The Economic Costs of Climate Change

This Version: August 25, 2020

Abstract

We estimate the economic costs of climate change using supply-chain networks. Specifically, we estimate the impact from changes in local temperature by comparing sales of intermediate goods across suppliers located in different counties that trade with the same client. We find that a one standard deviation increase in average daily temperature (1°C) in supplier counties leads to a reduction in sales of about 2%. In addition, episodes of extremely hot and cold weather lead to strong reductions in sales. The effects are more pronounced among suppliers in heat-sensitive, labor-intensive, and standardized goods industries, which is consistent with a labor productivity channel. We also show that changes in temperature affect corporate investment. Our results suggest that the economic costs of climate change are large.

JEL classification: G31, G32, L11, L14, Q54

Keywords: Climate change, Supply chain, Economic costs

1. Introduction

It is widely accepted among climate scientists that the global mean temperature is likely to increase by at least 2°C (Intergovernmental Panel on Climate Change, 2007, 2012, 2014). This increase is expected to be associated with more frequent extreme weather events such as storms and floods, as well as the rise in sea levels and heat waves (Barriopedro et al., 2011). But what are the economic costs of such weather shocks for the real economy? Several studies focus on the direct economic consequences of weather shocks on agricultural outcomes and farmland value (Mendelsohn et al. (1994), Schlenker et al. (2005), Deschênes and Greenstone (2007), Schlenker and Roberts (2009), Schlenker and Lobell (2010), Chevet et al. (2011), and Roberts et al. (2012)). There is also growing evidence on the impact of climate change on total factor productivity (Graff-Zivin and Kahn (2016), Chen et al. (2018), and Zhang et al. (2018)). However, it is unclear whether how these shocks affect firm value. In particular, it is challenging to distinguish demand and supply effects as weather shocks can affect firm supply and client demand.

In this paper, we use supply-chain networks to study how weather shocks affect firm value. We use supply chains as an empirical setting to estimate the impact of changes in average temperature on firm supply while explicitly accounting for demand shocks. We use variation in average temperatures across suppliers of the same client in a given year to obtain an estimate of the impact of weather shocks on firm revenue controlling for firm-specific demand.[1]

[1] The supply chain is a channel through which climate change may affect the broader economy (Dasaklis and Papis (2013) and Colmer, Martin and Muuls (2019)). Anecdotal evidence also suggests that firms do take possible disruptions brought to the supply chain by climate change into account. For example, in its 2014 annual report, the pharmaceutical firm Pfizer published the following statement: "Climate change presents risks to our operations, including potential physical risks to our facilities and supply chain due to more frequent and severe weather events and water availability."

We obtain supplier-client pair sales data from Compustat Segment sales, gridded weather data from PRISM Climate Group (2019), and extreme weather events from the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database. We use an empirical strategy similar to Khwaja and Mian (2008) to quantify the impact of weather shocks to supplier-client sales, which includes client-by-year fixed effects to explicitly control for demand shocks to a client in a given year. In addition, the regressions include observable supplier financial characteristics as covariates, and include supplier-industry fixed effects and supplier county fixed effects to account for unobserved heterogeneity.

We find that increases in temperature lead to declines in supplier-client sales. A one standard deviation increase in the average daily temperature in supplier counties (1°C) is associated with a decrease in sales of about 2%. In addition, we find that extreme heat events and especially extreme cold events can have a disruptive effect on sales. While weather shocks affect the sales of intermediate goods at the intensive margin, we do not find evidence on the extensive margin, i.e. we do not find that weather shocks lead to termination of supply chain relationships.

We next investigate a possible channel through which weather shocks affect firm revenue. We show that our results are mostly driven by heat-sensitive industries, suggesting that our findings can be explained through a labor productivity channel as weather shocks can negatively affect productivity due to workers' absence or harder working conditions. Consistent with this idea, we find that the reduction in sales is more pronounced in more labor-intensive firms, and less pronounced in more capital-intensive firms. We also test the hypothesis that firm size can mediate the effect of weather shocks on sales. Indeed, we find that the effect of weather shocks on sales is less pronounced among larger firms, which should have more resources and flexibility to overcome weather shocks without disrupting production.

We also explore whether product market characteristics can amplify or mitigate the effect of weather shocks on supplier revenues. Clients buying standardized goods might avoid delays related to disruptions in the production of shocked suppliers by switching to other suppliers. In addition, clients could easily identify if suppliers compromise product quality. Thus, we expect a stronger negative effect of weather shocks for suppliers in industries producing standardized goods, relative to industries producing differentiated goods. We find that the reduction in sales is more pronounced in industries that sell standardized goods. This finding is consistent with the idea that the firm-specific economic costs of weather shocks are larger when switching costs are lower.

Next, we test whether weather shocks produce real effects. If firms anticipate a long-term impact of weather shocks, they might reduce their investment. While we do not find changes in local temperature to have an average impact on investment, we find that financially constrained firms reduce investment when local temperature is higher. These results suggest that financial frictions might amplify the negative effects of weather shocks, in the spirit of Bernanke et al. (1996).

Overall, our results suggest that climate change affects firm supply. We show for the same client buying from different suppliers, its purchases from suppliers affected by weather shocks decline significantly. The effects are economically significant and cannot be explained by changes in demand for supplier's products or services. Our results can be explained by both a labor productivity channel and a financial constraints channel.

This paper contributes to several strands of the literature. First, we contribute to the literature on the indirect costs of climate change on the economy. Graff-Zivin and Kahn (2016), Chen et al. (2018) and Zhang et al. (2018) find that heat affects total factor productivity. We complement these findings by showing that higher temperature affects supplier-client sales via a labor productivity channel. Addoum, Ng, and Ortiz-Bobea (2020) find no evidence that location-specific temperatures affect sales, productivity, and profitability using establishment-level data in the U.S.

We improve on the identification of the effect of temperature on sales by using detailed information of sales from suppliers to clients, and control for supplier financial characteristics, and confounding demand effects at the client level by including client-by-time fixed effects. In addition, while temperature and precipitation may impact agricultural outcomes in a non-linear fashion (Mendelsohn et al. (1994) and Schlenker and Roberts (2009)), we only find the level of average temperature to affect supplier sales and client purchases.

Second, we contribute to the literature on climate change and the supply chain. Dasaklis and Pappis (2013) outline how climate change may affect the supply chain qualitatively. Pankratz and Schiller (2019) find that heat waves and flooding at supplier locations lead to termination of relationships in global supply chain and reduction in client sales. In contrast, controlling for shocks to client demand, we show that both average weather shocks and extreme weather events lead to changes in supplier-client sales in the intensive margin, but not in the extensive margin.

2. Data and Methodology

2.1. Sample and variables

Our sample consists of supplier-client pairs whose headquarters are located in the U.S. To obtain this data, we rely on regulations SFAS numbers 14 and 131, which requires that publicly listed firms in the U.S. must disclose, on a yearly basis, the identity of clients and the sales to clients whose purchases represent more than 10% of total sales. We collect this information from the Compustat Segment files for the period 2000-2015. From these files we unambiguously identify the suppliers (using the GVKEY unique code from Compustat), and obtain the text names for their most important clients. Using text-searching algorithms complemented with manual searches, we match the reported client names to the Compustat database to obtain information about clients such as financials, location, and industry. As we restrict the searches to publicly traded firms in Compustat, we are unable to identify clients that are private firms, governments, or firms based outside of the U.S. Similarly, the reporting regulations imply that we cannot identify clients that buy small amounts or aggregate clients.

We obtain temperature and precipitation data from the PRISM Climate Group (2019). PRISM gathers climate observations from weather stations in continental U.S. and uses sophisticated climate modelling techniques to interpolate weather data at each 4km × 4 km grid (PRISM (2013)). The interpolation method takes elevation, slope orientation, wind direction, rain shadows, terrain complexity, proximity to coastlines and location of temperature inversions and cold air pools into account. This results in a balanced panel of weather data for continental U.S.

We obtain extreme weather events data from the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database (NOAA (2019)). This database records the occurrence of significant weather events that have enough intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce (NOAA (2018)).

We map the weather grids in PRISM and extreme weather event locations to counties in the U.S. Census Bureau files. We compute average daily weather variables at the county level for each year and the annual number of extreme weather events by event type at the county level for each year. Finally, we match the weather variables in each county to the firms in Compustat using the county location of the firms' main headquarters and the firm's fiscal year end. Since a firm's production plants and sales locations are not always located in the same county as their headquarters, our proxy of the exposure to temperature is prone to measurement error, which is likely to bias our results against finding any effect on a firm's sales.

2.2. Summary statistics

Panel A of Table I contains a year-by-year description of our sample. Our sample consists of 12,439 supplier-client-year observations for 1,856 unique suppliers and 419 unique clients over the period 2000-2015, with approximately 800 observations per year. Sales to clients in our sample account, on average, for 31.2% of the total sales of sample firms. Panel A also shows that the coefficient of our variable of interest is estimated using the variation in the change in temperature of more than four suppliers per client. The last two columns show that there is also a moderate time-series variation in the average temperatures in the counties where firms are located, with the change in average daily temperature in the counties where firms are headquartered ranging from minus 1.4°C to 0.88°C.

Panels B and C of Table I contain descriptive statistics for the firms in our pair-level sample. Panel B presents summary statistics for supplier firms. Panel C presents summary statistics for client firms. Client firms are larger than supplier firms both in terms of total assets and number of employees. This is due to regulation SFAS 14, which only requires disclose of the names of clients that account for at least 10% of the suppliers' total sales. Client firms more levered, hold less cash, have more tangible assets, and have a lower Tobin's Q than supplier firms. Average daily temperature and average daily precipitation in headquarters counties for both client firms and supplier firms are similar. Panel D of Table I contains descriptive statistics for the firms in our firm level sample. Table IA.I in the Internet Appendix reports descriptive statistics for the firm-segment level sample.

2.3. Methodology

Our main objective is to examine whether changes in local temperature affect the firms' economic activity, measured by sales to each client. To investigate this hypothesis, we estimate the following regression equation:

$$\Delta \ln(Sales)_{ijt} = \beta_1 Temp\ Chg_{it} + \beta_2 Prcp_{it} + \gamma X_{it-1} + \delta_{jt} + \varepsilon_{ijt}, \quad (1)$$

where indices i and j denote suppliers and clients respectively. The dependent variable measures the percentage change in the supplier's sales to each client.[2] The main independent variable, $Temp\ Chg_{it}$ is the change in average daily temperature in degrees Celsius in the county where supplier i is headquartered from year *t*-1 to year *t*. Following the climate economics literature, we include the average daily precipitation in inches in the county where supplier i is headquartered from year *t*-1 to year *t* ($Prcp_{it}$) as a control variable. In all specifications, we add a set of lagged supplier controls, X_{it-1}, which include firm size (*Assets*), Tobin's Q, cash to assets ratio (*Cash*), market leverage (*Leverage*) and asset tangibility (*Tangibility*). The inclusion of these firm-level controls, which affect the level of sales, reduces the variance of the estimated coefficients of the weather variables.

Importantly, our client-supplier data allows us to include client-by-year fixed effects, δ_{jt}. This ensures that identification comes from the variation in the change in temperature across the suppliers of a given client in the same year. Client-by-year fixed effects absorb all unobserved heterogeneity at the client level in a given year, and allow us to compare the changes in economic activity across suppliers selling to the same firm. Thus, our results are unlikely to be driven by changes in firm-specific demand. The estimated difference in sales can therefore be plausibly

[2] We require non-missing sales data in two consecutive years to calculate the change in sales for each client-supplier pair.

attributed to supply-side factors, such as changes in labor productivity of suppliers. Weather shocks can lead to lower output or an increase in operating costs. In addition, weather shocks can affect the quality of products or services. In more stringent specifications, we include supplier industry fixed effects and supplier industry-by-year fixed effects to absorb non-time varying and time varying unobserved heterogeneity at the supplier industry level. In more stringent specifications, we include supplier industry fixed effects, δ_s, to control for time-invariant differences across industries, and supplier industry-by-year fixed effects, δ_{st}, to control for time-varying differences across industries.

The main coefficient of interest is β_1, which estimates the effect of changes in temperature on supplier-client sales. A negative β_1 would indicate that suppliers that observe increases in average daily temperature in their county of location reduce their sales by larger amounts than otherwise similar suppliers selling to the same client. In our baseline regressions, we cluster the standard errors at the supplier county level as it corresponds to the variation we explore in the main explanatory variable. Table A.I in the Appendix provides variable definitions and data sources.

3. Results

3.1. Main results

Table II presents the estimates of the regression in equation (1). In all columns, we estimate the effect of changes in temperature on changes in supplier-client sales. We do not control for precipitation in columns (1)-(3), but we do in columns (4)-(6). We estimate the regressions using three different sets of fixed effects: client-by-year fixed effects in columns (1) and (4); supplier industry fixed effects and client-by-year fixed effects in columns (2) and (5); and supplier industry-by- year and client-by-year fixed effects in columns (3) and (6).

The results show that the temperature variable (*Temp Chg*) coefficient is negative and statistically significant in all specifications. The inclusion of precipitation as a control does not significantly affect the estimates. The effect of temperature on a supplier's sales is also economically significant. A one standard deviation increase in the change in temperature (1°C) in supplier counties leads to a 1.2% to 1.9% reduction in supplier-client sales.

In Table IA.II in the Internet Appendix, we include quadratic terms for changes in temperature and precipitation. We find that the coefficient on changes in temperature is negative and statistically significant across specifications, and the coefficient on squared changes in temperature is statistically insignificant, suggesting that the linear specification in Table II is more adequate.

3.2. Extreme weather events

We next examine whether extreme weather events affect firms' economic activity. In columns (1)-(3) of Table III, we test whether excessive heat in supplier counties affects supplier-client sales. The variable of interest is *Heat Events*, which measures the number of extreme heat events that takes place in the county where a supplier is located. The incidence of extreme heat events is rare in our sample. Table I shows that the average number of heat events in our sample is 0.0053, i.e. approximately one in 200 observations is hit by one such event during our sample period. We find that the coefficient of *Heat Events* is negative and significant. The effect of extreme heat events is also economically significant. An extreme heat event is associated with a further 6.2% to 8.0% reduction in sales, relative to firms with no such event.

In columns (4)-(6) of Table III, we test whether extreme cold events in supplier counties affect supplier-client sales. The variable of interest is *Cold Events*, the number of extreme cold events that takes place in the county where a supplier is located. The incidence of such events is low in our sample, with an average value of 0.0007, or slightly less than one in 1000 observations. We find that the *Cold Events* variable coefficient is negative and significant. The extreme cold events have an even more meaningful effect on firms' sale than the extreme heat events. Firms hit an extreme cold event suffer an additional reduction in their sales of 31.3% to 35.7%. These results suggest that extreme cold events, even if less often, can have a more disruptive effect on the firm's economic activity.

3.3. Extensive margin

Our baseline results in Table II are determined under the assumption that clients and suppliers maintain their relationship during two consecutive years; otherwise these transactions would not be observed in the data. Therefore, our baseline results are on the intensive margin. We also estimate an extensive margin regression based on equation (1), but replacing the dependent variable with a dummy that takes a value of one if we observe transactions in year t–1 but not in year t. A positive and statistically significant coefficient of change in temperature indicates that suppliers exposed to increases in temperature suffer a significant decrease in sales, such that sales to the client falls below the 10% reporting threshold and eventually to zero. Table IV presents these results of a linear probability model. We find that the coefficients are not statistically significant in any of the specifications, suggesting that changes in temperature do not lead to termination of supply chain relationships.

In Table V, we repeat the estimations on the extensive margin, with the number of extreme weather events as the main explanatory variable. In columns (1)-(3), we report the estimates for extreme heat, and in columns (4)-(6), we report the estimates for extreme cold events. While the coefficients are positive across specifications, only one is marginally significant at the 10% level.

Our results in Tables IV and V contrast with those of Pankratz and Schiller (2019), who find that heatwaves and natural disasters (floods) can disrupt the global supply chain in the extensive margin. Our findings show that within the U.S., changes in temperature and extreme weather events are not as likely to have such a disruptive effect. This may be explained by the fact that our sample is a domestic supply-chain network, rather than a global one, and client and suppliers may have stronger business relationships, and lower information asymmetries due to their geographical proximity.

3.4. Heterogeneous effects of weather shocks

In this section, we analyze whether certain types of industries might exhibit a sensitivity to temperature that differs from the average effects in Table II. For example, firms in industries with predominantly outdoor activities or manufacturing processes are expected to be more sensitive to heat. Following Graff-Zivin and Neidell (2014), we identify firms operating in heat sensitive industries as firms operating in agriculture, forestry, fishing, and hunting; construction; mining; and transportation and utilities; and manufacturing industries.

Firms in industries with more substitutable goods are also expected to be more sensitive to these shocks as it is less costly for clients to substitute away from a supplier. Note that we cannot identify whether observed changes in sales at the client-supplier pair level are supplier- or client-originated, though these are triggered by the weather events. It may be that supplier is indeed disrupted and therefore cannot supply the goods, or it may be the case that clients, observing the shock and anticipating possible disruption decide to reduce their purchases from the supplier and possibly switch to a different one. Following Burkart, Ellingsen and Giannetti (2011), we identify industries that are more likely to sell standardized products or, in other words, industries with lower costs of switching to other suppliers.

To analyze these issues, we estimate equation (1) on different subsamples. Table VI report the results. In columns (1)-(2), we find that increases in temperature negatively and significantly reduce sales for firms in heat sensitive industries, but not for firms in non-heat sensitive industries. A one standard deviation increase in the change in temperature (1°C) in supplier counties leads to a 2% reduction in supplier-client sales when suppliers are in heat sensitive industries.

In columns (3)-(4), we find that find that increases in temperature negatively and significantly reduce sales for firms in industries that sell more standardized goods, but not for firms in other industries. A one standard deviation increase in the change in temperature (1°C) in supplier counties leads to a 3.6% reduction in supplier-client sales of standardized goods.

Next, we analyze whether certain types of firms might exhibit a sensitivity to temperature that differs from the average effects in Table II. Previous research has shown that high temperatures have a negative impact on labor productivity (Chen, Huynh and Zhang (2019)). If this is the case, we expect that labor-intense firms to exhibit higher sensitivity of sales to the temperature. We also expect larger firms to be better prepared to deal with higher temperatures, as they might have more spare capacity or might hedge their exposures to higher temperatures.

To analyze these issues, we augment equation (1) by adding interaction terms between changes in temperature and proxies for labor intensity and firm size. Table VII presents the results. To proxy for labor intensity, we use the ratio of the number of employees to assets in column (1). To proxy for capital intensity, we use asset tangibility, i.e. the ratio of property, plant, and equipment to assets, a proxy for high capital intensity, in column (2). To proxy for firm size, we use the log of total assets in column (3). For ease of interpretation of the interaction terms, we standardize all interacted variables by subtracting sample mean then dividing by its standard deviation.

Columns (1) and (2) show that the sensitivity of supplier sales to changes in temperature is higher for firms that are more labor intensive. Columns (1) suggests that a 1°C change in local temperature leads to a -2.2% higher drop in sales for firms that have a one-standard deviation higher than average ratio of labor intensity (measured with the number of employees to assets). These effects are three times larger than our baseline estimates in Table II. In contrast, capital intensity does not affect the sensitivity of sales to changes in temperature: The estimates in column (2) shows that the coefficient of the interaction term between changes in temperature and capital intensity (measured with asset tangibility) is statistically insignificant. Finally, column (3) shows that larger firms are better able to mitigate the effects of increases in temperature on sales. The change in sales driven by a 1°C increase in local temperature is -0.03%, whereas it corresponds to -1.8% for firms that are smaller than the average by one standard deviation.

3.5. Real effects of temperature shocks

In this section, we analyze whether changes in temperature affects corporate investment. Previous sections provide evidence that increases in local temperature have a negative impact on total firm revenue. This suggests that weather shocks affect firm cash flows. If firms are financially constrained, corporate investment will be sensitive to cash flows (Fazzari, Hubbard and Petersen (1988)). If this is the case, we expect financially constrained firms to reduce corporate investment in response to increases in temperature.

For this purpose, we move from the client-supplier level to a firm-level analysis, using the full sample of Compustat firms over the 2000-2015 period, excluding regulated utilities (SIC 4900-4999), financial and real estate (6000-6999), public administration (9100-9729) and non-classifiable firms (9900-9999). To proxy for financial needs, we use the proportion of long-term debt maturing in the next year (*LT Debt Mat*). Almeida et al. (2011) argue that since the maturity of long-term debt is pre-scheduled, the proportion of long-term debt maturing in the upcoming year createsvariation in financial constraints that is pre-determined.

Table VIII presents the results. Columns (1)-(3) show that changes in temperature do not have an average effect on corporate investment. However, columns (4)-(6) show that increases in temperature significantly reduce corporate investment for financially constrained firms. A one standard deviation increase in local temperature translates into a 1.7% reduction capital expenditures if the proportion of long-term debt maturing (*LT Debt Mat*) is one standard deviation higher than a similar firm.

To further explore the impact of changes in temperature and corporate investment, we proceed to a firm-segment level analysis, using the full sample of Compustat firm segments data over the 2000-2015 period. Since Table VI shows that the impact of changes in temperature on supplier-client sales is driven by firms in heat sensitive industries and industries that sell more standardized goods, we expect the reduction in investment to manifest primarily in these segments in financially constrained firms.

Columns (1)-(3) in Table IX show that changes in local temperature significantly lower investment in business segments that are in heat-sensitive industries. For the median firm, a 1°C increase in local temperature translates into a 6.67% to 10% reduction in capital expenditures in heat-sensitive business segments if *LT Debt Mat* is one standard deviation higher than a similar firm. Columns (4)-(6) in Table IX show that changes in local temperature significantly lower investment in business segments that are in industries that sell more standardized goods. For the median firm, a 1°C increase in local temperature translates into a 6.67% reduction in capital expenditures in business segments that sell standardized goods if *LT Debt Mat* is one standard deviation higher than a similar firm.

3.6. Robustness

In this subsection, we discuss several robustness checks of our primary findings. The Internet Appendix shows these results.

A first concern is whether the segment sales data are representative of the total sales of the supplier firm. In particular, firms are only required to disclose the identity of any client representing more than 10% of the total sales. During our 2000-2015 sample period, the sum of reported sales represents on average of 31.2% of total sales (the median is 24.0%). We run our regressions with the sample of suppliers for which the sum of reported sales represents at least 24.0% (the median). Table IA.III reports the estimates, which are consistent with those in Table II but more imprecisely estimated. The magnitudes of the coefficients of average temperature are similar at about -1.9% to -2.2%. To further address this concern, we estimate firm-level (rather than client-supplier level) regressions similar to those in Table II using the change in total sales as a dependent variable. Table IA.IV reports the results for the full sample of Compustat firms.

Another concern is that there are missing values in capital expenditures. In Table IA.V, we use the change in net property, plant and equipment scaled by total assets as an alternative definition of investment. The coefficient of *Temp Chg x LT Debt Mat* is negative and statistically significant.

4. Conclusion

This paper studies the economic costs of changes in local temperature using supply-chain networks as a laboratory. We compare sales of intermediate goods across suppliers that trade with the same client but are exposed to different weather shocks, which allow us to distinguish supply from demand effects.

We show that changes in local temperature can have important effects on supply-chain networks activity at the intensive margin. A one standard deviation increase in local average daily temperature (1°C) in supplier counties leads to a reduction in sales of about 2%. We also show that suppliers exposed to episodes of extremely hot and cold weather suffer large reductions in sales.

We examine the channels by which changes in local temperature affect sales. The reduction in supplier-client sales in response to changes in local temperature is primarily driven by firms in heat sensitive industries, labor-intensive industries and industries that sell standardized goods. The evidence is consistent with a labor productivity channel in which weather shocks have a more pronounced negative effect on labor intensive industries. In addition, we find that larger firms are better able to deal with the adverse effects of increased local temperature and therefore suffer less from reductions in sales.

We analyze whether the weather shock affects corporate investment policies. While we do not find changes in local temperature to have an average impact on investment, we find that firms with greater financing needs reduce investment when local temperature is higher. The effect is more pronounced for business segments that are in heat sensitive industries and industries that sell more standardized goods.

Our results suggest that climate change can have important economic effects through supply-chain networks. Suppliers more likely to be affected by climate change can suffer significant decreases in production. The purchases and production of customers of climate change-sensitive suppliers can also be affected even though these customers may not be sensitive to climate change. Thus, supply-chain networks can transmit the effects of climate shocks to regions that are not necessarily exposed to these climate shocks. Of course, firms can anticipate climate risks and substitute in favor of suppliers in locations that are less vulnerable to climate risks.

References

Addoum, Jawad M., David T. Ng, and Ariel Ortiz-Bobea. (2020). Temperature shocks and establishment sales. *Review of Financial Studies* 33(3): 1331-1366.

Bernanke, Ben S., Mark Gertler, and Simon Glichrist, (1996). The financial accelerator and the flight to quality. *Review of Economics and Statistics*, 78(1):1–15

Chen, Chen, Thanh D. Huynh and Bohui Zhang. (2019). Temperature and Productivity: Evidence from Plant-level Data. *Working Paper*.

Chevet, Jean-Michel, Sébastien Lecocq, and Michael Visser. 2011. "Climate, Grapevine Phenology, Wine Production, and Prices: Pauillac (1800-2009)." *American Economic Review*, 101(3): 142-146.

Dasaklis, Thomas K., and Costas P. Pappis. 2013. "Supply Chain Management in View of Climate Change: An Overview of Possible Impacts and the Road Ahead." *Journal of Industrial Engineering and Management*, 6(4).

Deschênes, Olivier, and Michael Greenstone. 2007. "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather." *American Economic Review*, 97(1): 354-385.

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Petersen. 1988. "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity*, Volume 1988, Issue 1 (1988): 141-195.

Giannetti, Mariassunta, Mike Burkart, and Tore Ellingsen. 2011. "What you sell is what you lend? Explaining trade credit contracts." *Review of Financial Studies,* 24(4): 1261-1298.

Graff-Zivin, Joshua, and Mathew Neidell. 2014. "Temperature and the Allocation of Time: Implications for Climate Change." Journal of Labor Economics, 32(1): 1-26.

Graff-Zivin, Joshua, and Matthew Kahn. 2016. "Industrial Productivity in a Hotter World: The Aggregate Implications of Heterogeneous Firm Investment in Air Conditioning." *NBER Working Paper 22962*.

Hong, Harrison, Frank Weikai Li, and Jiangmin Xu. 2019. "Climate Risks and Market Efficiency." *Journal of Econometrics*, 208(1): 265-281.

Intergovernmental Panel on Climate Change. 2007. "Climate Change 2007: Synthesis Report." URL: https://www.ipcc.ch/report/ar4/syr/

Intergovernmental Panel on Climate Change. 2012. “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.” URL: https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/

Intergovernmental Panel on Climate Change. 2014. “Climate Change 2014: Synthesis Report.” URL: https://www.ipcc.ch/report/ar5/syr/

Intergovernmental Panel on Climate Change. 2019. “Special Report on Global Warming of 1.5 Degree Celsius.” URL: https://www.ipcc.ch/sr15/download/.

Khwaja, Asim Ijaz and Atif Mian. 2008. “Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market.” *America Economic Review,* 98(4): 1413-42.

Levermann, Anders. 2014. “Climate Economics: Make Supply Chains Climate-Smart.” *Nature*, 506(7486): 27-29.

Mendelsohn, Robert, William D. Nordhaus, and Daigee Shaw. 1994. “The Impact of Global Warming on Agriculture: A Ricardian Analysis.” *The American Economic Review*, 84(4): 753-771.

Pankratz, Nora M.C., and Christoph M. Schiller. 2019. “Climate Change and Adaptation in Global Supply-Chain Networks.” Available at SSRN 3475416.

Pew Research Centre. 2019. “Climate Change Still Seen as the Top Global Threat, but Cyberattacks a Rising Concern.” *Pew Research Centre Global Report 2018*.

PRISM Climate Group. 2019. “PRISM Gridded Climate Data.” http://prism.oregonstate.edu.

Roberts, Michael J., Wolfram Schlenker, and Jonathan Eyer. 2012. “Agronomic Weather Measures in Econometric Models of Crop Yield with Implications for Climate Change.” *American Journal of Agricultural Economics*, 95(2): 236-243.

Schlenker, Wolfram, W Michael Hanemann, and Anthony C Fisher. 2005. “Will U.S. Agriculture Really Benefit from Global Warming? Accounting for Irrigation in the Hedonic Approach.” *American Economic Review*, 95(1): 395-406.

Schlenker, Wolfram, and David B. Lobell. 2010. “Robust Negative Impacts of Climate Change on African Agriculture." *Environmental Research Letters*, 5(1).

Schlenker, Wolfram, and Michael J. Roberts. 2009. “Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change.” *Proceedings of the National Academy of Sciences*, 106(37): 15594-15598.

Zhang, Peng, Olivier Deschênes, Kyle Meng and Junjie Zhang. 2018. “Temperature Effects on Productivity and Factor Reallocation.” *Journal of Environmental Economics and Management*, 88: 1-17.

Table I: Sample Description and Summary Statistics

Panel A presents the number of observations (supplier-client pairs), number of suppliers, number of clients, average number of suppliers per client, average fraction of total sales of the supplier, average temperature at supplier firms' headquarter counties and client firms' headquarter counties included in the sample per year. Panels B and C present mean, median, 25th percentile, 75th percentile, standard deviation, and number of observations for each supplier and client variable, respectively. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Panel D presents mean, median, 25th percentile, 75th percentile, standard deviation, and number of observations for firm-level variables. Panel E presents mean, median, 25th percentile, 75th percentile, standard deviation, and number of observations for firm-segment level variables . The sample consists of yearly observations of Compustat firms in the 2000-2015 period. Variable definitions are in Table A.1 in the Appendix.

Panel A: Sample Description by Year

Year	Obs	Unique Suppliers	Unique Clients	Average Number of Suppliers per Client	Average Supplier Sales Coverage	Average Change in Temperature in Supplier Counties	Average Change in Temperature in Client Counties
2000	535	387	108	4.9537	0.3051	-0.6297	-0.5455
2001	807	552	152	5.3092	0.3206	0.4742	0.3255
2002	857	564	176	4.8693	0.3267	0.0165	-0.0054
2003	915	620	170	5.3824	0.3041	-0.5647	-0.6638
2004	896	596	172	5.2093	0.3087	0.2399	0.3559
2005	844	565	166	5.0843	0.3205	0.2973	0.2997
2006	899	593	169	5.3195	0.3082	0.4675	0.4955
2007	859	592	164	5.2378	0.3003	-0.4050	-0.4966
2008	800	565	151	5.2980	0.3007	-0.4545	-0.2122
2009	770	545	154	5.0000	0.3016	-0.1492	-0.2086
2010	747	522	143	5.2238	0.3094	0.5358	0.6431
2011	721	490	143	5.0420	0.3183	0.1185	-0.0354
2012	707	470	133	5.3158	0.3174	0.8309	0.8567
2013	713	465	138	5.1667	0.3212	-1.4147	-1.4008
2014	715	455	146	4.8973	0.3277	-0.2711	-0.2102
2015	654	428	134	4.8806	0.3209	0.9052	0.8825
Unique	--	1856	419	--	--	307	99
Total	12439	--	--	--	--	--	--

Panel B: Suppliers

Variable	Mean	25th Pct	50th Pct	75th Pct	Std Dev	Obs
Δlog(Sales)	0.0159	-0.1641	0.0363	0.2253	0.5081	12439
Tobin's Q	2.2007	1.1006	1.5232	2.3639	2.7290	12439
Cash	0.1623	0.0339	0.1065	0.2335	0.1718	12439
Log(Assets)	5.7910	4.4207	5.7189	7.1434	1.9850	12439
Tangibility	0.2229	0.0647	0.1488	0.3022	0.2187	12439
Leverage	0.1991	0.0024	0.1096	0.3125	0.2383	12439
Temp	13.7013	10.2014	13.2761	16.5212	4.2085	12439
Temp Chg	-0.0013	-0.5383	0.0364	0.5313	0.8520	12439
Prcp	2.5856	1.6308	2.7168	3.4307	1.1783	12439
Cold Events	0.0007	0	0	0	0.0269	12439
Heat Events	0.0053	0	0	0	0.1261	12439
Std Goods	0.3142	0	0	1	0.4642	11123
Heat Sensitive Industries	0.8394	1	1	1	0.3672	12439

Panel C: Clients

Variable	Mean	25th Pct	50th Pct	75th Pct	Std Dev	Obs
Δlog(Sales)	0.0159	-0.1641	0.0363	0.2253	0.5081	12439
Tobin's Q	1.8209	1.1427	1.5144	1.9989	1.1871	7556
Cash	0.0718	0.0274	0.0530	0.0977	0.0636	9588
Log(Assets)	10.5486	9.5921	10.5606	11.6768	1.4233	9792
Tangibility	0.2630	0.0869	0.1885	0.4331	0.2110	7681
Leverage	0.2492	0.1052	0.1740	0.3129	0.2219	9491
Temp	13.5199	10.6018	12.9288	15.7605	3.8481	7718
Temp Chg	-0.0083	-0.5093	0.0212	0.5290	0.8485	7718
Prcp	2.7238	1.9107	2.8200	3.4682	1.1309	7718
Cold Events	0.0005	0	0	0	0.0228	7718
Heat Events	0.0056	0	0	0	0.0744	7718

Panel D: Firms

Variable	Mean	25th Pct	50th Pct	75th Pct	Std Dev	Obs
Δlog(Sales)	0.0733	-0.0525	0.0614	0.1887	0.4157	40662
EBIT/Assets	-0.0952	-0.0566	0.0557	0.1184	0.6584	40662
Net Income/Assets	-0.1769	-0.1151	0.0192	0.0722	0.8104	40662
CapEx/Assets	0.0615	0.0149	0.0325	0.0672	0.0936	40662
(CapEx + R&D)/Assets	0.1281	0.0297	0.0660	0.1421	0.1966	40662
ΔPPE/Assets	0.0216	-0.0165	0.0008	0.0272	0.1321	40662
Tobin's Q	2.8243	1.0807	1.4980	2.3940	5.8275	40662
Cash	0.1264	0.0211	0.0689	0.1683	0.1570	40662
Log(Assets)	5.3724	3.6975	5.5103	7.1014	2.4579	40662
Tangibility	0.2725	0.0840	0.1947	0.4009	0.2377	40662
Leverage	0.2624	0.0566	0.1873	0.4021	0.2487	40662
Temp	14.0663	10.4941	13.3446	17.1437	4.4286	40662
Temp Chg	-0.0096	-0.5383	0.0524	0.5265	0.8492	40662
Prcp	2.7258	1.9225	2.8938	3.5042	1.1632	40662
Cold Events	0.0010	0	0	0	0.0351	40662
Heat Events	0.0071	0	0	0	0.1465	40662
LT Debt Mat	0.1181	-0.7205	-0.4335	0.5234	1.1597	40662

Table II: Baseline Results

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable Δlog(*Sales*) is the change in the log of sales from supplier *i* to client *j* between years *t*-1 and *t*. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for supplier *i* in between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg	-0.012*	-0.013*	-0.017**	-0.014*	-0.014*	-0.019**
	(0.085)	(0.072)	(0.023)	(0.069)	(0.052)	(0.015)
Prcp				-0.007	-0.008	-0.009
				(0.236)	(0.166)	(0.124)
Tobin's Q	0.013***	0.013***	0.014***	0.013***	0.013***	0.014***
	(0.002)	(0.001)	(0.000)	(0.002)	(0.001)	(0.000)
Cash	-0.082	-0.076	-0.072	-0.084	-0.078	-0.075
	(0.137)	(0.180)	(0.221)	(0.127)	(0.166)	(0.201)
Log(Assets)	0.014***	0.013***	0.013***	0.014***	0.013***	0.013***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Tangibility	-0.014	-0.045	-0.044	-0.014	-0.045	-0.044
	(0.673)	(0.308)	(0.326)	(0.675)	(0.313)	(0.328)
Leverage	-0.053**	-0.051**	-0.047*	-0.052**	-0.050**	-0.046*
	(0.018)	(0.031)	(0.072)	(0.023)	(0.035)	(0.079)
Constant	-0.066***	-0.054*	-0.059**	-0.047	-0.033	-0.035
	(0.006)	(0.056)	(0.049)	(0.133)	(0.345)	(0.338)
Observations	12,439	12,439	12,439	12,439	12,439	12,439
R-squared	0.298	0.302	0.333	0.298	0.302	0.334
Client-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	Yes	No
Industry-Year FE	No	No	Yes	No	No	Yes

Table III: Extreme Weather Events

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable Δlog(*Sales*) is the change in the log of sales from supplier *i* to client *j* between years *t*-1 and *t*. *Cold Events* is the number of cold events recorded in the county of corporate headquarters between years *t*-1 and *t*. *Heat Events* is the number of heat events recorded in the county of corporate headquarters between years *t*-1 and *t*. *Temp* is the average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* between years *t*-1 and *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for supplier *i* between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Heat Events	-0.062**	-0.064**	-0.080**			
	(0.024)	(0.020)	(0.024)			
Cold Events				-0.313***	-0.333***	-0.357***
				(0.006)	(0.004)	(0.003)
Temp	-0.016	-0.015	-0.020*	-0.016	-0.016	-0.021*
	(0.156)	(0.168)	(0.078)	(0.146)	(0.157)	(0.071)
Prcp	0.007	0.006	0.007	0.006	0.006	0.007
	(0.620)	(0.650)	(0.617)	(0.631)	(0.661)	(0.632)
Tobin's Q	0.013***	0.013***	0.015***	0.013***	0.013***	0.015***
	(0.002)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Cash	-0.091	-0.085	-0.081	-0.092	-0.085	-0.082
	(0.102)	(0.145)	(0.185)	(0.101)	(0.142)	(0.181)
Log(Assets)	0.016***	0.014***	0.015***	0.016***	0.014***	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tangibility	-0.056	-0.081	-0.080	-0.056	-0.082	-0.081
	(0.193)	(0.143)	(0.153)	(0.188)	(0.142)	(0.151)
Leverage	-0.039	-0.040	-0.039	-0.039	-0.039	-0.039
	(0.106)	(0.127)	(0.180)	(0.107)	(0.130)	(0.183)
Constant	0.131	0.138	0.189	0.136	0.144	0.196
	(0.427)	(0.399)	(0.256)	(0.406)	(0.378)	(0.237)
Observations	12,413	12,413	12,412	12,413	12,413	12,412
R-squared	0.323	0.327	0.358	0.323	0.327	0.358
Client-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	Yes	No
Industry-Year FE	No	No	Yes	No	No	Yes

Table IV: Extensive Margin

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable is an indicator variable that takes a value of one if the client-supplier relationship has been terminated. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for supplier *i* in between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg	-0.004	-0.004	-0.004	-0.005	-0.005	-0.006
	(0.241)	(0.227)	(0.220)	(0.177)	(0.114)	(0.115)
Prcp				-0.005	-0.007	-0.008
				(0.538)	(0.307)	(0.292)
Tobin's Q	0.004**	0.003**	0.003*	0.004**	0.003**	0.003*
	(0.017)	(0.039)	(0.054)	(0.020)	(0.043)	(0.060)
Cash	-0.016	-0.019	-0.012	-0.017	-0.022	-0.015
	(0.669)	(0.598)	(0.748)	(0.626)	(0.543)	(0.686)
Log(Assets)	-0.021***	-0.017***	-0.016***	-0.021***	-0.017***	-0.016***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Net PPE/Assets	-0.050	-0.041	-0.040	-0.050	-0.042	-0.041
	(0.329)	(0.521)	(0.550)	(0.325)	(0.513)	(0.540)
Leverage	0.068**	0.049*	0.060**	0.068**	0.049*	0.060**
	(0.026)	(0.077)	(0.043)	(0.024)	(0.076)	(0.042)
Constant	0.574***	0.556***	0.546***	0.586***	0.575***	0.567***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	23,193	23,193	23,193	23,193	23,193	23,193
R-squared	0.427	0.440	0.455	0.427	0.440	0.455
Client-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	Yes	No
Industry-Year FE	No	No	Yes	No	No	Yes

Table V: Extreme Weather Events and Extensive Margin

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable is an indicator variable that takes a value of one if the client-supplier relationship has been terminated in year *t*. *Cold Events* is the number of cold events recorded in the county of corporate headquarters between years *t*-1 and *t*. *Heat Events* is the number of heat events recorded in the county of corporate headquarters between years *t*-1 and *t*. *Temp* is the average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* between years *t*-1 and *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for supplier *i* between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Heat Events	0.034	0.038*	0.044			
	(0.104)	(0.084)	(0.192)			
Cold Events				0.041	0.044	0.061
				(0.582)	(0.552)	(0.491)
Temp	-0.007	-0.007	-0.008	-0.007	-0.007	-0.008
	(0.226)	(0.214)	(0.147)	(0.232)	(0.220)	(0.153)
Prcp	-0.007	-0.007	-0.005	-0.007	-0.007	-0.005
	(0.273)	(0.237)	(0.374)	(0.274)	(0.238)	(0.376)
Tobin's Q	0.003*	0.003	0.003	0.003*	0.003	0.003
	(0.095)	(0.132)	(0.163)	(0.097)	(0.134)	(0.165)
Cash	-0.024	-0.027	-0.021	-0.024	-0.027	-0.020
	(0.475)	(0.418)	(0.547)	(0.482)	(0.425)	(0.555)
Log(Assets)	-0.023***	-0.019***	-0.018***	-0.023***	-0.019***	-0.018***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Net PPE/Assets	-0.106**	-0.101*	-0.098	-0.106**	-0.102*	-0.098
	(0.034)	(0.083)	(0.111)	(0.034)	(0.083)	(0.112)
Leverage	0.092***	0.089***	0.102***	0.092***	0.089***	0.102***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.714***	0.691***	0.693***	0.713***	0.689***	0.691***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	23,179	23,179	23,178	23,179	23,179	23,178
R-squared	0.478	0.486	0.501	0.478	0.486	0.500
Client-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	Yes	No
Industry-Year FE	No	No	Yes	No	No	Yes

Table VI: Industry Characteristics

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable Δlog(*Sales*) is the change in the log of sales from supplier *i* to client *j* between years *t*-1 and *t*. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for supplier *i* in between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Heat sensitive industries are defined as in Graff-Zivin and Neidell (2014). Standardized goods are defined as in Giannetti, Burkart and Ellingsen (2011). Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
Temp Chg	-0.020**	0.035	-0.036*	-0.011
	(0.015)	(0.111)	(0.083)	(0.276)
Prcp	-0.010*	0.002	-0.035***	0.004
	(0.096)	(0.855)	(0.001)	(0.510)
Tobin's Q	0.018***	0.011**	0.020***	0.015**
	(0.000)	(0.047)	(0.002)	(0.018)
Cash	-0.131*	0.094	-0.219	-0.002
	(0.074)	(0.301)	(0.115)	(0.970)
Log(Assets)	0.010**	0.035***	0.000	0.018***
	(0.013)	(0.000)	(0.950)	(0.000)
Tangibility	-0.001	-0.121	-0.100	-0.023
	(0.986)	(0.467)	(0.223)	(0.660)
Leverage	-0.031	-0.167*	0.056	-0.049
	(0.211)	(0.075)	(0.354)	(0.130)
Constant	-0.021	-0.210***	0.147**	-0.129***
	(0.583)	(0.008)	(0.019)	(0.000)
Subsample	Heat Sensitive	Non-Heat Sensitive	Std Goods	Non-Std Goods
Observations	10,224	1,432	3,120	7,247
R-squared	0.315	0.380	0.278	0.313
Client-Year FE	Yes	Yes	Yes	Yes

Table VII: Firm Size, Labor Intensity and Capital Intensity

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable Δlog(*Sales*) is the change in the log of sales from supplier *i* to client *j* between years *t*-1 and *t*. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for supplier *i* in between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. *Employee/Assets* is the number of employees divided by total assets. *Log(Assets)*, *Employee/Assets* and *Tangibility* are standardized by subtracting mean then dividing by sample standard deviation. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)
Temp Chg	-0.023***	-0.013*	-0.021**
	(0.009)	(0.085)	(0.012)
Prcp	-0.007	-0.007	-0.007
	(0.261)	(0.238)	(0.227)
Temp Chg x Employee/Assets	-0.022*		
	(0.077)		
Temp Chg x PPE/Assets		0.001	
		(0.870)	
Temp Chg x Log(Assets)			0.018**
			(0.024)
Employee/Assets	-0.032**		
	(0.018)		
Log(Assets)	0.030***	0.037***	0.037***
	(0.000)	(0.000)	(0.000)
Tangibility	-0.004	-0.004	-0.004
	(0.698)	(0.667)	(0.688)
Constant	-0.011	-0.003	-0.003
	(0.600)	(0.887)	(0.892)
Controls	Yes	Yes	Yes
Observations	12,252	12,439	12,439
R-squared	0.300	0.299	0.299
Client-Year FE	Yes	Yes	Yes

Table VIII: Investment and Financial Constraints

This table presents estimates of ordinary least squares (OLS) panel regressions at the firm level. The dependent variable *CapEx/Assets* is capital expenditures in year *t* divided by total assets in year *t*–1. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for firm *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for firm *i* in between years *t*-1 and *t*. *LT Debt Mat* is the proportion of long term debt maturing in the next year. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. *LT Debt Mat* is standardized by subtracting mean then dividing by sample standard deviation. All financial variables are lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat firms in the 2000-2015. Robust *p*-values clustered at the county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg	-0.000	-0.000	0.000	0.000	-0.000	0.000
	(0.999)	(0.595)	(0.518)	(0.813)	(0.714)	(0.358)
Prcp	0.000	-0.000	0.001	0.000	-0.001	0.001
	(0.778)	(0.508)	(0.214)	(0.801)	(0.490)	(0.223)
Temp Chg x LT Debt Mat				-0.001**	-0.001**	-0.001**
				(0.024)	(0.050)	(0.023)
LT Debt Maturing				-0.002***	-0.002***	-0.002***
				(0.001)	(0.000)	(0.002)
Constant	0.035***	0.174***	0.173***	0.055***	0.069***	0.066***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	40,662	40,662	40,662	40,662	40,662	40,662
R-squared	0.364	0.600	0.624	0.365	0.601	0.625
Year FE	Yes	Yes	No	Yes	Yes	No
Industry FE	Yes	No	No	Yes	No	No
County FE	Yes	No	No	Yes	No	No
Firm FE	No	Yes	Yes	No	Yes	Yes
Industry-Year FE	No	No	Yes	No	No	Yes

Table IX: Firm Segments

This table presents estimates of ordinary least squares (OLS) panel regressions at the firm-segment level. The dependent variable *Segment CapEx/Segment Assets* is capital expenditure into a business segment in year *t* divided by total assets in the business segment in year *t*–1. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for firm *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for firm *i* in between years *t*-1 and *t*. *LT Debt Mat* is the proportion of long term debt maturing. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are lagged one period. Heat sensitive industries are defined as in Graff-Zivin and Neidell (2014). Standardized goods are defined as in Giannetti, Burkart and Ellingsen (2011). *LT Debt Mat* is standardized by subtracting mean then dividing by sample standard deviation. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat firm segments in the 2000-2015. Robust *p*-values clustered at the county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg x Heat Sen Seg x LT Debt Mat	-0.003***	-0.002**	-0.002**			
	(0.005)	(0.043)	(0.028)			
Temp Chg x Std Goods Seg x LT Debt Mat				-0.002**	-0.002*	-0.002*
				(0.044)	(0.089)	(0.056)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	38,570	38,570	38,570	38,570	38,570	38,570
R-squared	0.125	0.366	0.527	0.125	0.366	0.527
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	No	Yes	Yes	No
Firm FE	No	Yes	No	No	Yes	No
Firm-Segment FE	No	No	Yes	No	No	Yes

Appendix

Table A.I: Variable Definitions

Variable	Definition
Assets	Total assets (Compustat AT).
CapEx	Capital expenditures (Compustat CAPX).
Cash	Cash and cash equivalents (Compustat CHE).
LT Debt Mat	Proportion of long term debt maturing next year (Compustat DD1/(DD1 + DDLT)).
Employee	Total number of employees (Compustat EMP).
Market Leverage	Total debt, defined as debt in current liabilities plus long-term debt, divided by market value of assets (Compustat (DLC + DLTT) / (DLC + DLTT + CSHO ´ PRCC_F).
R&D	R&D expenses (Compustat XRD).
Sales	Total sales (Compustat SALE).
Tangibility	Asset tangibility. Property, Plant and Equipment net of accumulated depreciation divided by total assets (Compustat PPENT / AT).
Tobin's Q	Total assets plus market value of equity minus book value of equity divided by total assets (Compustat AT + CSHO ´ PRCC_F - [AT - (LT + PSTKL) + TXDITC] / AT).
Temp	Average daily temperature in a county in year *t* in degree Celsius (PRISM).
Temp Chg	Change in average daily temperature in a county from year *t*-1 to t in degree Celsius (PRISM).
Prcp	Average daily precipitation in a county in year *t* in millimeters (PRISM).
Cold Events	Number of Cold events in a county recorded in NOAA Storm Events Database. A Cold event is an episode (a period) of low temperature (or wind chill temperatures) that reaches or exceeds locally/regionally defined advisory conditions (typical value is -18 degrees Fahrenheit or colder) (NOAA Storm Events Database).
Heat Events	Number of Heat events in a county recorded in NOAA Storm Events Database. A Heat event is an episode where heat index values meet or exceed locally/regionally established advisory thresholds (NOAA Storm Events Database).

Internet Appendix for
Climate Change and Supply Chain

Cláudia Custódio
Imperial College Business School, CEPR, ECGI

Miguel A. Ferreira
Nova School of Business and Economics, CEPR, ECGI

Emilia Garcia-Appendini
University of Zurich

Adrian Lam
Imperial College Business School

Table IA.I: Sample Description and Summary Statistics

The table presents mean, median, 25th percentile, 75th percentile, standard deviation, and number of observations for firm-segment level variables . The sample consists of yearly observations of Compustat firms in the 2000-2015 period. Variable definitions are in Table A.1 in the Appendix.

Variable	Mean	25th Pct	50th Pct	75th Pct	Std Dev	Obs
Seg CapEx/Seg Assets	0.0543	0.0124	0.0300	0.0622	0.0846	38570
Tobin's Q	2.8572	1.0913	1.4739	2.2349	6.3702	38570
Cash	0.1188	0.0202	0.0619	0.1494	0.1562	38570
Log(Assets)	0.4254	-0.2136	0.5254	1.1085	0.9550	38570
Tangibility	-0.0980	-0.6796	-0.2860	0.3015	0.7474	38570
Leverage	-0.0580	-0.7852	-0.3136	0.4302	0.8978	38570
Temp Chg	-0.0062	-0.5850	0.0751	0.5955	0.9001	38570
Prcp	2.8015	2.1806	2.9198	3.4976	1.0927	38570
LT Debt Maturing	0.0277	-0.7204	-0.4744	0.2811	1.0969	38570
Heat Sensitive Seg	0.7314	0	1	1	0.4432	38570
Std Goods Seg	0.2453	0	0	0	0.4303	38570
Number of Segments	1.5349	1	1	2	1.0275	25128

Table IA.II: Baseline Results with Quadratic Weather Variables

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable Δlog(*Sales*) is the change in the log of sales from supplier *i* to client *j* between years *t*-1 and *t*. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Temp Chg Sq* is the square of *Temp Chg*. *Prcp* is the average daily precipitation in degree Celsius in the county of the corporate headquarters for supplier *i* between years *t*-1 and *t*. *Prcp Sq* is the square of Prcp. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat supplier-client pairs in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg	-0.012*	-0.012*	-0.017**	-0.013*	-0.014*	-0.018**
	(0.095)	(0.079)	(0.024)	(0.083)	(0.062)	(0.016)
Temp Chg Sq	0.003	0.003	-0.000	0.004	0.004	0.001
	(0.486)	(0.549)	(0.997)	(0.415)	(0.428)	(0.821)
Prcp				0.001	-0.003	-0.007
				(0.957)	(0.876)	(0.748)
Prcp Sq				-0.002	-0.001	-0.000
				(0.675)	(0.803)	(0.927)
Tobin's Q	0.013***	0.013***	0.014***	0.013***	0.013***	0.014***
	(0.002)	(0.001)	(0.000)	(0.002)	(0.001)	(0.000)
Cash	-0.082	-0.076	-0.072	-0.084	-0.078	-0.075
	(0.138)	(0.182)	(0.221)	(0.128)	(0.166)	(0.201)
Log(Assets)	0.014***	0.013***	0.013***	0.014***	0.013***	0.013***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Tangibility	-0.015	-0.045	-0.044	-0.016	-0.046	-0.045
	(0.651)	(0.299)	(0.326)	(0.642)	(0.301)	(0.325)
Leverage	-0.053**	-0.051**	-0.047*	-0.052**	-0.050**	-0.046*
	(0.019)	(0.031)	(0.072)	(0.024)	(0.035)	(0.079)
Constant	-0.068***	-0.056**	-0.059**	-0.058	-0.040	-0.038
	(0.005)	(0.046)	(0.049)	(0.134)	(0.331)	(0.374)
Observations	12,439	12,439	12,439	12,439	12,439	12,439
R-squared	0.298	0.302	0.333	0.299	0.302	0.334
Client-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	Yes	No
Industry-Year FE	No	No	Yes	No	No	Yes

Table IA.III: Sample with Above Median Sales Coverage

This table presents estimates of ordinary least squares (OLS) panel regressions at the supplier-client pair level. The dependent variable Δlog(*Sales*) is the change in the log of sales from supplier *i* to client *j* between years *t*-1 and *t*. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in degree Celsius in the county of the corporate headquarters for supplier *i* between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are for the supplier and lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample is restricted to suppliers for which client sales coverage is above (28.7%). Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg	-0.016*	-0.017*	-0.019*	-0.017*	-0.019**	-0.022*
	(0.084)	(0.057)	(0.069)	(0.071)	(0.045)	(0.051)
Prcp				-0.007	-0.008	-0.011
				(0.345)	(0.272)	(0.216)
Tobin's Q	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Cash	-0.110	-0.105	-0.113	-0.111	-0.106	-0.115
	(0.126)	(0.156)	(0.168)	(0.119)	(0.150)	(0.159)
Log(Assets)	0.006	0.006	0.005	0.006	0.006	0.005
	(0.222)	(0.267)	(0.395)	(0.239)	(0.265)	(0.390)
Tangibility	-0.062	-0.083	-0.121*	-0.062	-0.081	-0.119*
	(0.316)	(0.214)	(0.091)	(0.320)	(0.227)	(0.099)
Leverage	-0.061*	-0.049	-0.051	-0.060*	-0.049	-0.052
	(0.055)	(0.146)	(0.156)	(0.058)	(0.143)	(0.151)
Constant	0.045	0.045	0.060	0.064	0.067	0.088*
	(0.180)	(0.210)	(0.120)	(0.137)	(0.140)	(0.074)
Observations	7,286	7,284	7,222	7,286	7,284	7,222
R-squared	0.310	0.317	0.359	0.311	0.317	0.359
Client-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	Yes	No
Industry-Year FE	No	No	Yes	No	No	Yes

Table IA.IV: Firm Level Cash Flows

This table presents estimates of ordinary least squares (OLS) panel regressions at the firm level. In Column (1), the dependent variable Δlog(*Sales*) is the change in the log of sales between years *t*-1 and *t*. In Column (2), the dependent variable *Net Sales/Assets* is net sales in year *t* scaled by total assets in year *t*-1. In Column (3), the dependent variable *EBIT/Assets* is operating profit in year *t* scaled by total assets in year *t*-1. In Column (4), the dependent variable *Net Income/Assets* is net income in year *t* scaled by total assets in year *t*-1. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for supplier *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in degree Celsius in the county of the corporate headquarters for firm *i* between years *t*-1 and *t*. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. All financial variables are lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat firms in the 2000-2015 period. Robust *p*-values clustered at the supplier county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
	Δlog(Sales)	ΔNet Sale/Assets	ΔEBIT/Assets	ΔNet Income/Assets
Temp Chg	-0.002	-0.003	0.000	0.003
	(0.356)	(0.235)	(0.922)	(0.306)
Prcp	0.001	-0.002	-0.001	-0.007
	(0.770)	(0.664)	(0.627)	(0.187)
Tobin's Q	0.009***	0.007***	-0.006***	-0.006**
	(0.000)	(0.000)	(0.000)	(0.028)
Cash	0.127***	0.010	-0.119***	-0.036
	(0.001)	(0.716)	(0.000)	(0.359)
Log(Assets)	-0.045***	-0.102***	-0.049***	-0.063***
	(0.000)	(0.000)	(0.000)	(0.000)
Tangibility	-0.077	-0.109**	0.124***	0.243***
	(0.116)	(0.014)	(0.000)	(0.000)
Leverage	-0.212***	-0.216***	0.101***	0.245***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.350***	0.714***	0.248***	0.256***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	40,662	40,662	40,662	40,662
R-squared	0.293	0.352	0.244	0.193
Firm FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes

Table IA.V: Investment and Financial Constraints

This table presents estimates of ordinary least squares (OLS) panel regressions at the firm level. The dependent variable **Δ***PPE/Assets* is capital expenditures in year *t* divided by total assets in year *t*–1. *Temp Chg* is the change in average daily temperature in degree Celsius in the county of the corporate headquarters for firm *i* from year *t*-1 to year *t*. *Prcp* is the average daily precipitation in millimeters in the county of the corporate headquarters for firm *i* in between years *t*-1 and *t*. *LT Debt Mat* is the proportion of long term debt maturing. Tobin's *q* is the ratio of the market value of assets to book value of assets. *Cash* is the ratio of cash and equivalents to total assets. *Assets* is total assets. *Tangibility* is the ratio of net fixed assets to total assets. *Leverage* is the ratio of total debt to the market value of assets. *LT Debt Mat* is standardized by subtracting mean then dividing by sample standard deviation. All financial variables are lagged one period. Variable definitions are provided in Table A.1 in the Appendix. The sample consists of yearly observations of Compustat firms in the 2000-2015. Robust *p*-values clustered at the county level are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Temp Chg	-0.001	-0.001	0.000	-0.001	-0.001	0.000
	(0.229)	(0.116)	(0.942)	(0.369)	(0.198)	(0.608)
Prcp	-0.001	-0.002	0.000	-0.001	-0.002	0.000
	(0.622)	(0.216)	(0.802)	(0.593)	(0.204)	(0.830)
Temp Chg x LT Debt Maturing				-0.002***	-0.002***	-0.003***
				(0.005)	(0.002)	(0.000)
LT Debt Maturing				-0.007***	-0.005***	-0.004***
				(0.000)	(0.000)	(0.000)
	(0.000)	(0.000)	(0.000)			
Constant	0.037***	0.364***	0.346***	0.019***	0.051***	0.044***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	40,662	40,662	40,662	40,662	40,662	40,662
R-squared	0.124	0.364	0.405	0.127	0.365	0.406
Year FE	Yes	Yes	No	Yes	Yes	No
Industry FE	Yes	No	No	Yes	No	No
County FE	Yes	No	No	Yes	No	No
Firm FE	No	Yes	Yes	No	Yes	Yes
Industry-Year FE	No	No	Yes	No	No	Yes