1711-2
		172	1721-3; 1729
		173	1730
18	Wearing apparel; dressing and dyeing of fur	181	1810
		182	1820
19	Tanning and dressing of leather	191	1911-12
		192	1920
20	Wood and of products of wood and cork, except furniture	201	2010
		202	2021-3; 2029
21	Paper and paper products	210	2101-2; 2109
22	Publishing, printing and reproduction of recorded media	221	2211-3; 2219
		222	2221-2
		223	2230
23	Coke, refined petroleum products and nuclear fuel	231	2310
		232	2320
		233	2330
24	Chemicals and chemical products	241	2411-3
		242	2421-4; 2429
		243	2430
25	Rubber and plastics products	251	2511; 2519
		252	2520
26	Other non-metallic mineral products	261	2610
		269	2691-6; 2699
27	Basic metals	271	2710
		272	2720
		273	2731-2
28	Fabricated metal products, except machinery and equipment	281	2811-3
		289	2891-3; 2899
29	Machinery and equipment (not elsewhere classified)	291	2911-5; 2919
		292	2921-7; 2929
		293	2930
30	Office, accounting and computing machinery	300	3000
31	Electrical machinery and apparatus (not elsewhere classified)	311	3110
		312	3120
		313	3130
		314	3140
		315	3150
		319	3190
32	Radio, television and communication equipment	321	3210
		322	3220
		323	3230
33	Medical, precision and optical instruments	331	3311-3
		332	3320
		333	3330
34	Motor vehicles, trailers and semi-trailers	341	3410
		342	3420
		343	3430
35	Other transport equipment	351	3511-2
		352	3520
		353	3530
		359	3591-2; 3599
36	Furniture; manufacturing (not elsewhere classified)	361	3610
		369	3691-4; 3699

[28] Details about the ISIC classification can be found here.

Appendix B. Summary statistics

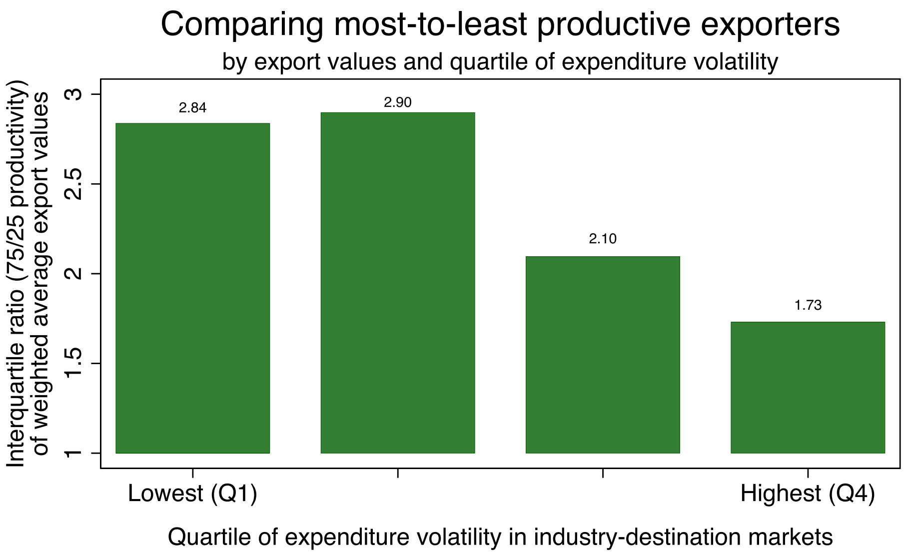
Table B1
Summary statistics.

	Nb. Obs.	Mean	Std. Dev.	Min.	Max.
At firm-destination-(4-digit-)industry-year level:					
Ln Mean Expenditure (lag)	4,775,533	14.356	1.776	4.776	19.812
Ln Expenditure Volatility	4,775,533	-1.847	0.708	-5.055	0.918
Expenditure Skewness	4,775,533	0.508	1.200	-3.460	5.539
Ln Productivity	4,775,533	4.151	0.709	-4.984	12.178
Ln Value Exports	4,775,533	2.207	2.720	-6.908	15.961
At destination-(3-digit-)industry-year level:					
Ln Mean Expenditure (lag)	22,321	12.710	2.292	4.776	19.912
Ln Expenditure Volatility	22,321	-1.468	0.788	-5.055	0.918
Expenditure Skewness	22,321	0.441	1.102	-3.460	5.539
At firm-year level:					
Ln Productivity	435,746	3.998	0.695	-4.984	12.179

Notes: Summary statistics on French export data by firm, industry and destination over the 2000–2009 period.

Appendix C. Firm-level evidence: Heterogeneous impact of volatility on exports

We supplement the analysis of the heterogeneous impact of volatility on exports by presenting reduced-form graphical evidence. We exploit here differences in productivity across firms, following a simple intuition: the more productive the firm is, the greater the export values and, therefore, the higher the risk at the margin. Fig. C1 compares the most to the least productive exporters in terms of industry export values and expenditure volatility in destination markets between 2000 and 2009. Each industry-destination-year is divided into bins based on the quartile of its expenditure volatility (x-axis), with bins from Q1 to Q4, where Q1 is the lowest and Q4 the highest quartile of volatility. The y-axis displays the interquartile ratio of the 25% most productive firms to the 25% least productive firms in terms of the weighted average export values for each quartile of expenditure volatility. The weighted average export values are computed at the destination-(4-digit-)industry-year level. The weights are the mean expenditures of the destination-industry-year triplets $\mathbb{E}(R^K_{jt})$, as defined in Section 2.2.



The figure compares most-to-least productive exporters in terms of export values and expenditure volatility in destination markets between 2000 and 2009: on average, the 25% most productive firms sell 2.8 times more than the 25% least productive ones in Q1 vs 1.7 in Q4. The x-axis displays the quartiles of expenditure volatility in 3-digit industry-destination-year triplets. The y-axis displays the interquartile ratio that compares the highest 25% of productive firms to the lowest 25% in terms of weighted average export values for each quartile of expenditure volatility. The weighted average export values are computed at the 4-digit industry-destination-year level. The weights are the lagged mean absorption of the industry-destination-year triplets.

Fig. C1. Export difference in values between least and most productive exporters (Volatility in destination-industry-year markets – 2000–2009).

They are designed to account for possible self-selection of firms into destinations with different levels of expenditure. The figure depicts an interesting and striking result: expenditure volatility reduces the export difference between the least and the most productive exporters. According to Fig. C1, the 25% most productive firms export, on average, 2.8 times more than the 25% least productive firms in less volatile markets (Q1), while this difference shrinks to 1.7 in the most volatile markets (Q4).

Appendix D. Firm-level evidence: Mono- and multi-destination and mono- and multi-industry firms

We consider firms along different dimensions over the 2000–2009 period. Our sample comprises a total of 106,267 exporting firms. Among them, 45% (47,323 firms) are considered as mono-industry firms; that is, they export products in only one 4-digit industry during the whole period. Additionally, 22% (23,175) are multi-industry firms, and 33% are switchers (e.g., they export products in only one industry in a particular year and in multiple industries in a different year). Firms also differ in terms of destinations. As documented in the literature, a large share of firms only export to one destination during the whole period (43,799 firms, i.e., 41%), while 30% export to multiple destinations (31,786 firms) and 29% are switchers (e.g., they export to one destination in a particular year and to multiple destinations in another year). Additionally, the literature mentions that many firms export only in one industry and to one destination during the whole period (35,182 firms, i.e., 33%), while 16% of the firms (16,522) export to multiple destinations in multiple industries. A smaller number of firms exports to one destination and in multiple industries (3,754) or to multiple destinations and in one industry (5,481).

Tables D1 to D4 exploit the above decompositions to check the robustness of our results on the intensive and extensive margins of trade. The general picture that emerges from these tables supports the heterogeneous impact of volatility on exports uncovered in Section 4. In most of the regressions, the impact is stronger for multi-destination firms and/or multi-industry firms, which are the most productive exporters. For instance, in column 1 of Table D2, the effect of volatility on values is only negative for multi-destination and multi-industry firms. The extensive margin results show that the probability of entry decreases relatively more for multi-destination and multi-industry firms with greater volatility (columns 1 and 2 of Tables D3 and D4).

D.1. Intensive margin - Export values

Table D1
Intensive margin: Firm export values.

(Mono- and multi- industry firms vs. mono- and multi- destination firms)	Industry export values: $\ln v_{jt}^{k}$			
	(1)	(2)	(3)	(4)
Ln Mean Expenditure$_{j,t-1}^{K}$	0.060^{a}	0.077^{a}	0.186^{a}	0.186^{a}
	(0.016)	(0.020)	(0.024)	(0.024)
Expenditure Skewness$_{jt}^{K}$	0.012^{a}	0.013^{a}	0.007^{a}	0.007^{a}
	(0.004)	(0.005)	(0.002)	(0.002)
Ln Productivity$_{ft}$			0.147^{a}	0.147^{a}
			(0.003)	(0.003)
Volatility for Mono-Industry Firms	0.017			0.031^{a}
	(0.021)			(0.006)
Volatility for Multi-Industry Firms	-0.038^{a}			-0.019^{a}
	(0.010)			(0.006)
Volatility for Mono-Destination Firms		-0.145^{a}	0.050^{a}	
		(0.035)	(0.007)	
Volatility for Multi-Destination Firms		-0.046^{a}	-0.017^{a}	
		(0.013)	(0.005)	
Observations	3,975,771	3,180,244	3,945,943	3,945,943
R^2	0.644	0.469	0.845	0.845
Sets of Fixed Effects:				
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes			
Destination$_{j}$	yes			
Firm-by-Destination-by-Year$_{fjt}$		yes		
(4-digit-)Industry$_{k}$		yes		
Firm-by-Destination-by-(4-digit-)Industry$_{fjk}$			yes	yes
FE Year$_{t}$			yes	yes

Notes: dependent variable is firm-level export values in logs aggregated at the 4-digit k level. Number of years: 10; Number of destinations: 90; Number of 4-digit industries: 119; Number of firms: 105,724. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. The productivity of firm f in year t is measured using the value-added per employee. Robust standard errors are in parentheses, clustered by destination-4-digit industry level, with ^{a} denoting significance at the 1% level.

Table D2
Intensive margin: Firm export values.

(Interactions: mono-/multi-industry, mono-/multi-destination firms)			
	Industry export values: ln v_{jt}^{k}		
	(1)	(2)	(3)
Ln Mean Expenditure$_{j,t-1}^{K}$	0.060[a]	0.079[a]	0.186[a]
	(0.016)	(0.020)	(0.024)
Expenditure Skewness$_{jt}^{K}$	0.013[a]	0.010[b]	0.008[a]
	(0.004)	(0.005)	(0.002)
Ln Productivity$_{ft}$			0.147[a]
			(0.003)
Volatility for:			
Mono-Destination & Mono-Industry Firms			0.028
			(0.043)
Multi-destination & Mono-Industry Firms	-0.020		-0.034
	(0.051)		(0.030)
Mono-Destination & Multi-Industry Firms		-0.147[b]	-0.012
		(0.066)	(0.048)
Multi-Destination & Multi-Industry Firms	-0.056[a]	-0.041[a]	-0.023[a]
	(0.009)	(0.012)	(0.006)
Observations	3,975,771	3,180,244	3,945,943
R^2	0.644	0.469	0.845
Sets of Fixed Effects:			
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes		
Destination$_j$	yes		
Firm-by-Destination-by-Year$_{fjt}$		yes	
(4-digit-)Industry$_k$		yes	
Firm-by-Destination-by-(4-digit-)Industry$_{fjk}$			yes
FE Year$_t$			yes

Notes: dependent variable is firm-level export quantities in logs aggregated at the 4-digit k level. Number of years: 10; Number of destinations: 90; Number of 4-digit industries: 119; Number of firms: 105,724. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. The productivity of firm f in year t is measured using the value-added per employee. Robust standard errors are in parentheses, clustered by destination-4-digit industry level, with [a] and [b] denoting significance at the 1% and 5% level respectively.

D.2. Extensive margin

Table D3
Extensive margin: Firm entry and exit probabilities.

(Mono- and multi- industry firms vs. mono- and multi- destination firms)				
Dependent variable:	Proba. of entry		Proba. of exit	
	$Prob(y_{fjk,t}=1)\|Prob(y_{fjk,t-1}=0)$		$Prob(y_{fjk,t}=0)\|Prob(y_{fjk,t-1}=1)$	
	(1)	(2)	(3)	(4)
Ln Mean Expenditure$_{jt}^{K}$	0.002[a]	0.002[a]	-0.013[a]	-0.008[a]
	(0.0002)	(0.0002)	(0.002)	(0.002)
Expenditure Skewness$_{jt}^{K}$	0.0004[a]	0.0002[a]	-0.001	-0.001[c]
	(0.0001)	(0.0001)	(0.0004)	(0.0005)
Volatility for Mono-Industry Firms	0.007[a]		0.005	
	(0.001)		(0.006)	
Volatility for Multi-Industry Firms	-0.004[a]		0.005[a]	
	(0.0002)		(0.001)	
Volatility for Mono-Destination Firms		0.0004[a]		-0.003
		(0.0001)		(0.002)
Volatility for Multi-Destination Firms		-0.001[a]		0.005[a]
		(0.0002)		(0.001)

(*continued on next page*)

Table D3 (*continued*)

(Mono- and multi- industry firms vs. mono- and multi- destination firms)				
Dependent variable:	Proba. of entry		Proba. of exit	
	$Prob(y_{fjk,t}=1)\|Prob(y_{fjk,t-1}=0)$		$Prob(y_{fjk,t}=0)\|Prob(y_{fjk,t-1}=1)$	
	(1)	(2)	(3)	(4)
Observations	48,145,780	38,954,820	3,388,796	2,464,377
R^2	0.086	0.343	0.374	0.423
Sets of Fixed Effects:				
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes	-	yes	-
Destination$_j$	yes	-	yes	-
Firm-by-Destination-by-Year$_{fjt}$	-	yes	-	yes
(4-digit-)Industry$_k$	-	yes	-	yes

Notes: dependent variable is probability for a firm to enter the export market (columns 1–2) and probability for a firm to exit the export market (columns 3–4). Entry sample: 9 years, 89 destinations, 119 4-digit industries, and 75,791 firms. Exit sample: 9 years, 89 destinations, 119 4-digit industries, and 73,270 firms. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. Robust standard errors are in parentheses, clustered by destination-4-digit industry level, with ^{a} and ^{c} denoting significance at the 1% and 10% level respectively.

Table D4
Extensive margin: Firm entry and exit probabilities.

(Interactions: mono-/multi- industry, mono-/multi- destination firms)				
Dependent variable:	Probability of entry $Prob(y_{fjk,t}=1)\|Prob(y_{fjk,t-1}=0)$		Probability of exit $Prob(y_{fjk,t}=0)\|Prob(y_{fjk,t-1}=1)$	
	(1)	(2)	(3)	(4)
Ln Mean Expenditure$^K_{jt}$	0.002^a	0.002^a	-0.013^a	-0.008^a
	(0.0002)	(0.0001)	(0.002)	(0.002)
Expenditure Skewness$^K_{jt}$	0.001^a	0.0002^a	-0.001	-0.001
	(0.0001)	(0.0001)	(0.0004)	(0.0005)
Volatility for:				
Multi-Destination & Mono-Industry Firms	-0.004^a		0.014^b	
	(0.001)		(0.006)	
Mono-Destination & Multi-Industry Firms		0.0003^b		-0.003
		(0.0001)		(0.003)
Multi-Destination & Multi-Industry Firms	-0.007^a	-0.001^a	0.006^a	0.005^a
	(0.0003)	(0.0002)	(0.001)	(0.001)
Observations	48,145,780	38,954,820	3,388,796	2,464,377
R^2	0.087	0.343	0.374	0.423
Sets of Fixed Effects:				
Firm-by-(4-digit-)Industry-by-Year$_{fkt}$	yes	-	yes	-
Destination$_j$	yes	-	yes	-
Firm-by-Destination-by-Year$_{fjt}$	-	yes	-	yes
(4-digit-)Industry$_k$	-	yes	-	yes

Notes: dependent variable is probability for a firm to enter the export market (columns 1–2) and probability for a firm to exit the export market (columns 3–4). Entry sample: 9 years, 89 destinations, 119 4-digit industries, and 75,791 firms. Exit sample: 9 years, 89 destinations, 119 4-digit industries, and 73,270 firms. Expenditure is defined as apparent consumption (production minus net exports) at the 3-digit K level. See the paper for computational details about expenditure moments. Robust standard errors are in parentheses, clustered by destination-4-digit industry level, with ^{a} and ^{b} denoting significance at the 1% and 5% level respectively.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2019.103342.

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