Exporters under Foreign Heat

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Abstract:

In this paper, I estimate the effect of foreign weather shocks on firm-level exports, exploiting the French firm-level customs data from 1995 to 2009. I find support for a small, negative impact of foreign temperatures on average but estimate a robust and strong differential effect across exporters, leading to composition changes. Larger firms are more negatively harmed by foreign weather shocks than small exporters. Regarding mechanisms, demand-side mechanisms (such as import demand changes) are mainly at play, whereas I find no evidence for supply-side (competition) mechanisms.

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 foreign production, revenues, and GDP, which, in turn, affects the import demand and export sales of foreign firms[2]. Many studies have estimated a large and negative correlation between temperature

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

[2] 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)).

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))

The present paper 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. 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. Estimates suggest an average 0.5 % decrease in exports following a 1°C increase in temperatures. Besides, this result is not precisely estimated. Beyond significance, 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 firm, the more negative the effect on sales and exports in this destination. On the contrary, small firms’ exports are insignificantly affected by foreign weather shocks. This result is independent of the measure of firm size and 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 for this 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 find that these demand-side effects rationalize the export patterns at both the average level and across firms' size deciles. Simultaneously controlling for GDP or import demand in destination countries shuts down the negative effect of temperatures and its increasing effect with firm size. I infer from this result that larger firms are more harmed by demand shocks abroad than smaller firms.

Fourth, the differential effects of temperatures across exporters in a specific destination lead to a composition effect in the market share of exporters serving this market. 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 at the firm level. I find robust differential impacts of these shocks and almost no effect on average across firms. Note that results 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 explain 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 period 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, results show that import demand changes are quantitatively sufficient to rationalize the export patterns. On top of demand, channels related to competition changes and firm selection do not receive empirical support.

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 Models

I investigate the export effects of temperature variations, using various empirical models, detailed in this section.

Model 1: 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:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta_1 Precip_{jt} + \beta_2 Wet_{jt} + \delta FirmSize_{it-1} + \lambda_{it} + \lambda_{ij} + \varepsilon_{ijt} \tag{1}$$

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 also include $Precip_{jt}$ and Wet_{jt} which measure precipitations and humidity in destination. I control for firm size using a set of variables denoted $FirmSize_{it-1}$. I consider two main measures of firm size: the benchmark measure is the lagged total exports of the firm. I will also consider lagged assets size. 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. In the analysis, identification relies on fixed effects. I first include firm x country fixed effects λ_{ij}, 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 firm x year fixed effects, λ_{it}, 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 (French) weather conditions, changes in labor productivity, etc. When included, they also absorb the set of variables of lagged exports and lagged assets. Including these two sets of fixed effects implies that the main coefficients are identified within a destination across years and then compared across destinations for a given firm[3].

Model 2: Heterogeneity 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:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta_1 Precip_{jt} + \beta_2 Wet_{jt} + \delta FirmSize_{it-1} + \gamma\left(Temp_{jt} \times FirmSize_{it-1}\right)$$
$$+\lambda_{it} + \lambda_{ij} + \lambda_{jt} + \varepsilon_{ijt} \qquad (2)$$

in which γ is of interest. While α measures the (average) effect of temperatures on exports, γ measures the conditional impact of firm size controls (lagged exports, lagged assets) on this effect. 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, λ_{jt} , in some specifications, to provide a complete "within" estimation. This destination-year FE absorbs the variance across destination-year couples (and among others the "multilateral resistance" terms) and only focuses on variation across firms within each couple. In that case, I only identify the *differential* impact of firm size on the trade effect of temperatures, controlling for total exports to that destination by French exporters.

Model 3: Decile-specific response.

I complement the heterogeneity analysis by estimating a regression of the following form:

$$Exports_{ijt} = \alpha Temp_{jt} + \beta_1 Precip_{jt} + \beta_2 Wet_{jt} + \sum_{d=1}^{10} \alpha_d 1[Decile_{it-1} = d] \times Temp_{jt}$$
$$+ \lambda_{it} + \lambda_{ij} + \lambda_{jt} + \varepsilon_{fjt} \qquad (3)$$

in which α_d are the decile-specific effect of temperatures on exports. I estimate the average differential effect of temperatures on exports across deciles of firm size variables. This model allows a non-linear relationship between firm size and the marginal effect of temperatures.

Model 4: Potential Mechanisms.

[3] 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.

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

$$Exports_{ijt} = \alpha Temp_{jt} + \beta_1 Precip_{jt} + \beta_2 Wet_{jt} + \delta FirmSize_{it-1} + \eta\, Mechanism_{jt} + \lambda_{it} + \lambda_{ij} + \varepsilon_{ijt} \qquad (4)$$

in which I include the additional term $Mechanism_{jt}$ Including this term challenges the estimated α, by allowing some destination-year variables to have some influence on the export simultaneously to the temperatures. Including these variables will inform on the potential mechanisms through which temperatures affect exports.

Suppose for instance that temperatures affect exports only through GDP. Simultaneously controlling for GDP changes should dampen the impact of temperatures on exports, α. More generally, the destination-specific controls that lead to a significant η and to a non-significant γ can then be interpreted as driving the effect of temperatures on exports.

This set of variables $Mechanism_{jt}$ will contain both demand-related variables, such as GDP, as well as supply-side variables, capturing changes in competition in foreign market.

Model 5: Potential Mechanisms on the differential effects.

$$Exports_{ijt} = \alpha Temp_{jt} + \beta_1 Precip_{jt} + \beta_2 Wet_{jt} + \sum_{d=1}^{10} \alpha_d 1[Decile_{it-1} = d] \times Temp_{jt} + \sum_{d=1}^{10} \eta_d\, 1[Decile_{it-1} = d] \times Moderator_{jt} + \lambda_{it} + \lambda_{ij} + \lambda_{jt} + \varepsilon_{fjt} \qquad (5)$$

Finally, I will run a model challenging the differential effects of temperatures across firms. 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, $Moderator_{jt}$) and firm characteristics on the other hand. As a result, leaving η_d unrestricted will challenge the significance of α_d and inform on the mechanisms through which weather affects exports.

Compared to model (4), this model will check that the mechanisms driving the effects of temperatures are at play for firms that are particularly harmed by temperatures, beyond the average effect across the distribution.

Trade Margins and Estimations Issues.

I study both the intensive and the extensive margins of trade. As for the extensive margin, I focus on the presence of firm in a destination-year, using a dummy variable. In this case a Linear Probability Model is used. Data is rectangularized at the firm-destination-year, including zero trade flows. Regarding the intensive margin of trade, the main outcome is the log export value of the firm to each destination (X_{ijt}) (i.e., conditional on the presence). The main model is hence a log-level model: for readability purpose, I have normalized the temperatures (by a factor of 100) to obtain estimates that can be directly interpreted as changes in percentage points of exports. Baseline estimations are obtained using an OLS estimator. In all estimations, I cluster the standard errors at country-year level, because temperature variations occur at this level of aggregation.

2.2. Data

The analysis combines 3 main datasets: (i) firm-level trade data on French export flows, (ii) firm size controls, and (iii) weather variables. Table A9 in the appendix provides the descriptive statistics of the 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.[4] 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*

[4] 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.

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 beyond cross-country variations in temperatures. I use temperatures in levels, in degrees Celsius. As controls, I will use other weather variables such as total precipitations and average humidity from the same source.

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.[5] The BRN database is constructed from reports of French firms to the tax administration, which are transmitted to INSEE (the French Statistical Institute). The BRN dataset contains between 650,000 and 750,000 firms per year over the period (around 60% of the total number of French firms). Importantly, this dataset is composed of both small and large firms, since no threshold applies on the number of employees. 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, come from the Penn World Tables. I also use BACI to compute import demand at the destination-year level (Gaulier and Zignago (2010)).

3. Main Results

3.1 Average Impact of Foreign Temperatures

Table 1 estimates the average impact of foreign temperatures on firm-level exports. Columns 1 to 3 focus on the extensive margin, whereas columns 4 to 6 estimate focus on the intensive margin of trade. First, no significant impact of foreign temperatures is estimated on the extensive margin of trade: none of the specifications display a significant coefficient associated to foreign temperatures, nor to other weather shocks. Foreign weather shocks do not affect the presence of exporters across time within a destination.

Second, columns 4 to 6 however estimate a significant negative effect of foreign temperatures on firm-level exports, i.e., at the intensive margin. Conditional on the presence of firm in a specific destination,

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

foreign temperatures variations reduce exports. In terms of quantification, estimates suggest an average 0.5% decrease in exports following a 1°C increase in temperatures. This result appears to be modest: the average export flow is hardly deterred by foreign temperatures. This result is in line with previous evidence (Li, Xiang, and Gu (2015); Dallmann (2019)). Besides, this effect is not precisely estimated: large standard errors (clustered at the country-year level) are estimated, despite a large sample size. This may be due to the small « within » variance of temperatures across years for any destination.

The negative but modest impact of foreign temperatures remains when introducing firm-year fixed effects and is stable when including additional weather covariates such as total precipitations (in mm) and average humidity index (col. 6).

3.2 Heterogeneity across firms

Table 2 investigates the heterogeneous impact of weather shocks across exporters at the intensive margin of trade. Taking advantage of the set of firm observables in our sample, I allow the impact of foreign weather shocks to have differential effects across firms, along the lines of models (2) and (3). Table 2 supports that foreign weather shocks have significant heterogeneous effects across firms.

I consider the main firm size measures presented above: lagged firm exports in columns 1 to 3 and lagged firm assets in columns 4 to 6. Results regarding other firm size measures are presented in Appendix, Table A3. Columns 1 and 2 (including a set of destination-year fixed effects) estimate significant and negative interactions between foreign temperatures and lagged firm exports. Holding 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. Using point estimates of column 2, the export effect to temperatures for firms at the 90th percentile of the lagged total exports distribution is around -0.4 whereas it is -0.003 (non-significant point estimate) for firms at the 10th percentile. These differential effects are confirmed by results in specification 3, that provide decile-specific effect of foreign temperatures. Results confirm the existence and the magnitude of the differential impact from previous estimations.

Columns 4 to 6 use lagged assets as the firm size proxy. All previous results hold, with similar magnitudes: larger firms are more negatively harmed by foreign temperatures than smaller firms.

The main message is that foreign temperatures deter exports *mainly* for major firms whereas small firms' exports are hardly deterred[6]. 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.

Note also that the average effect of temperature in the previous Table is also close to the effect for the top firms in the sample. In a sense, the average trade-deterring effect of foreign temperatures is thus driven by the largest firms only.

3.3 Heterogeneity within firms

Table 3 investigates the within-firm trade adjustment after foreign temperatures shocks. 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 (product 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. 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.

3.4 Potential Mechanisms

3.4.1 Demand and supply mechanisms

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 decrease after temperature shocks. This may impact aggregate demand and in particular import demand.

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[6] I found no significant differential effects of foreign temperatures on firm participation (defined as in Table 1) across exporters, both using interaction terms with lagged firm assets or with firm decile.

I use two measures to capture demand-side channels. I first consider GDP as a variable to capture aggregate demand changes. Second, I compute the import demand at the destination level using BACI dataset (Gaulier and Zignago (2010)):

$$ImportDemand_{jt} = \sum_{o \neq France} X_{ojt}$$

where X_{ojt} is the export flow from o to destination j (excluding France as an exporter). Aggregating all import flows of j in year t provides a measure of the import demand of each destination.

On the other hand, export supply may also be affected by temperatures. I hypothesize that weather shocks may affect the set of local and foreign competitors serving this destination. Consider for instance a weather shock in Mexico. Local, Mexican firms may be affected by the shock (because of adverse labor productivity shocks, decreasing labor supply, loss in agricultural yields, …) such that *domestic* firm selection is affected on the local market.[7] Besides, this change in local competition may trigger additional general-equilibrium changes in *foreign* competition (from the US for example). As a result, a destination could experience a change in competition, and thus, in firm-level exports.

I consider two supply-side variables to measure competition intensity at the destination-year level. First, I measure the average firm size of entrants in the destination market. Trade theories with heterogeneous firms and extensive margin (Melitz (2003); Melitz (2017)) argue that firm selection in foreign market is determined by a cut-off productivity level, under which potential entrants (with firm-specific productivity) are deterred from entering. As a result, the larger the cut-off, the tougher the selection of foreign firms serving a destination market. I cannot estimate this cut-off level as I only have access to French firm-level data. Yet, I can measure the average size (assets) of entrants (i.e., firms that serve a destination j in year t that did not in $t-1$) in any destination-year. By comparing the average assets of entrants across years for a given destination, I can infer a change in competition intensity to serve that destination-year. An increase in that variable would capture an increase in the intensity of competition on that destination-year: the productivity cut-off required to serve that market is larger than before. In theory terms, I would indirectly measure a change in the productivity cut-off, required to serve a destination over time. Second, I compute the number of French exporters selling to a destination-year.

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[7] 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.

3.4.2 Mechanisms: On the average effect.

Table 4 investigates the potential mechanisms driving the negative aggregate impact, using specification (4). More precisely, I estimate:

$$\begin{aligned} Exports_{ijt} &= \alpha Temp_{jt} + \beta_1 Precip_{jt} + \beta_2 Wet_{jt} + \delta FirmSize_{it-1} \\ &+ \eta_1\, GDP_{jt} + \eta_2 ImportDemand_{jt} + \eta_3 AssetsEntrants_{jt} \\ &+ \eta_4\, Nb.Fr.Exporters_{jt} + \lambda_{it} + \lambda_{ij} + \varepsilon_{ijt} \end{aligned}$$

The specification includes variables capturing potential channels of transmission of the effect of temperatures on exports. I consider demand-side and supply-side mechanisms. The objective of this model is to challenge the point estimate of the temperatures previously displayed (in Table 1, cols 4 to 6 for instance).

Table 4, column 1 shows that the negative impact of temperatures is insignificant, once accounting for GDP changes. Column 2 further shows that import demand also shuts down the average negative impact of temperatures on firm-level exports. Column 2 displays a reduction in point estimate (rather than an increase in standard errors, leading to insignificant results, in column 1), further supporting the mediation role of *import* demand.

Table 4, columns 3 and 4 finds no support for none of the supply-side mechanisms. Column 3 introduces the average assets of entrants (to avoid endogeneity with export outcomes) and estimate an insignificant effect of entrants' size on firm-level exports. I also estimate that controlling for this variable does not lead the effect of temperatures to get close to 0. The negative impact of temperatures remains significant, once accounting for changes in the average size of French entrants.

Column 4 introduces the number of foreign French exporters serving a destination-year. Even though I estimate a significant impact of the number of French sellers, the coefficient on temperatures is hardly affected compared to benchmark estimates. Considering that temperatures potentially affect the number of French sellers in the destination, the remaining effect of temperatures is still significant. I still estimate a negative and significant effects of temperatures, controlling for the potential competition in the foreign market and for the number of exporters.

Overall, once controlling for (proxies of) changes in competition abroad, I still estimate a significant impact of foreign temperatures on exports on average. On the contrary, controlling for demand-side channels such as import demand leads to shut down the effect of temperatures on exports. I thus conclude that the main effects of temperatures are at play because of demand-side mechanisms, and no effect in related to changes in export supply.

3.4.3 Mechanisms: differential effects

Foreign temperatures deter exports, especially for major firms whereas small firms' exports are hardly deterred (see Table 2). I now check that demand-related mechanisms particularly drive the exports of these large firms.

I thus use the previous 4 variables capturing both demand and supply mechanisms and interact them with dummies capturing firm size decile to estimate model 5 presented before. I include these interactions sequentially. Results are presented in Figure 1-A. Figure 1-A plots the estimated a_d as results of the different specifications, adding multiple interactions between firm size deciles and potential mechanisms.

The green specification provides the benchmark results, implied by column 3 of Table 2: larger firms are more harmed by temperatures. Specifications in blue (either dark or light) control for demand-side mechanisms. Controlling for the differential effect of GDP yields the light blue results whereas controlling for the differential effect of import demand yields the dark blue results. Both lines support that the differential effect of temperatures of larger firms is shut down. GDP tends to reduce the effect of temperatures on exports but part of the effect of temperatures remains significant. Controlling for import demand leads to insignificant impact of temperatures on all firms' exports. Dark blue dots and their confidence intervals support a null effect of temperatures independently of the size of firms, once controlling for import demand in the destination.

Then, the red specifications control for supply-side mechanisms (interacted with firm size decile). The picture is now different as the larger firms are still more harmed by temperatures than smaller firms, even when controlling for changes in competition, as argued above. I estimate significant effects temperatures for the larger firms.

Finally, the yellow specification displays the differential effect of temperatures when controlling for all mechanisms (all interacted with firm size decile). I find a zero effect. I infer this result is driven by the demand-side channels.

Figure 1-B shows results when considering lagged assets as firm size measure. All conclusions regarding the relative role of each mechanism are confirmed.

3.4.4. Conclusions on the mechanisms

Two results can be inferred from the previous exercises.

First, results support that temperatures affect exports through demand mechanisms and in particular import demand. The larger trade deterring effect of temperatures for larger firms also implies that larger firms could be more harmed by changes in demand than smaller firms. This result is plausible if firms face more or less elastic demands (Melitz and Ottaviano (2008)), or if larger firms' exports yields higher elasticity to demand shocks (Chowdhry and Felbermayr (2021); Bricongne et al. (2022)).

Second, we find no support for supply-side mechanisms, whereas competition changes are plausible. One explanation for this result would be that competition changes may take time to be observed, and that these may be triggered by repeated or medium-run changes in weather. Melitz (2017) among others argues that the short-run analysis does not allow entry responses. More generally, it is plausible that firm selection and the extensive margin of trade would be at play in the medium run. On the contrary, we identify year-to-year changes in exports from year-to-year weather changes. Our results must then be considered as the short-run effect of weather shocks, and in the short-run, these results are determined by demand only.

3.5 Aggregate Implications

Table 5 finally claims that the differential effects (documented in Table 2) determine the *average* exporter under foreign temperature shocks. Table 2 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:

$$AverageCharact_{jt} = \beta_0 + \beta_1 Temp_{jt} + \lambda_j + \lambda_t + \varepsilon_{jt} \qquad (6)$$

in which $AverageCharact_{jt}$ is a weighted average measure of exporters' characteristics serving destination *jt*. I thus estimate the correlation between temperatures variations and the average characteristics of exporters 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 2 and 3 display a negative correlation between average (lagged) size of firms and temperatures. When temperatures increase, exports are tilted towards smaller firms, in terms of lagged assets (col. 2) and lagged productivity (col. 3). I find no significant association between temperatures and average exports. 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 3, 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 Alternative specifications

Table A1 checks the sensitivity of the results with respect to the empirical specifications. Column 1 controls for both temperatures in t and temperatures in t-1. Column 2 includes a quadratic polynomial of temperatures to allow for non-linearities. Column 3 goes further in this direction allowing for an interaction between temperatures in t and in t-1. Column 4 introduces a linear year trend interacted with country dummies. Column 5 controls for the bilateral tariff rate (averaged across products) as a trade shifter. Column 6 includes lagged population as a trade shifts. All results confirm the negative and small effect of temperatures on average, which is not threatened by non-linearities or by lagged effects.

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 a measure 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

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

and $Degree\ Days_{jt} = \sum_d DegreeDays_{jdt}$

This measure captures the cumulative number of days of with temperatures larger than 8°C and the intensity of the temperatures (pairwise correlation with average temperature= 0.875). Note that it is not a measure of extreme heat, as extreme temperatures (above 32°C) are neutralized by the exercise. This measure has been used in many economy-wide analyses (such as Jessoe, Manning, and Taylor (2018)).

Table A2 shows results when considering this alternative measure. Results confirm (i) the small 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 demand-side mechanisms mainly explain the observed export pattern both on average and 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 HS6 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 Omitted Destination Characteristics

Table A4 checks that the differential effects of temperature variations do not overlap with other differential 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. The differential effect of firm size could be a result of larger firms serving riskier countries which may also be facing larger temperatures variations. 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 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, 4 and 6 allow the other weather variables and lagged temperatures to have a differential effect across firms. Column 5 controls for the potential differential effect of tariffs. All those controls do not affect the significance of the differential effect of temperatures across firms.

4.5 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 A5 explicitly deals with this concern. I first measure imports from country j using a dummy capturing whether firm i imports from country j in year t or not ($\mathbf{1}(M_{ijt} > 0)$) Then, I use the level of imports M_{ijt}.

The first 4 columns show that firm-level imports, either measured by the dummy or by using imports values, are unaffected by foreign temperatures. Then, the last two columns support that import exposure at the firm-level does not drive the differential impact of temperatures on exports.

4.6 Alternative Estimator: PPML

Table A6 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.

4.7 Variations across and within sectors

4.7.1 Subsamples: Agricultural and Manufacturing Exports

Table A7 replicates the baseline estimations separating export flows between agricultural exports (HS2 chapters 1 to 27) and manufacturing exports (HS2 chapters 28 to 96). I find that the negative impact of foreign temperatures may be more at play regarding manufacturing good exports, than for agri-food products. Yet, the same demand-related channels seem to be at play, in both samples.

4.7.2 Results for each HS2 level

Figure A1 in Appendix further shows results for each HS2. I estimated model (1) for each HS2 sector separately. Figure A1 plots the estimated coefficient on temperatures in agricultural products and Figure A2 plots results for manufacturing goods.

4.7.3 Within sector estimations

Table A8 shows results when including more demanding HS2 sector fixed effects, together with the benchmark set of fixed effects. Table A8 includes firm-sector-destination, firm-sector-year, and destination-sector-year fixed effects. The differential effect of firm size holds within sector and across all firms that serve the same destination-HS2 sector at the same time. Results also hold regarding the demand-related channel as the main mechanism.

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 at the firm-level. I exploit the French firm-level customs data from 1995 to 2009 and various models to estimate (i) the average effect of foreign temperatures and (ii) the differential effect across exporters facing the same foreign weather shock.

I find support for a small, 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 demand-side mechanisms are at play. The main explanation 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 find that these demand-side effects rationalize the export patterns at both the average level and across firms' size deciles. I also hypothesize that competition in the foreign market may also affected by foreign temperatures, but results do not support the role of these supply-side effects.

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.

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Tables

Table 1 - Average Impact of Foreign Temperatures

	Extensive Margin			Intensive Margin		
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable:		$\mathbf{1}(X_{ijt} > 0)$			$\text{Ln } X_{ijt}$	
Temperatures (in levels)	-0.018	0.003	-0.039	-0.422**	-0.501**	-0.476**
	(0.055)	(0.040)	(0.040)	(0.211)	(0.236)	(0.234)
Assets (t-1)	0.029***			0.307***		
	(0.001)			(0.007)		
Firm Exports (t-1)	0.062***			0.303***		
	(0.001)			(0.010)		
Precipitations			-0.029	-0.121**		-0.085
			(0.019)	(0.053)		(0.053)
Humidity			0.043	0.188**		0.194**
			(0.030)	(0.081)		(0.083)
Observations	5676242	5676242	5676242	1762360	1762360	1762360
R^2	0.413	0.573	0.599	0.798	0.862	0.862
Firm-Destination FE	x	x	x	x	x	x
Firm-Year FE		x	x		x	x
Year FE	x			x		
Estimator	LPM	LPM	LPM	OLS	OLS	OLS

Note: 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. LPM stands for Linear Probability Model. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table 2: Heterogeneity across firms.

Dep. Variable	Ln X_{ijt}					
	(1)	(2)	(3)	(4)	(5)	(6)
Firm Size Measure	Lagged Total Exports			Lagged Assets		
Temperatures	0.403			-0.377*		
	(0.262)			(0.217)		
Temperatures x Firm Size (t-1)	-0.066***	-0.079***		-0.091***	-0.106***	
	(0.008)	(0.007)		(0.010)	(0.008)	
Temperature x Firm Size Decile 2			-0.032***			-0.040***
			(0.012)			(0.012)
Temperature x Firm Size Decile 3			-0.065***			-0.076***
			(0.016)			(0.016)
Temperature x Firm Size Decile 4			-0.107***			-0.129***
			(0.019)			(0.019)
Temperature x Firm Size Decile 5			-0.121***			-0.165***
			(0.022)			(0.022)
Temperature x Firm Size Decile 6			-0.169***			-0.186***
			(0.026)			(0.025)
Temperature x Firm Size Decile 7			-0.209***			-0.223***
			(0.029)			(0.027)
Temperature x Firm Size Decile 8			-0.265***			-0.271***
			(0.032)			(0.030)
Temperature x Firm Size Decile 9			-0.329***			-0.341***
			(0.035)			(0.033)
Temperature x Firm Size Decile 10			-0.405***			-0.373***
			(0.040)			(0.037)
Observations	1762360	1762360	1762360	1762360	1762360	1762360
R^2	0.843	0.844	0.844	0.815	0.816	0.816
Firm-Destination FE	x	x	x	x	x	x
Firm-Year FE	x	x	x	x	x	x
Dest-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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table 3 - Average Effects Across Trade Margins

Dep. Variable:	Quantity	Unit Value	Av. X/Prod.	Nb. Prod.	X (Main Prod.)
	(1)	(2)	(3)	(4)	(5)
Temperatures (in levels)	-0.577**	0.122	-0.367**	0.011	-0.457**
	(0.244)	(0.095)	(0.177)	(0.093)	(0.211)
Observations	1762360	1762360	1762360	1762360	1762360
R^2	0.893	0.931	0.847	0.849	0.843

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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table 4: Mechanisms

	(1)	(2)	(3)	(4)	(5)
Dep. Variable:			Ln X_{ijt}		
Temperatures	-0.333	-0.107	-0.366**	-0.397**	0.082
	(0.204)	(0.163)	(0.177)	(0.179)	(0.088)
Precipitations	-0.122**	-0.088**	-0.095*	-0.120***	-0.079**
	(0.051)	(0.041)	(0.055)	(0.046)	(0.040)
Humidity	0.128	0.101	0.139	0.155**	0.119*
	(0.080)	(0.064)	(0.086)	(0.072)	(0.063)
GDP	0.387***				0.139***
	(0.048)				(0.035)
Import Demand		0.573***			0.458***
		(0.028)			(0.026)
Entrants Assets			-0.024		-0.002
			(0.015)		(0.007)
Nb. Fr. Exporters				0.330***	0.242***
				(0.013)	(0.010)
Observations	1762360	1762360	1762360	1762360	1762360
R^2	0.815	0.815	0.819	0.813	0.818
Firm-Destination FE	x	x	x	x	x
Firm-Year FE	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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table 5 - Aggregate Implications: Composition effect

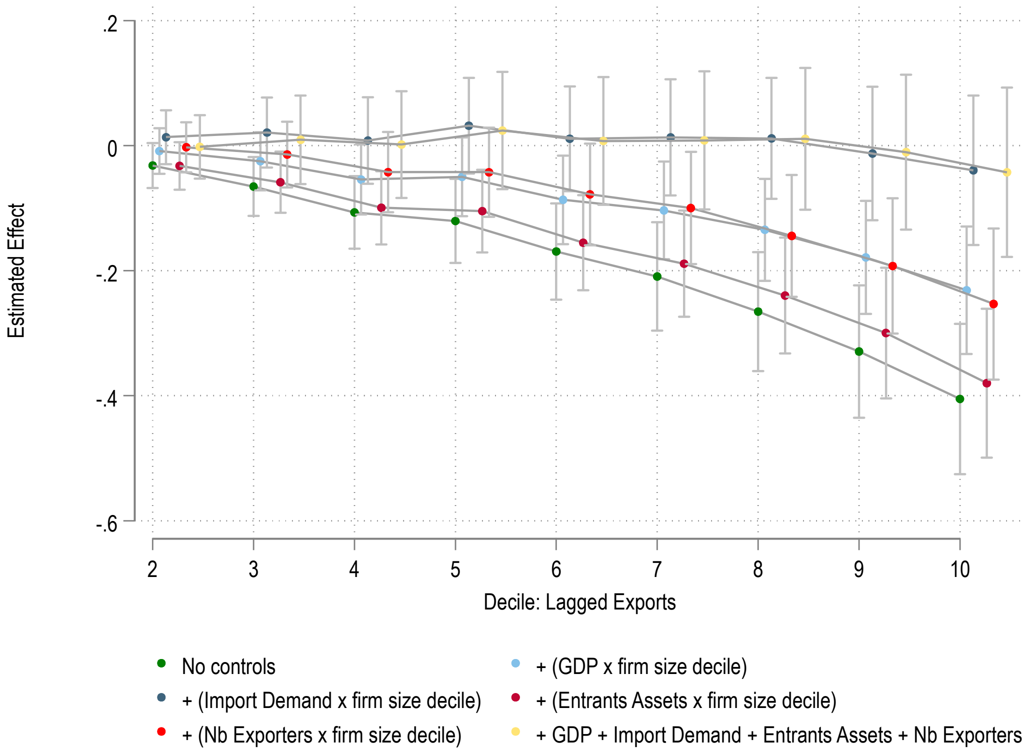
Dep. variable	Mean Total Exports	Mean Assets	Mean Labor Prod.	Mean Unit Values
	(1)	(2)	(3)	(4)
Temperatures	-0.165	-0.214*	-0.164*	0.505***
	(0.117)	(0.115)	(0.090)	(0.133)
Observations	1750	1750	1750	1750
R^2	0.871	0.625	0.916	0.617

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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

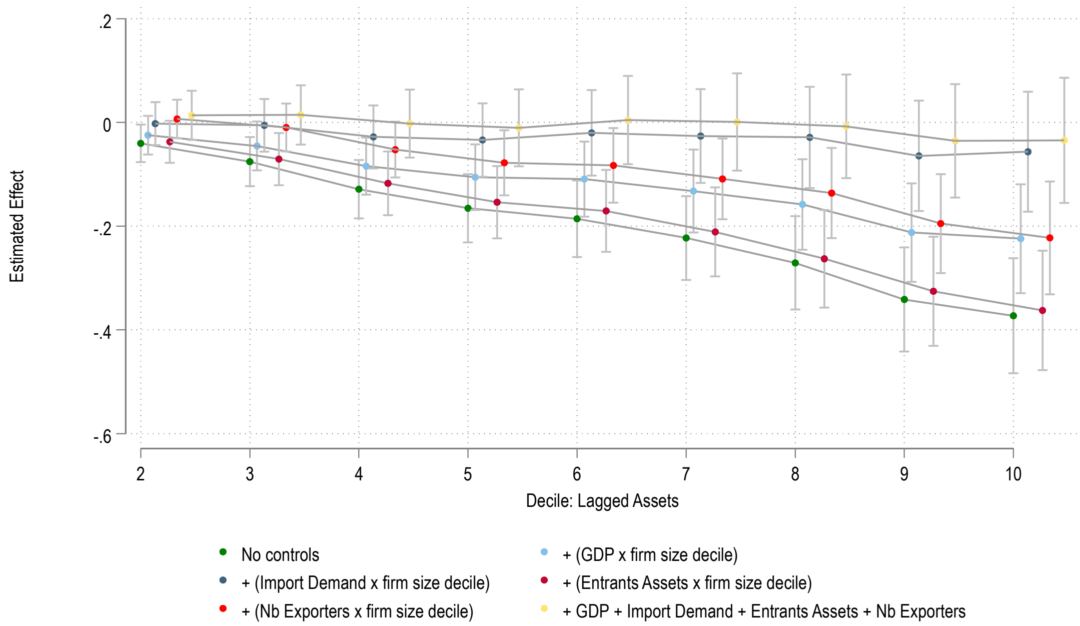
Figures

Figure 1 - Decile-specific response of firm-level exports to temperatures and potential mechanisms

A- Decile: Lagged Exports



B- Decile: Lagged Assets



Appendix – Published Online

Table A1 - Alternative specifications

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable:			Ln X_{ijt}			
Temperatures	-0.419*	-0.386**	-0.112	-0.059*	-0.386**	-0.248*
	(0.230)	(0.179)	(0.141)	(0.035)	(0.178)	(0.150)
Precipitations	-0.138**	-0.133**	-0.136**	-0.061*	-0.143**	-0.091**
	(0.056)	(0.056)	(0.054)	(0.034)	(0.056)	(0.039)
Humidity	0.213**	0.210**	0.214***	0.046	0.232***	0.216***
	(0.086)	(0.086)	(0.081)	(0.054)	(0.086)	(0.064)
Temperatures (t-1)	-0.242**		-0.043***			
	(0.102)		(0.015)			
Temperatures x Temperatures		0.174*				
		(0.097)				
Temperatures (t) x Temperatures (t-1)			0.002*			
			(0.001)			
Tariffs					-0.070**	
					(0.029)	
Population (t-1)						0.236**
						(0.102)
Observations	1762360	1762360	1762360	1762360	1761880	1762360
R^2	0.846	0.846	0.846	0.815	0.846	0.847
Year trend x Dest FE				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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table A2- Alternative Measure of temperature

Dep. Variable:	Ln X_{ijt}			
	(1)	(2)	(3)	(4)
Degree-Days	-0.174**	-0.029	0.261	-0.041
	(0.070)	(0.054)	(0.196)	(0.055)
Precipitations	-0.155**	-0.091**	-0.153**	-0.131***
	(0.062)	(0.046)	(0.066)	(0.046)
Humidity	0.162*	0.144**	0.223**	0.220***
	(0.094)	(0.071)	(0.093)	(0.069)
GDP		0.205***		0.133
		(0.055)		(0.122)
Import Demand		0.525***		0.018
		(0.034)		(0.106)
Entrants Assets		0.005		0.132***
		(0.008)		(0.049)
Nb. Fr. Exporters		0.246***		-0.236***
		(0.012)		(0.063)
Degree-Days x Firm Exports (t-1)			-0.027**	-0.005
			(0.012)	(0.009)
GDP x Firm Exports (t-1)				0.004
				(0.007)
Import Demand x Firm Exports (t-1)				0.036***
				(0.006)
Entrants Assets x Firm Exports (t-1)				-0.009***
				(0.003)
Nb. Fr. Exporters x Firm Exports (t-1)				0.032***
				(0.004)
Observations	1762360	1762360	1762360	1762360
R^2	0.819	0.823	0.848	0.847
Firm-Destination FE	x	x	x	x
Firm-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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

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	0.125	-0.189	-0.344	-0.352	-0.468**	-0.318
	(0.219)	(0.238)	(0.218)	(0.238)	(0.223)	(0.226)
Temperatures x Firm Size	-0.070***	-0.039***	-0.070***	-0.049***	-0.066***	-0.059***
	(0.006)	(0.006)	(0.007)	(0.013)	(0.008)	(0.006)
Firm Size					0.349***	0.339***
					(0.016)	(0.014)
Observations	1762360	1762360	1762360	1762360	1762360	1762360
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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table A4 – Potential Omitted Destination Characteristics

	Dep. Variable: ln X_{ijt}					
	(1)	(2)	(3)	(4)	(5)	(6)
Temp. x Firm Exports (t-1)	-0.049***	-0.066***	-0.082***	-0.075***	-0.049***	-0.035**
	(0.007)	(0.009)	(0.007)	(0.008)	(0.008)	(0.016)
Distance x Firm Exports (t-1)	-0.043***					
	(0.007)					
Pol. Stab. x Firm Exports (t-1)		0.012**				
		(0.005)				
Precipitations x Firm Exports (t-1)			-0.013***			
			(0.004)			
Humidity x Firm Exports (t-1)				0.006		
				(0.005)		
Tariffs x Firm Exports (t-1)					-0.026***	
					(0.002)	
Temp (t-1) x Firm Exports (t-1)						-0.045***
						(0.016)
Observations	1762360	1762360	1762360	1762360	1762360	1762360
R^2	0.844	0.854	0.844	0.844	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, firm-destination fixed effects. See details in text. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table A5 – The role of Imports

	Dimport $\mathbf{1}(M_{ijt} > 0)$	Log Imports: $\ln M_{ijt}$			log Exports: $\ln X_{ijt}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Temperatures	-0.001	-0.114	-0.747**	-0.372	0.750***	0.751***
	(0.016)	(0.187)	(0.310)	(0.311)	(0.181)	(0.181)
Precipitations	-0.010	-0.171	-0.065	-0.014	-0.133**	-0.133**
	(0.007)	(0.109)	(0.099)	(0.089)	(0.054)	(0.054)
Humidity	0.016	0.270	0.105	0.077	0.198**	0.198**
	(0.011)	(0.175)	(0.160)	(0.144)	(0.081)	(0.081)
Temp. x Firm Exports (t-1)			0.042**	0.040**	-0.064***	-0.065***
			(0.017)	(0.017)	(0.008)	(0.008)
GDP				-0.172		
				(0.207)		
GDP x Firm Exports (t-1)				0.013		
				(0.012)		
Import Demand				0.644**		
				(0.259)		
Import Demand x Firm Exports (t-1)				0.007		
				(0.015)		
Assets Entrants				-0.119		
				(0.101)		
Assets Entrants x Firm Exports (t-1)				0.003		
				(0.007)		
Nb. Fr. Exporters				0.121		
				(0.149)		
Nb. Fr. Exporters x Firm Exports (t-1)				0.000		
				(0.010)		
Dimport					0.166***	0.133***
					(0.006)	(0.013)
Dimport x Temp.						0.027***
						(0.010)
Observations	2974944	401093	401093	401093	1762360	1762360
R^2	0.802	0.863	0.879	0.881	0.843	0.843

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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table A6 - PPML estimations

Dep. Variable:	X_{ijt}			
	(1)	(2)	(3)	(4)
Estimator	PPML			
Temperatures	-0.263*	0.135	0.539**	-0.205
	(0.140)	(0.090)	(0.260)	(0.199)
Precipitations	-0.172**	-0.083*	-0.119*	-0.070
	(0.059)	(0.041)	(0.062)	(0.043)
Humidity	0.210**	0.161**	0.186**	0.133**
	(0.097)	(0.064)	(0.090)	(0.064)
GDP		0.093***		0.131
		(0.036)		(0.150)
Import Demand		0.537***		0.069
		(0.032)		(0.149)
Entrants Assets		-0.022**		0.088
		(0.009)		(0.051)
Nb. Fr. Exporters		0.250***		0.214*
		(0.013)		(0.098)
Temperatures x Firm Exports (t-1)			-0.042***	-0.007
			(0.013)	(0.011)
GDP x Firm Exports (t-1)				0.008***
				(0.003)
Import Demand x Firm Exports (t-1)				0.031***
				(0.002)
Entrants Assets x Firm Exports (t-1)				-0.001
				(0.002)
Nb. Fr. Exporters x Firm Exports (t-1)				0.014***
				(0.001)
Observations	5676242	5676242	5676242	5676242
R^2	0.819	0.823	0.848	0.847
Firm-Destination FE	x	x	x	x
Firm-Year FE	x	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.

Table A7 - Subsamples: Agricultural and Manufacturing Exports

Sample	Agriculture			Manufacturing		
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Variable				Ln X_{ijt}		
Temp.	-0.158	0.383	0.052	-0.517**	0.413	-0.370*
	(0.341)	(0.467)	(0.445)	(0.235)	(0.269)	(0.202)
Precipitations	-0.128*	-0.098	-0.111*	-0.124**	-0.135**	-0.109**
	(0.065)	(0.069)	(0.062)	(0.057)	(0.057)	(0.043)
Humidity	0.189*	0.135	0.172	0.185**	0.207**	0.178***
	(0.106)	(0.111)	(0.106)	(0.087)	(0.086)	(0.064)
Temp. x Firm Exports (t-1)		-0.040**	-0.007		-0.069***	-0.002
		(0.018)	(0.020)		(0.008)	(0.007)
GDP x Firm Exports (t-1)			0.012			0.006
			(0.013)			(0.005)
Import Demand			-0.354			0.003
			(0.235)			(0.091)
Import Demand x Firm Exports (t-1)			0.044***			0.034***
			(0.015)			(0.006)
Entrants Assets			0.138			0.120***
			(0.120)			(0.040)
Entrants Assets x Firm Exports (t-1)			-0.010			-0.008***
			(0.007)			(0.003)
Nb. Fr. Exporters			-0.071			-0.245***
			(0.147)			(0.056)
Nb. Fr. Exporters x Firm Exports (t-1)			0.023**			0.032***
			(0.009)			(0.004)
Observations	273090	267322	188494	1543170	1516068	1505876
R^2	0.891	0.889	0.895	0.840	0.837	0.838

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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table A8 – Within sector estimations

Dep Variable:	Ln X_{ijt}				
	(1)	(2)	(3)	(4)	(5)
Temp. x Firm Exports (t-1)	-0.039***	-0.003	-0.065***	-0.023***	0.003
	(0.006)	(0.007)	(0.008)	(0.007)	(0.008)
GDP x Firm Exports (t-1)	0.040***				0.005
	(0.004)				(0.006)
Import Demand x Firm Exports (t-1)		0.052***			0.033***
		(0.004)			(0.007)
Assets Entrants x Firm Exports (t-1)			-0.018***		-0.005*
			(0.004)		(0.003)
Nb. Fr. Exporters x Firm Exports (t-1)				0.078***	0.043***
				(0.006)	(0.007)
Observations	1762360	1762360	1762360	1762360	1762360
R^2	0.860	0.860	0.860	0.860	0.860
Firm-HS2 sec.-Destination FE	x	x	x	x	x
Firm-HS2 sec.-Year FE	x	x	x	x	x
HS2 sec.-Dest-Year FE	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. Temperatures are normalized such that estimates are interpreted as changes in percentage points of dependent variable.

Table A9– Descriptive Statistics

Panel A: Firm-country-year Variables

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

Panel B: Firm-year Variables

	Unit	Mean	Std. Dev.	min	max	N
Firm Exports	Euros	3318548.1	8953437.8	197.00	2.865e+08	305872
Assets	Euros	75066.88	5109769.6	0.76	1.266e+09	305872
Labor Prod.	Euros	75.13	615.35	-20732.91	194590	297908
Employment	Persons	116.02	2139.64	0.00	298487	305872
Value Added	Euros	22546.89	2837419.4	-475047.00	8.372e+08	299134
TFP	Euros	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

	Units	p25	Median	p75	p90	N
Firm Exports	Euros	182272.5	641404.5	2381435.00	7883886	305872
Assets	Euros	1555	4216	12409.50	38960	305872

Panel D: Country-year Variables

	Units	Mean	Std. Dev.	min	max	N
GDP	USD	425012.52	1491534.4	249.48	16748032	1750
Temperatures	°C	19.65	7.8	0.32	29.22	1750
Between Countries	°C		*7.96*			
Within Countries	°C		*0.463*			
Precipitations	Mm	96.07	68.74	1.82	409.59	1750
Humidity	Nb. of wet days per month	10.3	5.12	0.40	24.94	1750
Degree-Days (8C-32C)	See Def. in text	4992.57	2324.64	514.67	8690.2	963
Distance to France	Km	5734.79	3515.2	262.38	19263.88	1750
Nb. French Exporters	-	3451.33	6041.71	34.00	36789	1750

Panel E: Destinations with smallest and largest temperatures variations in sample

10 smallest temperatures variations: Finland, Côte d'Ivoire, Qatar, Gabon, Belgium, Norway, Malta, Mali, Iceland, Fiji.

10 largest temperatures variations: Thailand, Malaysia, India, Indonesia, Philippines, Saudi Arabia, Jamaica, Vietnam, Mexico, Mauritius.

Figure A1 - Effect for each HS2, Agriculture sample

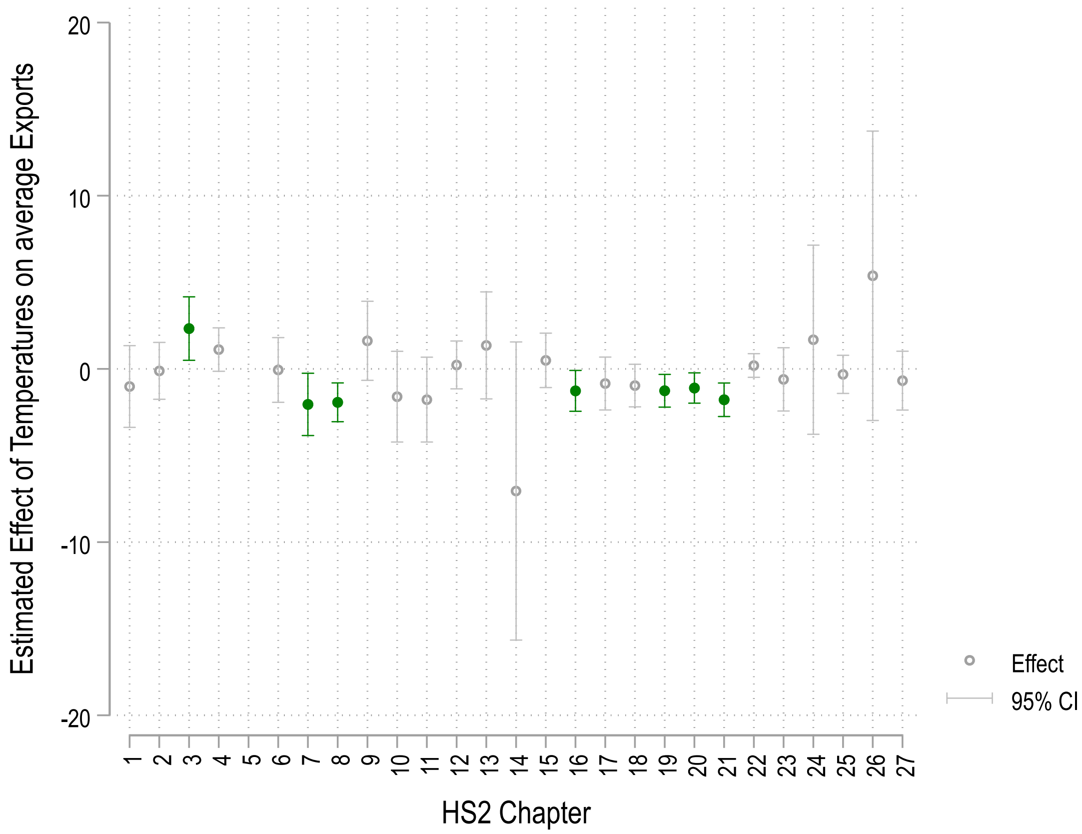


Figure A2 - Effect for each HS2, Manufacturing sample