Exporters under Foreign Heat

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Abstract:

In this paper, I estimate the effect of foreign weather shocks on firm-level exports. I exploit the French firm-level customs data from 1995 to 2009 and estimate a theory-consistent firm-level gravity model. I do not find support for a meaningful negative impact of foreign temperatures on average but estimate a robust, strong differential effect across exporters, leading to composition changes. Larger firms are more negatively harmed by foreign weather shocks than small exporters. Regarding mechanisms, both demand-side (import demand) and supply-side (competition and strategic interactions) channels are at play.

Keywords: Exports, Firms, Temperatures, Climate Change.

JEL Classification: F14, F18

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1. Introduction

Weather and the environment are major concerns for our societies and our activities. Understanding the effects of climate and weather shocks on economic outcomes is both challenging and necessary as uncertain, future climate shifts are likely to affect production, distribution, and many other economic outcomes. From the latest PWC reports, top executives of global firms are increasingly anxious about climate change and its effects. Strikingly, CEOs cite these concerns much more than other threats, such as geopolitical uncertainty, terrorism, or direct business risks, such as changing consumer behavior or new market entrants.[1]

Measuring the impacts of climate and weather shocks on economic outcomes is the subject of a large literature. The effects of weather variations, such as rising temperatures, rainfalls, or natural disasters, are extensively documented (Carleton and Hsiang (2016)). A large, quantitative empirical research indeed provides evidence of the important effects of climate shifts on health, agriculture, economics, conflict, migration, demographics, and other fields. Regarding the trade impact of weather shocks, evidence supports the negative impact on exports. Jones and Olken (2010) find an average 2% decrease in export growth in poor countries for each additional degree Celsius of temperature rise, and no effect of precipitation. Li, Xiang, and Gu (2015) estimate using Chinese data that exports decrease by 1.1% for every additional degree Celsius of temperature and estimate no effect on imports. Dallmann (2019) suggests that temperature shocks have a trade-deterring effect that varies across country pairs. Osberghaus (2019) provides a survey of the existing empirical results on the trade effect of weather shocks.

The existing literature has only focused on *local* weather shocks, i.e., how exporters cope with weather shocks at home. Yet, trade may be affected by weather shocks in the destination market as well. Exporters indeed care about foreign markets' trade conditions (Berman, Martin, and Mayer (2012); Mayer, Melitz, and Ottaviano (2014)). Foreign weather shocks, as any foreign shock, may deter

[1] For instance, see https://www.pwc.com/gx/en/ceo-survey/2018/pwc-ceo-survey-report-2018.pdf.

foreign production, revenues, and GDP[2], which, in turn, affects the import demand and export sales of foreign firms[3].

The present paper tackles this issue and studies exporting firms' reactions to temperature shocks in destination countries. The analysis is based on firm-level disaggregated export data from French Customs, from 1995 to 2009. It combines firm-level export data with temperature data (from the Climatic Research Unit, CRU, (Harris et al. (2014))) at the destination-year level, capturing the average weather conditions in the destination country. I consider the full universe of French exporters and use the exogenous occurrence of temperature shocks in the destinations served by these firms. In a firm-level gravity framework, I estimate the impact of temperatures on the exported values, controlling for firm size, local weather shocks, distance to destination, and other standard trade determinants. On top of the average effect, I estimate the *differential* impact on exports across firms that all face the same weather shock in the destination market.

Four main results emerge from the analysis. First, firm-level exports are on average hardly deterred by foreign temperatures. This result is identified from export variations across years for a given firm to a specific market. On average, estimates suggest a 1% decrease in exports following a 10% increase in temperatures. The average export flow is hardly affected by foreign temperatures, in line with previous evidence (Li, Xiang, and Gu (2015); Dallmann (2019)).

Second, this modest average effect hides a substantial differential effect across exporters. Taking advantage of the wide array of firm observables in the sample, I allow the impact of foreign weather shocks to have differential effects across exporters depending on their size. I find that the larger the

[2] Many studies have estimated a large and negative correlation between temperature and aggregate output. In the agricultural sector, temperatures decrease yields (Mendelsohn, Nordhaus, and Shaw (1994); Deschênes and Greenstone (2007); Schlenker and Roberts (2009); Schlenker and Lobell (2010); Moore and Lobell (2015); Chen, Chen, and Xu (2016)). Many studies have also documented the negative impact of temperatures on output in non-agricultural sectors (Hsiang 2010; Dell, Jones and Olken 2012; Cachon, Gallino and Olivares 2012; Dell, Jones and Olken 2014). Regarding the mechanisms at play, empirical evidence supports a negative relationship between temperatures and labor productivity (Heal and Park (2016); Graff Zivin, Hsiang, and Neidell (2018)).

[3] On the one hand, a decrease in foreign output decreases revenues and incomes, total demand, and thus import demand. On the other hand, if foreign output decreases, import demand could increase to make up for such a reduction. Finally, if the foreign output of a specific product drops after temperature shifts, exports of complementary products could decrease too, while exports of substitutes could increase. The observed response of exports is the total effect of these channels and also depends on geography and trade costs, as emphasized by the gravity literature (Head and Mayer (2014)).

firm, the more negative the effect on (relative) sales across (French) sellers in this market. On the contrary, small firms' exports are insignificantly affected by foreign weather shocks. This result is independent of the measure of firm size and of the measure of temperatures. The result is also robust to the inclusion of many potentially omitted variables and to various estimators.

Third, the main explanation in the literature for the negative impact of temperatures is related to import demand. Countries facing local weather shocks change their import demand, and thus foreign exporters are affected. I however find that these demand-side effects only partially rationalize the export patterns. Simultaneously controlling for GDP (or for TFP growth) in destination countries does not shut down the effect of temperatures. Beyond import demand, I hypothesize that competition in the foreign market is also affected by foreign temperatures and results confirm the role of these supply-side effects. I find that controlling for the number of competitors and for their average size shuts down the negative impact of temperatures on exports. Competition changes and strategic interactions are plausible mechanisms through which temperatures affect exports, on top of the already documented import demand channel.

Fourth, the differential effects of temperatures across exporters lead to a composition effect in the set of exporters serving foreign markets. Indeed, temperatures reduce the relative sales of large, productive, low-price exporters in a specific destination. Results support this composition effect, as a direct implication of the differential effect across firms: when foreign temperatures increase, exports are tilted towards smaller, low-productivity, high-price firms.

This article contributes to the literature in the following manners. First, results support that foreign weather shocks affect exports and trade, whereas most of the literature focused only on local weather shocks. To the best of my knowledge, the present paper is the first attempt to measure the importance of foreign temperature shocks on trade flows. I find robust differential impacts of these shocks and almost no effect on average across firms. Note that the results do also account for *local* weather shocks as I include demanding fixed effects that absorb heterogeneities across firms: the within-estimation setup implies that identification (partially) relies on export variations across destinations for a given firm-year, thus controlling for local weather shocks. In a sense, results provide the *additional* effects of weather shocks on exports, compared to local shocks. Results contribute to a more complete and detailed understanding of the trade effect of *global* weather shocks.

Second, the present results provide an explanation for the muted response of aggregate exports to foreign weather shocks (Li, Xiang, and Gu (2015); Dallmann (2019)). On this specific topic, recent contributions emphasize aggregation issues related to the geographic level of analysis (Burke and

Tanutama (2019); Colacito, Hoffmann, and Phan (2019)) or to the time span of exports (Karlsson (2021)). The present firm-level results complement these contributions by highlighting the potential aggregation issues related to heterogeneous firms in trade (Imbs and Mejean (2015); Bas, Mayer, and Thoenig (2017)). As a side note, results imply that using aggregate trade data omits part of the adjustment to climate change. Climate change may affect both the level of trade flows and the identity of exporters across markets.

Third, this paper advances our knowledge about the mechanisms through which weather shocks affect export outcomes. Whereas evidence on the potential mechanisms remains scarce, most of the literature supports that the effects are captured through changes in demand. My results show that this answer is only part of the process: demand changes are not quantitatively sufficient to rationalize the export patterns. On top of demand, results support an additional channel related to competition as a plausible mechanism. This additional channel is not documented in the existing literature.

As for the rest of the paper, the next section details the methods I use in the analysis. Section 3 presents the main results, and section 4 describes the robustness checks. Section 5 summarizes the results and concludes.

2. Empirical Strategy and Data

2.1 Empirical strategy

I use a firm-level gravity framework to investigate the exports effects of temperature variations.

General Specification. To investigate the effect of temperatures in destination *j* on export outcomes of firm *i* in year *t*, I first estimate the following specification:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta Controls_{jt} + \delta FirmSize_{it-1} + FE + \varepsilon_{ijt} \qquad (1)$$

I regress the export outcome of firm *i* in year *t* in destination market *j* on the temperature shocks in that market, denoted $Temp_{jt}$. I include in $Controls_{jt}$ a set of country-year trade determinants such as GDP and exchange-rate level that are other candidates than temperatures to explain the export patterns. I control for firm size using a set of covariates denoted $FirmSize_{it-1}$. I consider many measures of firm size: the benchmark measure is the lagged total exports of the firm. I will also consider lagged assets size as well as lagged labor productivity (defined as value added per worker). All these firm size proxies are measured at the end of year *t-1* to avoid endogeneity.

I control for unobserved heterogeneity using sets of fixed effects, denoted FE. I first include firm x country fixed effects, to control for unobserved relationships between a firm and a foreign market. For instance, a firm may be related to one market by historical links or by culture. When included, the coefficient is estimated from the time variation within a firm-destination observation. This fixed effect controls for all time-invariant destination-specific trade determinants, including distance to France for instance. I also include a firm x year FE to control for the effect of time-varying unobserved firm characteristics on export outcomes. This fixed effect absorbs the unobserved trade determinants at the firm-year level, including the local weather conditions, changes in labor productivity, etc. Including these two fixed effects implies that the main coefficients are identified within a destination across years and then compared across destinations for a given firm[4].

Heterogeneous effects across firms.

Next, the data at hand allows the investigate the heterogeneous effect of foreign weather shocks across exporters. To do so, I estimate the following augmented specification:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta Controls_{jt} + \delta FirmSize_{it-1} + \gamma\left(Temp_{jt} \times FirmSize_{it-1}\right) + FE + \varepsilon_{ijt} \quad (2)$$

in which γ is of interest. While α measures the (average) elasticity of exports to temperatures, γ measures the conditional impact of firm size controls on this elasticity. A negative γ means that firm size magnifies the negative impact of temperatures on trade flows: the negative impact of rising temperatures on trade flows is increased for large firms compared to small ones. I finally consider including a country-year fixed effect in some specifications, to provide a complete "within" estimation. This country-year FE absorbs the variance across market-year couples (in particular the "multilateral resistance" terms) and only focuses on variation across firms within each couple. In that case, I only identify the *differential* impact of size on the trade elasticity to temperatures, controlling for total exports to that market by French exporters.

[4] The two restrictions imposed by the exclusion of singletons are not neutral. Compared to the full universe of exporters, my estimation sample excludes firms serving 1 destination or being present 1 year only. This creates an upward bias in the firm size compared to the full exporters' universe.

Potential Mechanisms

Finally, I will study the potential mechanisms through which foreign weather shocks affect firm-level exports. To do so, I will estimate the following specification:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta Controls_{jt} + \delta FirmSize_{it-1} + \gamma\left(Temp_{jt} \times FirmSize_{it-1}\right) + \eta\left(Control_{jt} \times FirmSize_{it-1}\right) + FE + \varepsilon_{ijt} \quad (3)$$

in which I include the additional term $\left(Control_{jt} \times FirmSize_{it-1}\right)$. Including this term challenges the estimated γ, by allowing the destination characteristics to have some influence on the export outcomes and to interact with firm observables. This specification includes both the interactions between foreign temperatures and firm characteristics on the one hand, and the interaction between country-level observables (as potential mechanisms) and firm characteristics on the other hand. As a result, leaving η unrestricted will challenge the significance of γ and inform on the mechanisms through which weather affects exports. Suppose for instance that temperatures affect exports only through GDP. Simultaneously controlling for GDP changes should dampen the impact of temperatures on exports, γ. More generally, the destination-specific controls (such as GDP) that lead to a significant η and to a non-significant γ can then be interpreted as driving the effect of temperatures on exports. I will consider many destination characteristics which are plausible mechanisms: GDP, distance, competition, quality of governance, etc.

Trade Margins and Estimations Issues.

I study both the intensive and the extensive margin of trade. Regarding the intensive margin of trade, the primary outcome is the log export value of the firm to each destination (X_{ijt}). I also consider the product-intensive margin (Fontagné, Orefice, and Piermartini (2020)) and compute the average exports value per HS6 product. As for the extensive margin, I focus on the number of HS6 products exported by firms at the destination-year level (Arkolakis, Ganapati, and Muendler (2010)).

Baseline estimations are obtained using an OLS estimator. For robustness, I will consider using a pseudo-poisson maximum likelihood (PPML) estimator (Santos Silva and Tenreyro (2006)). In all estimations, I cluster the standard errors at country-year level, because temperature variations occur at this level of aggregation.

2.2. Data

This analysis combines 3 main datasets: (i) firm-level trade data on French export flows, (ii) firm size controls, and (iii) weather variables. Table A7 in the appendix provides the descriptive statistics of my sample.

Firm-level trade data. I use firm-level trade data from the French customs over the period 1995-2009. This database reports exports for each firm, by destination and year over our sample period. It reports the volume (in tons) and value (in Euros) of exports for each CN8 product (European Union Combined Nomenclature at 8 digits) and destination, for each firm located on the French metropolitan territory. Some shipments are excluded from this data collection, but these are related to a very small proportion of total exports.[5] For the econometric exercise, I censorize the sample, excluding the top and bottom 1% in export value and in export value growth rate over one year. This dataset allows me to aggregate exports and imports at the firm-destination-year level, to identify the set of HS6 products exported, the number of destinations served, and other outcomes used in the empirical analysis. I will also rely on this dataset to proxy competition intensity in any destination-year, by computing (i) the number and (ii) the average size of French exporters by destination-year.

Weather Variables. As a baseline measure for weather conditions, I use the country-year temperature data, from the Climatic Research Unit of the University of East Anglia (CRU version v4.02) ((Harris et al. (2014))). It provides a set of country-year average temperatures for the sample period. I use the *raw* average level of temperatures and do not compute any difference, change or variation by myself. Instead, my empirical strategy will be based upon fixed effects, such that identification comes from within-country and cross-country variations in temperatures. As controls, I will use other variables such as total precipitations and average humidity from the same source.

As robustness measures of temperatures, I follow the literature (mainly in agricultural economics) and convert daily mean temperatures into yearly degree-days, with thresholds at 32°C and 34°C (Burke, Hsiang, and Miguel (2015); Schlenker and Roberts (2009)).

Firm-level controls. I also use firm-level data contained in the dataset called BRN (*Benéfices Réels Normaux*) which provides balance-sheet data, i.e. value added, total sales, employment, capital stock and other variables.[6] The BRN database is constructed from reports of French firms to the tax administration, which are transmitted to INSEE (the French Statistical Institute). The BRN dataset

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[5] A more detailed description of the database is provided by (Eaton, Kortum, and Kramarz (2011)). Inside the European Union, firms are required to report their shipments by product and destination country only if their annual trade value exceeds the threshold of 150,000 Euros. For exports outside the EU all flows are recorded, unless their value is smaller than 1,000 Euros or one ton.

[6] A more detailed description of the database is provided in Berman, Martin and Mayer (2012).

contains between 650,000 and 750,000 firms per year over the period (around 60% of the total number of French firms). Importantly, this dataset is composed of both small and large firms, since no threshold applies on the number of employees. Balance-sheet and customs data can be merged using the firm identifier (SIREN number) and the year. Depending on the year, these firms represent between 90% and 95% of French exports contained in the customs data.

Other macroeconomic variables. Other macroeconomic variables, such as GDP, exchange rate level, or TFP in destination come from the Penn World Tables. I also include proxies of country-specific risks from the World Bank Governance Indicators gathered in (Teorell et al. (2019)). I also use the estimates of market potential from Head and Mayer (2004) to complement customs-derived measures of competition on destination markets.

3. Main Results

3.1 Average Impact of Foreign Temperatures

Table 1 estimates the impact of foreign temperatures on firm-level exports. Standard trade determinants have the expected signs and precision: GDP, real exchange rate and all measures of firm size positively impact firm-level exports. Columns 1 and 2 estimate a significant negative effect of foreign temperatures on firm-level exports. On average, estimates suggest a 1% decrease in exports following a 10% increase in temperatures (evaluated at the mean temperature). This result appears to be modest: the average export flow is hardly deterred by foreign temperatures. Besides, this effect is not precisely estimated: large standard errors (clustered at the country-year level) are estimated, despite a large sample size. The negative but modest impact of foreign temperatures is stable across specifications, allowing additional measures of firm size (col. 2), additional fixed effects (from col. 3 onwards) or including additional weather covariates such as total precipitations (in mm) and average humidity index (column 4 onwards). Allowing for non-linear effects of temperatures (Burke, Hsiang, and Miguel (2015); Deryugina and Hsiang (2017)) in column 5 does not alter the main message: foreign temperatures are always estimated to deter the average exports at the firm level but remain modest. The same conclusion is reached in column 6 which controls for lagged temperatures.

3.2 Average Effects Across Trade Margins

There are many explanations for this modest effect of foreign temperatures. Indeed, this coefficient is the elasticity of the average export flow in the sample. Yet, exports are highly heterogeneous both within firms and across firms. Aggregation issues are a plausible explanation for this modest effect.

On the one hand, there may be some *within-firm* aggregation issues. Table 2 digs further in this direction. Table 2 shows the different trade margins along which this negative impact occurs. Columns 1 and 2 decompose the total export value effect into a quantity and a price (unit value) effect. Export quantities are the main adjustment margin whereas exports' average prices are unaffected by foreign weather shocks (column 2). Columns 3 and 4 decompose the total trade effect into a product-intensive and product-extensive margin (using a terminology also used in Fontagné et al. 2020). The average export value per product (defined as the ratio of total exports to the number of HS6 products) decreases by the same amount as total exports (col. 3). On the contrary, the number of products (extensive margin) is unaffected by foreign weather shocks. This result is important as it excludes a potential channel of adjustment. Evidence does not support within-firm product rationalization as an adjustment mechanism. Rather, all products' exports are deterred. The effect of weather shocks does not go through a differential effect across products, but rather that all products exports are deterred. To further support this idea, column 5 shows that even exports of the best product (i.e., the one with the highest export value – per destination-year) are deterred, with a close magnitude to the average exports' elasticity, thereby excluding product churning.

3.3 Heterogeneity across firms

Another explanation for a modest aggregate impact of foreign temperatures on exports is the heterogeneity *across firms*. Table 3 investigates the heterogeneous impact of weather shocks across exporters. Taking advantage of the wide array of firm observables in our sample, I allow the impact of foreign weather shocks to have differential effects along the line of specification (2). Table 3 supports that, beyond the average effect, foreign weather shocks have significant heterogeneous effects across firms.

I consider the three main firm size measures presented above: lagged exports in columns 1 and 2, lagged assets in columns 3 and 4, and lagged labor productivity in columns 5 and 6. All interactions between foreign temperatures and lagged firm size measures are significantly, and negatively associated with firm-level exports. Conditional on the level of temperatures abroad, the larger the firm, the more negative the impact of temperatures. In other words, small exporters do not experience any decrease in their exports, but large exporters significantly lower their exports. In quantitative terms, the export elasticity to temperatures for firms at the 90th percentile of the lagged total exports distribution is around -0.3 whereas it is only -0.05 (point estimate) for firms at the 10th percentile.

The negative average impact of foreign temperatures is thus driven by the largest firms. Indeed, in columns 1, 3, and 5, the impact of foreign temperatures on exports is hardly significant for the smallest firms in sample[7]. This result is important as it shows that all firms are not homogeneously affected by foreign temperature shifts. On the contrary, only the top firms' exports are significantly and meaningfully deterred by these shocks. When the specification includes destination-year fixed effect, identification stems from variation in exports across time and across firms serving the same destination market: results can be interpreted in terms of market shares in the destination market. The larger the firm, the more negative is the effect of the temperature shock on relative sales across (French) sellers in this market.

The interaction coefficients in the above regressions capture the *average* differential effect across firms of temperatures. Figure 1 digs further into the relationship between the average effect of temperatures and the cross-firm differential effects. For each measure of firm size (highlighted in Table 3), this figure plots the decile-specific response of firm-level exports:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta Controls_{jt} + \sum_{d=1}^{10} \alpha_d 1[Decile_{it-1} = d] \times Temp_{jt} + FE + \varepsilon_{fjt}$$

Figure 1 (panels A, B, and C) plots the estimated coefficients α_d and the 5% confidence interval for each decile. Results confirm the magnitudes of the differential impact from previous estimations. Foreign temperatures deter exports *only* for major firms whereas small firms' exports are hardly deterred.

3.4 Potential Mechanisms

Table 4 investigates the potential mechanisms driving the differential effect of temperatures across exporters, and the modest aggregate impact, using specification (3) described above. The main specification now includes an interaction term between a potential channel of transmission and firm size, on top of the initial interaction with temperatures. The objective of this model is to challenge the point estimate of the (differential effect of) temperatures (displayed in Table 3, column 2 for instance).

On the one hand, as argued in the introduction, temperature shocks in a foreign country may act as a revenue shock. Foreign productivity may be deterred by temperatures and aggregate revenues may

[7] In a specification with both temperatures and the interaction between temperatures and firm size, the coefficient associated to temperatures identifies the effect of temperatures for firms that have a very low value of firm size.

decrease after temperature shocks. This may impact aggregate import demand. On the other hand, export supply may also be affected. I consider that, beyond GDP, foreign weather shocks may affect the set of competitors serving this destination. Consider for instance a weather shock in Mexico. Mexican firms may be harmed by the shock (because of adverse labor productivity shocks, decreasing labor supply, loss in agricultural yields, …) such that *domestic* firm selection is tougher on the local market.[8] Besides, this change in local competition may trigger additional general-equilibrium changes in *foreign* competition (from the US for example). Third, previous results show that temperatures have a differential effect across firms, implying reallocation of market shares *across foreign firms* from a specific exporting country (France in our case). As a result, a destination could experience a change in both the number of foreign firms and their average size, which in turn affects competition, and thus firm-level exports. I consider these explanations as supply-side mechanisms.

I find support in favor of both demand and supply channels. Table 4, column 1 shows that the negative impact of temperatures is smaller, once accounting for GDP changes. Precisely, increases in GDP would be a way to overcome the negative and differential impact of temperature shocks. Yet, results also imply that GDP changes are not sufficient to explain the export patterns after temperature shifts: the negative impact of temperatures remains significant when accounting for GDP changes. Column 2 brings the same conclusion by controlling for simultaneous changes in destination. Part of the effect of temperature variation on exports goes through a change in demand.

Regarding supply-side considerations, I use three measures of competition in each destination. First, I use the number of French exporters serving each destination-year. Table 4 column 3 shows that the negative impact of temperatures gets hardly significant, once accounting for changes in the number of French exporters across destinations. Considering that temperatures potentially affect the number of French sellers in the destination, the remaining effect of temperatures is getting close to 0. Note that the significance of this result is much more challenged than when controlling for GDP. Then, column 4 goes in the same direction by highlighting the role of the size of the competitors. Beyond their number, I use the weighted average size of the French exporters serving a destination-year, in terms of assets (to avoid endogeneity with export outcomes). Column 5 includes all demand and supply-side mechanisms, leading to close to null "residual" effect of foreign temperatures. To confirm this result, column 6 uses the estimates of market potential from Head and Mayer (2004) to measure

[8] On a related topic, Nedoncelle and Wolfersberger (2022) find that when facing local weather shocks, small exporters are disproportionately harmed compared to larger exporters. Whereas it does not show evidence on the domestic market, it supports that firm selection may be at play when weather shocks occur.

competition in destination markets and the results confirm the conclusion (even though the market potential data goes up to 2003, i.e. half of our time period).

Overall, both demand-side and supply-side mechanisms are at play. GDP acts as a plausible but remains a partial explanation to the effect of temperatures. Competition changes and strategic interactions are plausible additional mechanisms through which temperatures affect exports.

3.5 Aggregate Implications

Table 5 finally claims that the differential effects (documented in Table 3) determine the *average* exporter under foreign temperature shocks. Table 3 documented that, conditional on the temperature shock, large firms exhibit larger trade-deterring effects than smaller firms. How large are these composition effects?

To answer, I aggregate the data at the destination j -year t and estimate the following specification:

$$AverageCharact_{jt} = \beta_0 + \beta_1 Temp_{jt} + \beta_2 Controls_{jt} + \lambda_j + \lambda_t + \varepsilon_{jt} \qquad (4)$$

in which $AverageCharact_{jt}$ is a weighted average measure of exporters' characteristics serving market jt. I thus estimate the correlation between temperatures variations and the average size of exporters, controlling for other market-specific determinants (such as GDP), and absorbing unobserved heterogeneity using fixed effects (across markets, λ_j capturing distance with France for instance, and years λ_t). If there was no compositional effect associated to temperatures, β_1 would be non-significant. On the contrary, a significant β_1 implies a composition effect. Standard errors are clustered at the destination level (Bertrand, Duflo and Mullainathan 2004; Cameron and Miller 2015).

Table 5 confirms the existence of composition effects. Columns 1 to 3 display a negative correlation between average (lagged) exports size of firms and temperatures, controlling for other trade determinants and for distance. When temperatures increase, exports are tilted towards smaller firms, in terms of lagged exports (col. 1), lagged assets (col. 2) and lagged productivity (col. 3). Besides, in column 4, temperature increases tilt exports towards higher-price firms on average. This last regression strongly supports the composition effects: previous evidence (Table 2, column 2) showed that individual firms' prices are uncorrelated to temperatures. Yet, this result supports that temperature increases are correlated to higher prices and cannot be the result of distance (absorbed in the fixed effects), nor to changes in individual prices. Price increases are driven by composition changes across exporters. When temperatures increase, high-price, small exporters expand relatively to low-price high productivity firms in the destination market.

4. Robustness checks

4.1 Omitted Destination Characteristics.

Table A1 checks that temperature variations do not overlap with other country-specific observables and trade determinants. First, column 1 includes the time-invariant destination's distance from France in the discussion. Temperature variations may be higher for distant countries. In this case, the negative coefficient recovered from the interaction between temperatures and firm size could be driven by different export dynamics, between small and large firms, in remote, "difficult" destinations, also facing different temperature changes. This explanation is true but cannot explain the differential pattern across firms. Column 1 estimates a significant difference between small and large firms in their export variation under temperature changes both in close and distant markets.

Second, temperatures might also be confounded with other country-specific risks. Countries with increasing temperatures may also be riskier countries. I use the country-year measures of the "Political Stability and Absence of Violence" indicator as a proxy for country-specific risk (Teorell et al. 2019). Higher quality of institution (lower risk) is associated with higher exports even more for bigger firms, and this control does not affect the magnified effect of temperature along firm size. Increases in temperatures have something specific to them that cannot be controlled for by other dimensions of country-specific risks.

Columns 3 to 6 allow the exchange rates, the other weather variables, and lagged temperatures to have a differential effect across firms, without affecting the significance of the differential effect of temperatures across firms.

4.2 Sensitivity to Measures of Temperatures

Baseline estimates used the average destination-year mean temperature. For robustness, I use data from the NOAA Global Historical Climatology Network, Daily (GHCN-D) (Menne et al. (2012)), providing averaged temperatures at the weather station-country-day dimensions $T_{w(j)dt}$. I aggregate the data into 3 measures at the country-year level.

I first aggregate the data at the country-day year (T_{jdt}), and then aggregate the daily measures into yearly degree-days (DD_{jt}) using the following computation

$$DD_{jt} = \begin{cases} 0 & if\ T_{jdt} < 8 \\ T_{jdt} - 8 & if\ 8 < T_{jdt} < 32 \\ 24 & if\ T_{jdt} > 32 \end{cases}$$

This measure captures the cumulative number of days of high temperatures and the intensity of the high temperatures (pairwise correlation with average temperature= 0.875). Second, the same computation can be made using a threshold of 34°C instead of 32°C (pairwise correlation with DD_{jt} $(32°C) = 0.991$). Thirdly, *harmful* degree-days (intensity of very high temperatures only) are defined as:

$$HDD_{jt} = \begin{cases} 0 & if\ T_{jdt} < 34 \\ T_{jdt} - 34 & if\ T_{jdt} > 34 \end{cases}$$

(Pairwise correlation with average temperature = 0.588, pairwise correlation with DD_{jt} = 0.720).

Table A2 shows results when considering these three alternative measures. Results confirm (i) the insignificant average effect of foreign temperatures on firm-level exports, (ii) the larger trade-deterring effect of firm size, leading to a differential effect across firms, and (iii) that both demand- and supply-side mechanisms can explain the observed export pattern across firms.

4.3 Alternative Measures of Firm Size

The differential effects of temperatures across firms holds independent of the choice of the proxy of firm size. Table A3 considers various firm size proxies: TFP, value-added, employment at the end of year t-1, number of destinations served, number of HS6 products, and number of products-destinations served. All estimates are significant and negatively associated with firm-level exports, supporting the increasingly negative impact of foreign temperatures along firm size.

4.4 Role of imports

Foreign temperature shocks do not affect exports through simultaneous imports shifts. Indeed, foreign temperature shocks may affect the price and quantities of imported inputs that in turn could affect firm-level export outcomes. Table A4 explicitly controls for imports from country *j* using a dummy capturing whether firm *i* imports from country *j* in year *t* or not. The main coefficient is unchanged when controlling for the import status. Being an importer is significantly and positively correlated with firm-level exports and the negative impact of temperatures is dampened for firms that simultaneously import from the same country. While the size of the firm magnifies the negative effect of temperatures, being an importer tends to dampen this effect. Imports thus seem to act as a natural hedging mechanism against temperature shocks. This result is in line with existing evidence regarding natural hedging strategies against country-specific shocks in trade (as in Héricourt and Nedoncelle (2018) for instance).

4.5 Alternative Estimator: PPML

Table A5 shows results when considering a PPML estimator (Santos Silva and Tenreyro 2006) including the zero trade flows. All main results hold despite the change of estimator and the inclusion of zero-trade flows. Coefficients and standard errors are very close to the OLS results in significance and magnitude.

4.6 Subsamples: Agricultural and Manufacturing Exports

Table A6 replicates the baseline estimations separating export flows between agricultural exports (HS2 chapters 1 to 27) and manufacturing exports (HS2 chapters 28 to 96). All main results hold in both subsamples, further highlighting that results are not driven by agricultural goods only.

5. Conclusions

In this paper, I shed light on the effect of foreign weather shocks on firm-level exports. This is, to my knowledge, the only paper that investigates the impact of remote weather shocks. I exploit the French firm-level customs data from 1995 to 2009 and estimate a theory-consistent firm-level gravity model to estimate (i) the average effect of foreign temperatures and (ii) the differential effect across exporters facing the same foreign shock.

I do not find support for a meaningful negative impact of foreign temperatures on average but estimate a robust and strong differential effect across exporters. I find that the main cross-firm determinant of the impact is firm size, independently of the measure of this size. Whereas the main effect is across exporters, I do not estimate any price effect nor any within-firm rationalization (across products for instance).

On the way, an open question about these foreign temperature shocks is related to the mechanisms through which these shifts affect export outcomes. I tackle this issue and show that both demand-side and supply-side mechanisms are at play. Precisely, whereas most of the literature points towards negative import demand shock as the main mechanism, I find that these demand-side effects are only part of the mechanism. I hypothesize that competition in the foreign market is affected by foreign temperatures and results confirm the role of these supply-side effects. Competition changes and strategic interactions are plausible additional mechanisms through which temperatures affect exports.

Evidence in this paper calls for additional future research regarding the impact of these temperature-led changes. Some of these avenues are related to the consequences of these shocks for foreign consumers. Indeed, composition effects are not neutral for consumers in hotter markets. The average performance of the firms from which foreign consumer import is affected by weather shocks. As large firms reduce their presence in these markets, consumers may be forced to import ``lower quality'' goods and inputs, which may affect aggregate outcomes in the foreign country. These mechanisms deserve additional research, in a climate change context.

References

ARKOLAKIS, C., S. GANAPATI, AND M.-A. MUENDLER. (2010): The Extensive Margin of Exporting Products: A Firm-Level Analysis, NBER Working Papers, National Bureau of Economic Research, Inc.

BAS, M., T. MAYER, AND M. THOENIG. (2017): "From micro to macro : Demand , supply , and heterogeneity in the trade elasticity," *Journal of International Economics*, 108, 1–19.

BERMAN, N., P. MARTIN, AND T. MAYER. (2012): " How do Different Exporters React to Exchange Rate Changes? *," *The Quarterly Journal of Economics*, 127, 437–92.

BERTRAND, M., E. DUFLO, AND S. MULLAINATHAN. (2004): "How Much Should We Trust Differences-In-Differences Estimates?," *The Quarterly Journal of Economics*, 119, 249–75.

BURKE, M., S. M. HSIANG, AND E. MIGUEL. (2015): "Global non-linear effect of temperature on economic production," *Nature*, 527, 235–39.

BURKE, M., AND V. TANUTAMA. (2019): Climatic Constraints on Aggregate Economic Output,Cambridge, MA: National Bureau of Economic Research, W25779.

CACHON, G. P., S. GALLINO, AND M. OLIVARES. (2012): "Severe weather and automobile assembly productivity," *Columbia Business School Research Paper*, .

CARLETON, T. A., AND S. M. HSIANG. (2016): "Social and economic impacts of climate," *Science*, 353, aad9837.

CHEN, S., X. CHEN, AND J. XU. (2016): "Impacts of climate change on agriculture: Evidence from China," *Journal of Environmental Economics and Management*, 76, 105–24.

COLACITO, R., B. HOFFMANN, AND T. PHAN. (2019): "Temperature and Growth: A Panel Analysis of the United States," *Journal of Money, Credit and Banking*, 51, 313–68.

COLIN CAMERON, A., AND D. L. MILLER. (2015): "A Practitioner's Guide to Cluster-Robust Inference," *Journal of Human Resources*, 50, 317–72.

DALLMANN, I. (2019): "Weather Variations and International Trade," *Environmental and Resource Economics*, 72, 155–206.

DELL, M., B. F. JONES, AND B. A. OLKEN. (2012): "Temperature shocks and economic growth: Evidence from the last half century," *American Economic Journal: Macroeconomics*, 4, 66–95.

---. (2014): "What Do We Learn from the Weather? The New Climate-Economy Literature," *Journal of Economic Literature*, 52, 740–98.

DERYUGINA, T., AND S. HSIANG. (2017): The Marginal Product of Climate,Cambridge, MA: National Bureau of Economic Research, W24072.

DESCHÊNES, O., AND M. GREENSTONE. (2007): "The economic impacts of climate change: evidence from agricultural output and random fluctuations in weather," *American Economic Review*, 97, 354–85.

EATON, J., S. KORTUM, AND F. KRAMARZ. (2011): "An Anatomy of International Trade: Evidence From French Firms," *Econometrica*, 79, 1453–98.

FONTAGNÉ, L., G. OREFICE, AND R. PIERMARTINI. (2020): "Making small firms happy? The heterogeneous effect of trade facilitation measures," *Review of International Economics*, 28, 565–98.

GRAFF ZIVIN, J., S. M. HSIANG, AND M. NEIDELL. (2018): "Temperature and human capital in the short and long run," *Journal of the Association of Environmental and Resource Economists*, 5, 77–105.

HARRIS, I., P. D. JONES, T. J. OSBORN, AND D. H. LISTER. (2014): "Updated high-resolution grids of monthly climatic observations – the CRU TS3.10 Dataset," *International Journal of Climatology*, 34, 623–42.

HEAD, K., AND T. MAYER. (2004): "Market potential and the location of Japanese investment in the European Union," *Review of Economics and Statistics*, 86, 959–72.

---. (2014): "Chapter 3 - Gravity Equations: Workhorse,Toolkit, and Cookbook," in *Handbook of International Economics*, ed. by Gopinath, G., E. Helpman, and K. Rogoff. . Handbook of International EconomicsElsevier, 131–95.

HEAL, G., AND J. PARK. (2016): "Reflections—temperature stress and the direct impact of climate change: a review of an emerging literature," *Review of Environmental Economics and Policy*, 10, 347–62.

HÉRICOURT, J., AND C. NEDONCELLE. (2018): "Multi-destination firms and the impact of exchange-rate risk on trade," *Journal of Comparative Economics*, 46, 1178–93.

HSIANG, S. M. (2010): "Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America," *Proceedings of the National Academy of sciences*, 107, 15367–72.

IMBS, J., AND I. MEJEAN. (2015): "Elasticity Optimism," *American Economic Journal: Macroeconomics*, 7, 43–83.

JONES, B. F., AND B. A. OLKEN. (2010): "Climate Shocks and Exports," *American Economic Review*, 100, 454–59.

KARLSSON, J. (2021): "Temperature and Exports: Evidence from the United States," *Environmental and Resource Economics*, 80, 311–37.

LI, C., X. XIANG, AND H. GU. (2015): "Climate shocks and international trade: Evidence from China," *Economics Letters*, 135, 55–57.

MAYER, T., M. J. MELITZ, AND G. I. P. OTTAVIANO. (2014): "Market Size, Competition, and the Product Mix of Exporters," *American Economic Review*, 104, 495–536.

MENDELSOHN, R., W. D. NORDHAUS, AND D. SHAW. (1994): "The impact of global warming on agriculture: a Ricardian analysis," *The American Economic Review*, , 753–71.

MENNE, M. J., I. DURRE, B. KORZENIEWSKI, S. MCNEILL, K. THOMAS, X. YIN, S. ANTHONY, ET AL. (2012): "Global Historical Climatology Network - Daily (GHCN-Daily), Version 3,"NOAA National Centers for Environmental Information.

MOORE, F. C., AND D. B. LOBELL. (2015): "The fingerprint of climate trends on European crop yields," *Proceedings of the National Academy of sciences*, 112, 2670–75.

NEDONCELLE, C., AND J. WOLFERSBERGER. (2022): "Temperatures, Firm Size and Exports in Developing Countries," *hal-03753384*, .

OSBERGHAUS, D. (2019): "The Effects of Natural Disasters and Weather Variations on International Trade and Financial Flows: a Review of the Empirical Literature," *Economics of Disasters and Climate Change*, , 1–21.

SANTOS SILVA, J., AND S. TENREYRO. (2006): "The Log of Gravity," *The Review of Economics and Statistics*, 88, 641–58.

SCHLENKER, W., AND D. B. LOBELL. (2010): "Robust negative impacts of climate change on African agriculture," *Environmental Research Letters*, 5, 14010.

SCHLENKER, W., AND M. J. ROBERTS. (2009): "Nonlinear temperature effects indicate severe damages to US crop yields under climate change," *Proceedings of the National Academy of sciences*, 106, 15594–98.

TEORELL, J., S. DAHLBERG, HOLMBERG SÖREN, ROTHSTEIN BO, N. ALVARADO PACHON, AND R. SVENSSON. (2019): *The Quality of Government Standard Dataset, Version Jan19*, University of Gothenburg. The Quality of Government Institute.

Tables

Table 1 - Average Impact of Foreign Temperatures

	Dep. Variable: ln X_{ijt}					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures	-0.118*	-0.117*	-0.147**	-0.134**	-0.281*	-0.258*
	(0.067)	(0.067)	(0.069)	(0.068)	(0.163)	(0.135)
GDP	0.481***	0.485***	0.459***	0.458***	0.459***	0.441***
	(0.054)	(0.054)	(0.053)	(0.053)	(0.053)	(0.055)
RER	0.040	0.040	0.062**	0.065**	0.065**	0.054*
	(0.027)	(0.027)	(0.025)	(0.026)	(0.026)	(0.028)
Firm Exports (t-1)	0.403***	0.344***				
	(0.010)	(0.010)				
Assets (t-1)		0.293***				
		(0.005)				
Labor Prod. (t-1)		0.055***				
		(0.003)				
Precipitations				-0.116**	-0.118**	-0.054
				(0.057)	(0.057)	(0.057)
Humidity				0.158*	0.161*	0.119
				(0.083)	(0.083)	(0.085)
Temperatures x Temp.					0.055	
					(0.061)	
Temperatures (t-1)						-0.245**
						(0.118)
Temperatures x Temp. (t-1)						0.094
						(0.090)
Observations	2425255	2425255	2422711	2422711	2422711	1745303
R^2	0.799	0.799	0.840	0.840	0.840	0.857
Firm-Destination FE	x	x	x	x	x	x
Firm-Year FE			x	x	x	x
Year FE	x	x				

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level.

Table 2 - Average Effects Across Trade Margins

Dep Variable:	Quantity	Unit Value	Av. X/Prod.	Nb. Prod.	Exports (Main Prod.)
	(1)	(2)	(3)	(4)	(5)
Temperatures	-0.199***	0.048	-0.134**	-0.013	-0.146**
	(0.076)	(0.032)	(0.055)	(0.028)	(0.065)
GDP	0.554***	-0.101***	0.380***	0.078***	0.444***
	(0.057)	(0.021)	(0.039)	(0.022)	(0.049)
RER	-0.002	0.065***	0.001	0.061***	0.047**
	(0.029)	(0.010)	(0.020)	(0.010)	(0.024)
Observations	2374473	2374473	2422711	2422711	2422711
R^2	0.888	0.927	0.836	0.846	0.836

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year and firm-destination fixed effects.

Table 3 - Heterogeneity across firms

	Dep. Variable: ln X_{ijt}					
Firm size measure	*Firm Exports (t-1)*		*Assets (t-1)*		*Labor Prod. (t-1)*	
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures	0.367**		-0.143**		-0.140**	
	(0.178)		(0.069)		(0.068)	
Temperatures x Firm Size	-0.035***	-0.053***	-0.052***	-0.048***	-0.031***	-0.029***
	(0.011)	(0.010)	(0.012)	(0.010)	(0.008)	(0.006)
GDP	0.463***		0.454***		0.456***	
	(0.054)		(0.054)		(0.054)	
RER	0.061**		0.064**		0.064**	
	(0.025)		(0.025)		(0.025)	
Observations	2422711	2422711	2422711	2422711	2422711	2422711
R^2	0.840	0.841	0.840	0.841	0.840	0.841
Destination-Year FE		x		x		x

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year and firm-destination fixed effects.

Table 4 - Potential Mechanisms

	Dep. Variable: $\ln X_{ijt}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures x Firm Size	-0.034***	-0.041***	-0.013*	-0.032***	-0.012*	0.003
	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)	(0.008)
Destination GDP x Firm Size	0.048***	0.048***	0.032***	0.048***	0.032***	0.038***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
Destination TFP x Firm Size		0.142***				
		(0.020)				
Nb. Fr. Exporters x Firm Size			0.061***		0.060***	
			(0.005)		(0.005)	
Average Size Fr. Exporters x Firm Size				-0.024***	-0.015***	
				(0.005)	(0.005)	
Market Potential x Firm Size						0.029***
						(0.004)
Observations	2542849	2378090	2542849	2542849	2542849	1391093
R^2	0.839	0.842	0.839	0.839	0.839	0.867

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year, firm-destination, and destination-year fixed effects. Firm Size is measured by the lagged total firm exports (over all destinations). See details in text.

Table 5 - Aggregate Implications: Composition effect

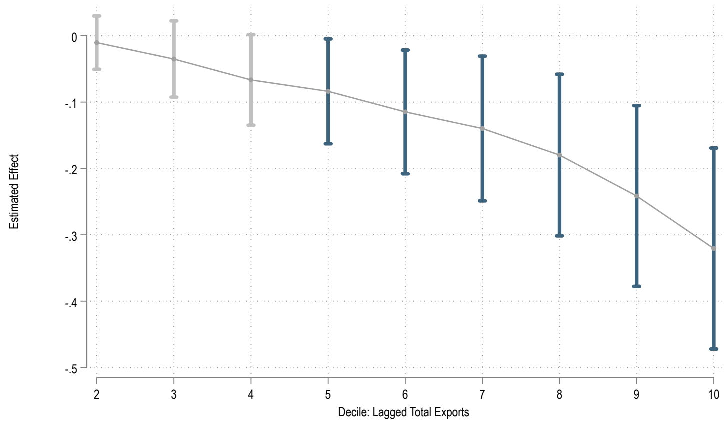
Dep. variable	Mean Total Exports	Mean Assets	Mean Labor Prod.	Mean Unit Values
	(1)	(2)	(3)	(4)
Temperatures	-0.237*	-0.506*	-0.242*	1.027***
	(0.121)	(0.258)	(0.142)	(0.276)
Observations	1750	1750	1750	1750
R^2	0.922	0.587	0.766	0.689

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the destination level. All columns include destination-specific and year-specific fixed effects. All columns include destination GDP and RER as controls.

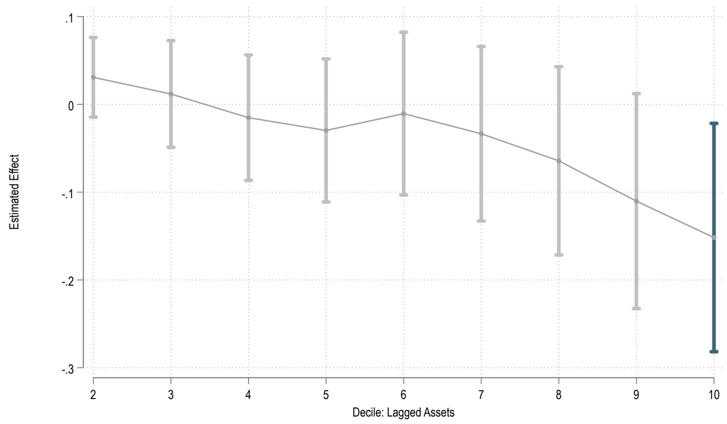
Figures

Figure 1 - decile-specific response of firm-level exports to temperatures.

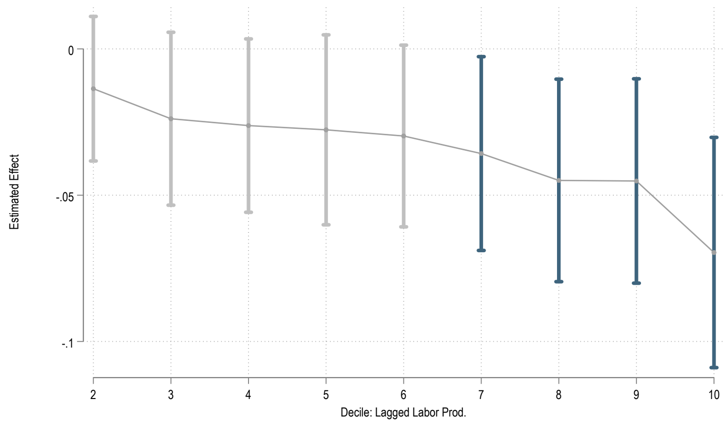
A Decile of lagged exports



B Deciles of lagged assets



C Deciles of lagged labor productivity



Appendix - Not for publication.

Table A1 – Potential Omitted Destination Characteristics.

	Dep. Variable: ln X_{ijt}					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures x Firm Size (t-1)	-0.020**	-0.040***	-0.023**	-0.061***	-0.043***	-0.028**
	(0.009)	(0.011)	(0.009)	(0.009)	(0.009)	(0.012)
Distance x Firm Size (t-1)	-0.058***					
	(0.006)					
Pol. Stab. x Firm Size (t-1)		0.019***				
		(0.004)				
RER x Firm Size (t-1)			0.034***			
			(0.002)			
Precipitations x Firm Size (t-1)				-0.008**		
				(0.004)		
Humidity x Firm Size (t-1)					0.027***	
					(0.006)	
Temp. (t-1) x Firm Size (t-1)						-0.026**
						(0.012)
Observations	2542849	1805882	2422711	2542849	2542849	1825693
R^2	0.839	0.849	0.841	0.839	0.839	0.856

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year, firm-destination, and destination-year fixed effects. Firm Size is measured by the lagged total firm exports (over all destinations). See details in text.

Table A2 - Sensitivity to Measures of Temperatures

	Dep. Variable: ln X_{ijt}								
Measure of temperatures	*Degree-Days (8C-32C)*			*Degree-Days (8C-34C)*			*Harmful Degree Days (>34C)*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Temperatures	-0.028			-0.023			0.015**		
	(0.071)			(0.070)			(0.006)		
GDP	0.519***			0.519***			0.535***		
	(0.073)			(0.073)			(0.077)		
RER	-0.126***			-0.125***			-0.141***		
	(0.047)			(0.047)			(0.047)		
Temp. x Firm Size (t-1)		-0.058***	-0.032***		-0.058***	-0.032***		-0.008***	-0.002*
		(0.011)	(0.008)		(0.011)	(0.007)		(0.002)	(0.001)
GDP x Firm Size(t-1)			0.032***			0.031***			0.024***
			(0.004)			(0.004)			(0.004)
Nb. Fr. Exporters x Firm Size (t-1)			0.058***			0.058***			0.079***
			(0.007)			(0.007)			(0.007)
Average Size Fr. Exporters x Firm Size (t-1)			-0.022***			-0.022***			-0.018***
			(0.007)			(0.007)			(0.006)
Observations	2184574	2102361	2184574	2184574	2102361	2184574	1659282	1587236	1659282
R^2	0.843	0.846	0.845	0.843	0.846	0.845	0.848	0.852	0.850
Destination-Year FE		x	x		x	x		x	x

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year and firm-destination fixed effects. Firm Size is measured by the lagged total firm exports (over all destinations). See details in text.

Table A3 – Alternative Measures of Firm Size

	Dep. Variable: ln X_{ijt}					
Measure of firm size	*TFP (t-1)*	*Val. Add. (t-1)*	*Employ. (t-1)*	*Nb. Dest. (t-1)*	*Nb. Prod. (t-1)*	*Nb. Markets (t-1)*
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures x Firm Size	-0.043***	-0.038***	-0.030***	-0.050***	-0.066***	-0.058***
	(0.007)	(0.006)	(0.008)	(0.012)	(0.009)	(0.008)
Firm Size					0.452***	0.433***
					(0.026)	(0.022)
Observations	2282715	2422711	2422711	2422711	2422711	2422711
R^2	0.843	0.841	0.841	0.841	0.844	0.844

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year, destination-year, and firm-destination fixed effects.

Table A4 – Controlling for Imports

	Dep. Variable: ln X_{ijt}								
Measure of Firm Size	*Exports (t-1)*	*Assets (t-1)*	*Labor Prod. (t-1)*	*TFP (t-1)*	*Val. Add. (t-1)*	*Employ. (t-1)*	*Nb. Dest. (t-1)*	*Nb. Prod. (t-1)*	*Nb. Markets (t-1)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Temperatures x Firm Size	-0.057***	-0.050***	-0.031***	-0.045***	-0.040***	-0.032***	-0.051***	-0.067***	-0.059***
	(0.009)	(0.010)	(0.006)	(0.007)	(0.006)	(0.008)	(0.012)	(0.009)	(0.007)
Firm Size								0.450***	0.430***
								(0.025)	(0.021)
Dimport=1	0.095***	0.099***	0.106***	0.097***	0.099***	0.101***	0.103***	0.095***	0.093***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)
Dimport=1 x Temperatures	0.028***	0.026***	0.023***	0.026***	0.026***	0.025***	0.024***	0.023***	0.024***
	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Observations	2542849	2542849	2542849	2396376	2542849	2542849	2542849	2542849	2542849
R^2	0.839	0.839	0.839	0.841	0.839	0.839	0.839	0.842	0.842

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year, destination-year, and firm-destination fixed effects. *Dimport* is a dummy variable equal to 1 if the firm imports from country *j* in year *t*.

Table A5 - PPML estimations

	Dep. Variable: X_{ijt}			
	(1)	(2)	(3)	(4)
Temperatures	0.006			
	(0.057)			
GDP	0.542***			
	(0.046)			
RER	0.015			
	(0.031)			
Precipitations	-0.127***			
	(0.045)			
Humidity	0.174**			
	(0.068)			
Temperatures x Firm Size (t-1)		-0.042***	-0.019**	-0.012
		(0.010)	(0.008)	(0.008)
GDP x Firm Size (t-1)			0.045***	0.039***
			(0.003)	(0.004)
Nb. Fr. Exporters x Firm Size (t-1)				0.020***
				(0.006)
Average Size Fr. Exporters x Firm Size (t-1)				-0.012**
				(0.006)
Observations	6676286	6676286	6676286	6676286
Destination-Year FE		x	x	x

Note: PPML estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year and firm-destination fixed effects. Firm Size is measured by the lagged total firm exports (over all destinations).

Table A6 - Subsamples: Agricultural and Manufacturing Exports

	Dep. Variable: ln X_{ijt}					
Sample:	Agricultural Exports			Manufacturing Exports		
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures	-0.154*			-0.138*		
	(0.092)			(0.071)		
GDP	0.459***			0.361***		
	(0.056)			(0.045)		
RER	-0.101***			-0.100***		
	(0.039)			(0.032)		
Temperatures x Firm Size (t-1)		-0.045***	-0.013		-0.059***	-0.013*
		(0.014)	(0.014)		(0.010)	(0.007)
GDP x Firm Size (t-1)			0.033***			0.031***
			(0.005)			(0.004)
Nb. Fr. Exporters x Firm Size (t-1)			0.065***			0.060***
			(0.009)			(0.005)
Av. Size Fr. Exporters x Firm Size (t-1)			-0.023**			-0.014***
			(0.010)			(0.005)
Observations	380842	380778	380778	2218545	2218539	2218539
R^2	0.883	0.885	0.885	0.833	0.834	0.835
Destination-Year FE		x	x		x	x

Note: OLS estimations. Robust standard errors in parentheses with ***, ** and * respectively denoting significance at the 1%, 5% and 10% levels. All standard errors are clustered at the country-year level. All columns include firm-year and firm-destination fixed effects. Firm Size is measured by the lagged total firm exports (over all destinations). Agricultural exports: HS2 chapters 1 to 27; Manufacturing exports: HS2 chapters 28 to 96. See details in text.

Table A7 – Descriptive Statistics

Panel A: Firm-country-year Variables

	Mean	Std. Dev.	min	max	N
Exports: Value	348646.34	1177764.4	35.00	39957916	2542849
Exports: Volume	215848.56	3580413.8	0.00	7.833e+08	2542849
Unit Value	271.67	13909.56	0.00	13071488	2501961

Panel B: Firm-year Variables

	Mean	Std. Dev.	min	max	N
Firm Exports	3318548.1	8953437.8	197.00	2.865e+08	305872
Assets	75066.88	5109769.6	0.76	1.266e+09	305872
Labor Prod.	75.13	615.35	-20732.91	194590	297908
Employment	116.02	2139.64	0.00	298487	305872
Value Added	22546.89	2837419.4	-475047.00	8.372e+08	299134
TFP	5132.56	138225.92	1.39	60906928	295838
Nb. HS6 Products	3.62	7.02	1.00	539	305872
Nb. Destinations	13.12	12.91	2.00	162	305872

Panel C: Distribution of the main Firm Size Measures

	p25	Median	p75	p90	N
Firm Exports	182272.5	641404.5	2381435.00	7883886	305872
Assets	1555	4216	12409.50	38960	305872
Labor Prod.	38.73	53.29	77.00	115.68	297908

Panel D: Country-year Variables

	Mean	Std. Dev.	min	max	N
GDP	425012.52	1491534.4	249.48	16748032	1750
Temperatures	19.65	7.8	0.32	29.22	1750
Precipitations	96.07	68.74	1.82	409.59	1750
Humidity	10.3	5.12	0.40	24.94	1750
Degree-Days (8C-32C)	4992.57	2324.64	514.67	8690.2	963
Degree-Days (8C-34C)	5085.22	2415.76	514.67	9158.4	963
Harmful Degree-Days (>34C)	480.29	641.4	0.00	2979.7	963
Distance to France	5734.79	3515.2	262.38	19263.88	1750
Nb. French Exporters	3451.33	6041.71	34.00	36789	1750