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Climate Change, Firm Performance, and Investor Surprises

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Abstract

In this study, we link records of firm performance, forecasts of analysts, and the returns after earnings announcements to firm-specific measures of heat exposure for more than 13,000 firms in 93 countries from 1995 to 2019. We find that increasing exposure to extremely high temperatures reduces firms' revenues and operating income: Relative to firms' performance over the financial quarter, a one standard deviation increase in the number of hot days decreases revenues (operating income) by 0.3% (1.3%). Moreover, the deviation in analyst estimates from actual financial performance and the earnings announcement returns become more negative when firms' heat exposure increases. These findings indicate that investors do not fully anticipate the economic repercussions of heat as a first-order physical climate risk.

JEL Codes: G39, G140, Q54

Keywords: Climate Change, Firm Performance, Analyst Forecast Accuracy

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1 Introduction

According to the Task Force on Climate Change-related Financial Disclosures (TCFD)[1], climate change is "one of the most significant, and perhaps most misunderstood, risks that organizations face today" [TCFD, 2017, p.3]. In particular, central banks and international financial institutions express concerns that investors might not anticipate the effects of climate change, and that this could endanger financial stability [Bank for International Settlements, 2018, Bank of England, 2019, Board of Governors of the Federal Reserve System, 2021, European Central Bank, 2021, International Monetary Fund, 2021]. In corporate finance and investments, these concerns are reflected in two fundamental questions: First, do past records indicate that physical climate risk affects the financial performance of listed firms? And second, if so, do investors anticipate that the physical risks of climate change affect firms' earnings?

In this paper, we investigate these questions in the context of high temperatures for a global sample of more than 13,000 firms in 93 countries from 1995 to 2019. Understanding the financial effect of heat is particularly important as the IPCC projects high temperatures to become much more frequent [IPCC, 2013]. While major change has yet to occur, the new millennium has given a preview of what these projections entail as it has so far recorded 19 of the 20 hottest years since 1850 [NASA, 2021].

To address the question of whether temperatures affect the financial performance of listed firms, we estimate the past sensitivity of earnings to extremely high temperatures. We causally identify the net effect of extremely high temperatures by using year-to-year variation in firms' exposure to days of extreme temperatures. This variation is exogenous and randomly distributed conditional on spatial and temporal fixed effects, and therefore resembles an ongoing natural experiment[2] We find that high temperatures negatively affect both revenues and operating income. Subsequently, we test whether investors and analysts anticipate these effects on performance.

To measure heat exposure, we use within-location and -season variation in the number of days per financial quarter on which firms are exposed to heat. To classify days as hot, we use two different approaches: First, physiologic studies [Pilcher et al., 2002, Sepannen et al., 2006] indicate

[1] The task force aims to help "companies disclose decision-useful information which will enable financial markets to better understand climate-related financial risks and opportunities" and was formed by the Financial Stability Board (FSB) in 2015 [Bloomberg, 2018].

[2] See Auffhammer et al. [2013] and Dell et al. [2014] for discussions of the econometric approach.

that task performance falls substantially when temperatures exceed 30° Celsius (C). As worker performance constitutes one important channel through which temperatures could affect firm performance, we use 30°C as the first temperature threshold. Second, whether temperatures cause economic repercussions could be contingent on local levels of adaptation, driven by historical temperature conditions. Therefore, our second measure defines days as hot when temperatures exceed both 30°C and the 90^{th} percentile of the location- and season-specific temperature distribution.[3] We derive both measures from spatially and temporally granular information on daily maximum temperatures from a global temperature reanalysis[4] data set, ERA5. To link financials and temperatures, we determine the coordinates of firms' addresses and spatially match them with the ERA5 grid. Further, we measure performance through revenues and operating income, obtain analysts' revenue and income estimates as a proxy for investor expectations of financial performance, and calculate daily abnormal returns around public earnings announcements.

Our study connects to the micro- and macroeconomic evidence that heat decreases the supply[5] of inputs as well as studies which illustrate a negative relation between heat stress and the productivity of unlisted firms[6]; household incomes, and aggregate economic output[7]. Earlier studies have stressed a persistent negative effect on the cognitive and physical performances of workers (see Pilcher et al. [2002], Sepannen et al. [2006], Xiang et al. [2014] for reviews) and on the quantity of hours worked [Graff-Zivin and Neidell, 2014]. In addition, some studies argue that the employee-related effects compound to economically relevant magnitudes that could explain the observed performance sensitivity at the firm level (e.g., Somanathan et al. [2021], Zhang et al. [2018]).

Building on these studies, we investigate if the negative effect of heat also manifests itself at the level of individual, listed firms. While the International Energy Agency reports that air conditioning

[3] In robustness tests, we estimate the results for alternative thresholds, and investigate the functional form of the responses in firm performance to temperatures using a bin specification.

[4] Reanalyses combine past climate-related observations with scientific models to generate complete time series of climate outcomes such as temperatures, and are "among the most-used data sets in the geophysical sciences" [Copernicus Climate Change Service (C3S), 2019].

[5] Studies show that electricity prices (water supply) increase (decrease) with heat exposure [Mishra and Singh, 2010, Pechan and Eisenack, 2014].

[6] E.g., Li et al. [2016], Somanathan et al. [2021], Traore and Foltz [2017], Xie [2017], Zhang et al. [2018].

[7] The negative relation between heat and output appears to persist not only across but also within countries, with a documented decrease of 1.2 to 1.9% in municipal income per additional degree Celsius [Dell et al., 2009]. Countries in tropical and sub-tropical climates are found to be more severely affected by rising temperatures [Dell et al., 2012, Hsiang, 2010]. However, [Burke et al., 2015] document that the negative effect holds for both developed and developing countries and in- and outside of the agricultural sector. Moreover, [Bansal et al., 2016] find that long-run temperature changes carry a positive equity risk premium.

(AC) rates outside of the US are low [IEA, 2018], firms could adjust to high temperatures in other ways in the absence of AC, for instance by adapting the combination of inputs used or by rescheduling operations around temperature peaks. These efforts to adapt could be substantial, and the general economic logic indicates that firms adapt to the extent that the marginal benefits of additional measures equal the marginal costs. With our identification strategy, we capture firms' remaining sensitivity to heat net of all realized adaptation. Implicitly, we adopt the null hypothesis that if firms have already invested in adaptation to an extent that makes them resilient to fluctuations in extreme temperatures, we should not observe a relation between exogenous variation in high temperature exposure and firm performance.

We find that on average, an additional day of heat exposure significantly reduces both revenues and operating income: Assuming that every day of the financial quarter is equally important in generating quarterly revenues (income), an additional day of heat decreases firms' daily[8] revenues (operating income) over assets by 8.13% (25.29%) in the course of four financial quarters. These estimates are economically significant and reject our null hypothesis. Relative to firms' performance over the financial quarter, a one standard deviation increase in the number of hot days results in a decrease in revenues (operating income) of 0.3% (1.3%). Compared to the mean total assets of the firms in our sample, the decrease in operating income corresponds to an absolute *quarterly* decrease of 543,188 US dollars per financial quarter.[9]

To better understand the economic channels behind this effect, we conduct a series of additional tests. First, we find increases in the costs of goods sold as well as selling, general, and administrative expenses when firms have been exposed to prolonged periods of heat, which could in part be driven by increased costs of cooling. Second, we find that firms' total wages increase after two financial quarters. This lagged effect is consistent with the temporal structure which we observe for the effects of heat on firm performance, and is in line with the idea that firms increase labor inputs in later quarters to compensate for earlier decreases in performance. In addition, the response in wages is consistent with physiologic and micro-economic studies which indicate that the effect on workers

[8] We calculate the hypothetical, daily figure as the quarterly revenues or operating income divided by 90.

[9] A one standard deviation of this within-firm-quarter variation accounts for 5.4 and 6.3 days. To put this short-run variation in context, the mean projected increase in days above 30°C from 2006 to 2019 to mid-century (calculated based on daily temperatures projections for 2040 to 2059) is 12 days for a scenario assuming some degree of policy intervention (RCP 4.5), and 22 days for a scenario closer to a business as usual approach to mitigation (RCP 8.5). The numbers are calculated as the average of all ensembles of the MPI-ESM-LR model of the fifth phase of the Coupled Model Intercomparison Project (CMIP5).

is an important channel through which heat exposure affects the economy. Third, we observe that the performance reduction is attenuated when firms have large shares of foreign customers which are not subject to the prolonged periods of heat themselves. However, the results differ depending on how we measure the share of foreign sales, and in line with the recent literature [Custodio et al., 2020, Pankratz and Schiller, 2019], it appears plausible that both demand- and supply shocks are at play.[10] Fourth, while we find that firms across a large, diverse, and international sample are on average adversely affected, some firms might benefit from high temperatures. For instance, our estimates indicate that the financial performance of firms in colder areas of the world might increase with the exposure to heat.

Subsequent to the cross-sectional tests, we investigate the question of whether financial markets anticipate the net physical effect of high temperatures on firms through all potential economic channels. Given that firms' revenues and income prove to be heat-sensitive, do investors and analysts anticipate the net performance repercussions of extreme temperatures at the firm level? Whereas financial theory argues that asset prices quickly adjust to and reflect all publicly available information, recent debates by central banks, regulators, and the investment community raise doubts about the extent to which the market absorbs information on climate change. With regard to mitigating climate change and the transition to a low carbon economy, financial assessment is often complicated by policy and climate uncertainty.[11] The case of extremely high temperatures as a physical risk, in contrast, provides a clean setting to test investors' anticipation for two reasons: First, information on heat exposure is widely and publicly available, particularly as analysts and investors can acquire information on a firm-by-firm basis[12]. Second, extreme temperatures cannot be influenced externally, and that enables an objective study of whether or not the performance repercussions are anticipated by participants in financial markets.

To find out whether investors have anticipated the effect of heat on financial performance to date, we conduct two tests. First, we use analysts' forecasts of revenue and operating income as a proxy for investors' expectations and test if performance surprises are negatively related to randomly

[10] The objective of this study is to understand if investor anticipate the *net impact* of heat exposure on firm performance. The decomposition of the effect by economic channels is important, but is not the focus of this paper.

[11] Furthermore, Fiedler et al. [2021] point out limitations to using current climate models in assessing (future) financial risks.

[12] Whereas reanalysis data on global temperatures may become public with a delay, market participants concerned with the performance of individual firms have timely access to local forecasts, weather and news reports.

distributed deviations in corporate exposure to heat above average conditions. If extremely high temperature days are financially material and analysts do not anticipate this effect, their forecasts of revenue and operating income should be systematically too high in periods when firms are affected by more extremely warm days than usual. Hence, deviations in the forecasts from the actual performance should become more negative with increasing heat exposure unless analysts correctly assess and sufficiently incorporate information on high temperatures. To ensure that information on location-specific exposure is available, we use revenue and income forecasts that could have been updated after the heat exposure of the firm was realized, but before earnings were announced.

Despite the fact that this test ensures that analysts have sufficient time to update their expectations, we find that surprises about revenue and operating income become more negative with increased corporate exposure to heat. The finding that the financial effect of heat is not fully anticipated is surprising in light of the efficient market hypothesis. Particularly, as the firms in our sample are firms with some degree of geographic concentration, the exposure to extreme weather conditions is more straightforward to assess than in the case of firms with global, complex production networks. At the same time, analysts might not have the capacity to follow the firms closely enough to respond to local, environmental conditions; even if these conditions are performance relevant[13].

We conduct a second test to corroborate that our findings are predictive of investors' capacity to assess the performance repercussions of heat in general that are not solely attributable to analysts' inertia in re-assessing small and mid caps. In this test, we study earnings announcement returns to investigate if investors are surprised by firms' financial sensitivity to heat. Again, we hypothesize that exogenous year-to-year changes in firms' heat exposure should not be systematically related to announcement returns if investors incorporate information on temperatures in their expectations on performance prior to the announcement. However, we find that announcement returns become more negative when firms are exposed to more days with extremely high temperatures. Hence, our results indicate that not only analysts but also investors do not fully anticipate the effect of heat on firm performance.

The first part of our study adds to the growing economic literature on heat exposure and firm productivity as well as the financial literature on the impact of climate hazards on firm performance

[13] On average, the number of estimates per revenue and income prediction is 2.7 in our sample

and financing decisions. Firm-level research on temperatures has initially focused on unlisted firms in developing countries, and predominantly studies economic measures of productivity: Somanathan et al. [2021] analyse the effect of heat on the productivity and attendance of workers in India and find a sizeable negative effect. Li et al. [2016] show that temperature shocks reduce Chinese firms' export quantities. Zhang et al. [2018] similarly find that heat reduces the productivity of a large sample of Chinese production facilities. Traore and Foltz [2017] study a detailed data set of firms in the Ivory Coast and find a negative link between high temperatures and performance. Xie [2017] shows that thermal stress drives exit probabilities of Indonesian firms. Consistent with these studies, we find that heat significantly affects revenues and profitability. Thereby, we extend this literature by studying the effect of heat exposure on firms through a capital market lens, and by testing whether analysts and investors anticipate the financial repercussions of heat at the firm-level. Instead of analyzing productivity, we focus on financial measures that are of interest to investors and analysts, and which we can compare with subsequent tests of analyst' forecasts and investors' surprises.

In a concurrent study, Addoum et al. (2020) investigate the effect of abnormal temperatures on establishment sales and productivity in the United States. Apart from a positive impact of low temperature on sales in the energy sector, and a marginally positive impact on healthcare firms, they find no significant effects of abnormally high or low temperatures on firm sales. This result could indicate that firms located in more developed countries build capacity to withstand extreme weather, although our results point to a significant negative effect of heat across a wide range of developed countries outside the United States.

Further, this study closely relates to research on corporate finance and other environmental hazards. Barrot and Sauvagnat [2016] study the effect of natural disasters on sales growth and find that disasters negatively affect both the sales growth of directly exposed firms and their largest customers. Adopting a behavioral perspective, Dessaint and Matray [2017] provide evidence that corporate managers overreact to hurricane strikes that are in close proximity but which do not increase real firm risk: firms neighboring areas that experience a natural disaster – but are not affected by it - increase cash holdings following the disaster. Brown et al. [2021] study cold spells and the use of credit and find that extreme cold represents a shock to firms' cash holdings. In contrast to Brown et al. [2021], we focus on high-temperature extremes due to the projection that high temperatures in particular could become much more frequent in economically important areas.[14]

Beyond the literature on the performance implications of environmental conditions, the second part of this study extends the literature on investor reaction to physical climate risks. Recent studies find that exposure to sea level rise affects property values, municipal bond yields and underwriter fees [Baldauf et al., 2020, Bernstein et al., 2019])[15]. Moreover, Anttila-Hughes [2016] finds that NASA announcements of temperature records and collapsing ice shelves affect the returns of energy companies. Further, the literature shows that investors may over- or under-react to climate- and weather-related phenomena.[16] For example, Alok et al. [2020] find that U.S mutual fund managers who experience a major natural disaster subsequently underweight disaster-zone stocks. Huynh and Xia [2021] provide evidence that US firms exhibit higher future stock and bond returns after a natural disaster strikes. Choi et al. [2020] find that people increase attention to global warming after experiencing locally extreme temperatures, and this attention affects returns on local "emission-minus-clean" stock portfolios. Hong et al. [2019] conclude that investors under-react to the effects of drought on the profitability of food-sector companies, as firms located in countries with severe drought trends experience not only weaker profit growth but also lower abnormal stock returns. Evidence from surveys of investors, policy makers and academics further supports the view that markets underestimate climate risk [Krueger et al., 2020, Stroebel and Wurgler, 2021].[17] Our results extend Hong et al. [2019] by showing that heat exposure affects firm performance beyond the food and agricultural sectors, and that this temperature effect contributes to investors' surprises about firms' earnings. These results also contribute to debates about the efficient pricing of climate risk raised in recent studies [Hong et al., 2020].

Moreover, our results connect to studies on the financial materiality of environmental information. Considerable research in this area investigates how firms' impact on the environment

[14] Furthermore, we use measures of heat which can be consolidated with projections for increases of extreme temperature days of the IPCC, and estimate our main tests with controls for cold days to ensure that our results are driven by heat and not by changes at the other extreme end of temperature distributions.

[15] Murfin and Spiegel [2020] study coastal home sales and find limited price effects.

[16] Also, there is a large amount of literature on the direct effect of the weather on investors' sentiment and returns [Cao and Wei, 2005, Kamstra et al., 2003, Symeonidis et al., 2010].

[17] Specifically, Stroebel and Wurgler [2021] survey finance professionals, academics, and regulators about their views on climate issues, whereas Krueger et al. [2020] survey institutional investors. In Stroebel and Wurgler [2021], most respondents agree that climate risk is insufficiently priced in markets, a view that is especially pronounced among respondents with a professional interest in climate finance. In Krueger et al. [2020], institutional investors state the view that climate risks may not be fully reflected in equity valuations.

is reflected in realized and expected stock returns (i.e., Bolton and Kacperczyk [2021], Flammer [2013], Krüger [2015]), spreads on bank loans [Chava, 2014] and corporate bond spreads [Seltzer et al., 2020]. In addition, Huynh and Xia [2021] find that corporate bonds have lower future returns when they offer greater potential to hedge against climate risk news, and Delis et al. [2019] associate fossil fuel reserves with higher bank loan rates. Beyond equity and bond markets, Ilhan et al. [2021] document that uncertainty about climate policy is priced in the option market. In contrast to these studies, which primarily associate corporate environmental impacts with financially relevant policy and regulatory risks, we focus on the effect of the environment on firms.[18]

Amongst other international financial institutions, the European Central Bank [Bank for International Settlements, 2018, European Central Bank, 2021], the IMF [International Monetary Fund, 2021], and the Federal Reserve [Board of Governors of the Federal Reserve System, 2021] voice growing concern with regard to the threat climate change poses to financial stability. In addition, legislators in France[19] and the European Union[20] have recently integrated climate risk into corporate and financial disclosure requirements. To provide guidance, the European Bank of Development and Reconstruction (EBRD) proposes specific climate risk metrics, including an assessment of the financial effect of heat exposure as one out of six first-order physical risks [EBRD, 2018]. Our study closely connects to the policy debates on climate change-related disclosure and global warming as a financial risk.

[18] More recently, studies propose textual analysis of corporate disclosures to measure firm-level exposure to climate risks. Sautner et al. [2020] extract exposures from earnings conference calls. Their measure of regulatory risk is associated with lower firm value, whereas their measure of physical risk displays a statistically insignificant association. The insignificant response to physical risk measure could imply that investors undervalue physical climate risks, consistent with our results. On the other hand, the absence of attention for physical risks among analysts directly affects the content of conference calls, and this in turn could affect measurements of physical risk based on call transcripts.

[19] "Article 173 of the French Law on Energy Transition and Green Growth passed August 2015 requires major institutional investors and asset management companies to [...] report on the impacts of both physical risks and transition risks caused by climate change [...]." [Four Twenty Seven, 2018a]

[20] "The EU laid out a clear plan to move towards mandatory climate risk disclosure as part of a new set of regulations to finance sustainable growth and support the transition to a low-carbon economy. The European Commission's Action Plan lays out a two year time line for implementation, with a goal to create a taxonomy for climate adaptation finance by the end of 2019." [Four Twenty Seven, 2018b]

2 Financial Data and Temperatures

2.1 Firms' Locations

For our analyses, we use the universe of firms in the Standard & Poor's Compustat Global Database database. As information on establishments and firm activities by establishment are scarce in a global context, we link records of firm performance with firms' exposure to temperatures based on the location of headquarters. For this purpose, we obtain firm locations from Factset Fundamentals, and cross-check whether the countries match with Compustat Global records. Subsequently, we geocode street-level addresses using the Bing Maps API, and match firms and ERA-5 grid nodes by minimizing the respective distance. Clearly, headquarter locations may not represent locations with significant firm operations. To limit the potential distortions caused by such mismatches, we obtain a measure of firms' geographic concentration of assets from Factset's international segment records. In many jurisdictions, publicly listed firms are required to disclose information on their activities by geographic segments in their interim financial reports by adding information on all segments representing more than 10% of total assets, sales, or income. The granularity of the reported segments differs across firms and ranges from state to continental levels. We limit our sample to firms that report segments on a country-by-country basis, and obtain information of the concentration of assets in firms' home countries. Ex-ante, it is unclear which threshold is adequate to eliminate firms with mismatched temperature data from our sample, without imposing unnecessary constraints on the sample and validity of the findings. In a similar setting, Barrot and Sauvagnat [2016] focus on firms with more than 10% of their employees based at headquarter locations to match firms with data on natural disasters. We follow this choice and exclude firms which hold less than 10% of their total assets in their home country.[21] Regardless of this adjustment, we cannot prevent that firms' exposure to heat is measured with error. However, it is reasonable to expect that the measurement error is randomly distributed, and therefore likely to attenuate our estimates. The firms in the sample are mapped in Figure 1.

[21] Applying this threshold leads to an exclusion of 7,638 firms with unknown asset concentration and firms with less than 10% of assets in the country of their headquarters. Later in the paper, we conduct additional tests to better understand the sensitivity of our results to different asset concentration thresholds.

2.2 Financial Performance

We collect financial and accounting performance records from Compustat Global. To measure financial performance, we focus on quarterly revenues and operating income. Both revenues and operating income are narrowly defined metrics at the top of the income statement and therefore should be relatively less distorted by accounting choices as compared to metrics further down the income statement. We trim the measures below the 1^{st} and above the 99^{th} percentile[22], scale both revenues and operating income by firms' total assets lagged by one year, and convert all values from local currencies to US dollars by using WRDS tables on exchange rates. Table 1a shows descriptive statistics. The total asset values in this sample lie between 44 and 581 million US dollars between the 25^{th} and the 75^{th} percentile, with a median of 154 million US dollars in firms' total assets.[23]

2.3 Temperatures and Temperature Thresholds

To calculate a firm-specific measure of heat exposure, we obtain global records of daily maximum temperatures from the European Center for Medium-term Weather Forecasts. The ERA5 reanalysis data of the atmosphere provides continuous daily coverage of a $0.3 \times 0.3°$ grid dating back 1979 to today. Hersbach [2016] provides a detailed description of the dataset. For robustness tests, we also calculate country-level averages of daily maximum temperatures based on ERA5, and obtain the output of the ERA-5 dataset with daily coverage of a $0.75 \times 0.75°$ grid. We observe firms' financial performance on a quarterly basis, and obtain a matching measure of heat exposure by counting the number of days per financial quarter on which firms were exposed to heat. In constructing this measure, we carefully accommodate firms' individual reporting schedules and take different calendar dates of the fiscal year end into account.

In our main tests, we use two different approaches to classify days as hot, as there are economic arguments for the use of absolute thresholds as well as other reasons to rely on place- and time-contingent thresholds. First, physiologic studies show that there are absolute temperatures

[22] This approach is common in the finance and accounting literature, as accounting-based financial variables often exhibit extreme values (see Chen and Yang [2019] and Hsu et al. [2021] for recent examples).

[23] Compared to the overall US stock market capitalization – the corresponding share of firms on the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) – the firms in our sample are similar in size to a large share of US firms. According to statistics by the US Securities and Exchange Commission, firms with less than 568 million US dollars in assets make up the lower 76% of firms listed on the NYSE and AMEX [SEC, 2005]. In terms of their other financial characteristics, the firms in this sample have a mean operating income before depreciation (revenue) over assets of 2.1% (24.2%) per quarter.

above which workers have to reallocate energy from task performance to physical cooling functions. Specifically, Seppanen et al. [2003] document that individual productivity begins to drop at 25°C [Tanabe et al., 2013], and falls with an increasing rate beyond 30°C. As worker performance constitutes one important channel through which temperatures could affect firm performance, we choose 30°C as our first temperature threshold. At the same time, individuals and organizations are likely to adapt to typical weather conditions. Whether temperatures cause economic repercussions could therefore be contingent on the local level of adaptation, driven by historical temperature conditions. To test if temperatures are particularly damaging when they are unusual given the place and time of the year, our second threshold combines the absolute threshold of 30°C with a location-specific indicator of whether temperatures are extreme compared to past temperature distributions. To construct this indicator, we first derive historical temperature distributions by day of the year and location by aggregating temperatures from 1980 and 1999 on the day (e.g., July 15) itself as well as the previous and subsequent five days (generating an estimation window from July 10 to July 20). Next, we determine the historical 90^{th} percentile threshold of the resulting distribution for every location and day of the year. We classify days as hot when the daily maximum temperature during the sample period exceeds the historical 90^{th} percentile threshold.[24]

Table 1b shows the summary statistics of the measures of heat exposure for the firms in the sample from 1995 to 2019. Since we estimate all empirical tests based on within-firm variation, we show both the cross-sectional variation and within variation ($FirmFE$) in the number of high temperature days. The median temperature per financial quarter in this sample is 23.4°C, with 16.2°C at the 25^{th} percentile and 29.5° at the 75^{th} percentile. On average, firms are exposed to 22.5 days per financial quarter on which temperatures exceed 30°C. The exposure varies strongly between firms (25^{th} percentile: 0 days, 75^{th} percentile: 41 days). As Figure 2 shows, the choice of the absolute thresholds in isolation leads to a setting in which some firms are "always treated", with temperatures exceeding 30°C on every day of the respective financial quarter. However, when days are classified as exposed based on both the absolute and the relative percentile thresholds, all firm financial quarters are subject to within variation. The standard deviation in the number of days exposed to temperatures above 30°C deviating from the location-specific average is 6.3 days

[24] This approach is commonly used to reflect different local conditions when characterizing heatwaves [Perkins and Alexander, 2013] and for projections of future temperature days in the IPCC reports [IPCC, 2013].

per quarter, and 5.4 days under the combined 30°C and 90^{th} percentile threshold.

3 Heat Exposure and Financial Performance

In our first analysis, we test whether firm performance is sensitive to short-term changes in exposure to extreme temperatures. In contrast to Somanathan et al. [2021] and Zhang et al. [2018], we focus specifically on the capital market lens. Therefore, we choose revenues and operating income over assets as our outcome variables instead of economic concepts that measure productivity. These outcomes are of particular interest to analysts and investors, and allow us to align the tests for the sensitivity of firm performance to extreme temperatures with analyses of investor and analyst expectations later in the paper. Our identification strategy accounts for long-term corporate decision-making that frequently involves the climate. For instance, production decisions might be based on the average climate exposure in a given location, or entrepreneurs might choose to establish businesses in places that provide optimal operational conditions. If firms with particular observable or unobservable characteristics choose to locate (produce) in a specific place (certain products or use particular technologies), these characteristics could be correlated both with the climate and the observed financial performance. In contrast, year-to-year differences in the realized weather cannot be influenced by the firms' decisions, and cannot be predicted with a high level of accuracy in the long run. Therefore, we can causally identify the impact of heat exposure on firm performance – net of all short-term adaptation potential that firms realize – based on the variation in the number of realized hot days over time. Compared to the location- and season-specific average temperature conditions, the realization in any given year is randomly distributed and exogenously determined conditional on spatial and temporal fixed effects (see Auffhammer et al. [2013] and Dell et al. [2014] for a discussion of the approach). Figure 2b illustrates this variation and shows that the number of days when firms are exposed to heat in a given financial quarter compared to the average number of days of exposure varies substantially by firm.

To isolate this variation, we use pooled ordinary least squares (OLS) regressions with firm times season fixed effects. Instead of simple firm fixed effects, we rely on firm times season fixed effects as there are pronounced and potentially confounding firm-specific patterns of seasonality. For instance, if firms in certain industries face either particularly low or high returns in the warmest quarter of the year, lower temperatures would by construction be associated with lower firm performance. Addressing this seasonality with separate firm and quarter fixed effects does not adequately address this concern, as seasonality may vary by firm depending on the firm's operations and location. Equations 1 and 2 outline the OLS specification,

$$\frac{revenues_{ist}}{assets_{ist-1}} = \sum_{t=-3}^{0} \beta\ Heat\ Exposure_{ist} + \mu_{is} + \gamma_{mt} + \delta\ Trend_{ct} + \epsilon_{ist} \tag{1}$$

$$\frac{operating\ income_{ist}}{assets_{ist-1}} = \sum_{t=-3}^{0} \beta\ Heat\ Exposure_{ist} + \mu_{is} + \gamma_{mt} + \delta\ Trend_{ct} + \epsilon_{ist} \tag{2}$$

where i stands for the firm, s stands for the fiscal quarter of the year ($s = 1, ..., 4$) based on the financial reporting schedule of each firm, and t stands for the observed year. To ensure that our results are not confounded by potential shocks of heat on assets, we lag assets by one year in $\frac{revenues}{assets}_{ist}$ and $\frac{operating\ income}{assets}_{ist}$. μ_{is} represents the firm $\times$ financial quarter-fixed effect to absorb the firm-location and firm-season-specific levels of heat exposure. γ_{mt} stands for an industry-year fixed effect to absorb the variation in financial performance due to technological change or industry-specific economic trends, with m as an index for $m = 1, ..., M$ industries determined by i. $\delta\ Trend_{ct}$ indicates country linear trends, with c as an index for $c = 1, ..., C$ countries determined by the location of i. $Heat\ Exposure$ stands for the number of days in a quarter on which firm i is exposed to heat. As it is ex-ante unclear when the financial effects of heat become apparent, we include three lags of $Heat\ Exposure$ in our main tests. To ensure that our results are driven by heat and not by changes at the other extreme end of temperature distributions, we control for the number of cold days between -5 and 0 and below -5°C. We cluster standard errors two-way at the country and year-quarter level.[25].

As location-specific variation in heat exposure over time cannot be actively influenced by the

[25] To address the potential spatial or temporal dependence of heat exposure, standard errors have to be clustered at the level of treatment. In practice, choosing the right clustering dimensions is challenging, as heat can be spatially heterogeneous within large and small countries, is unlikely to be represented well by administrative boundaries, and as the correlation between grid nodes is contingent on unobserved variables such as topography. Reflecting these challenges, related papers show a wide range of different approaches to clustering standard errors. In our main specification, we cluster standard errors at the country and year-quarter level, as temperatures are likely to be correlated across firms in the same country and within seasons. However, the country-level could be too narrow or broad depending on country-size and heterogeneity of climate zones, and temperatures may or may not be correlated mostly within or also across seasons. To test the validity of our test design and to provide alternative p-values, we conduct a permutation test (Figure A1). Further, we find that the results are robust to adjusting for spatial and serial correlation in errors using the approach of Conley [1999] (Table A2)

choices of the firm, there should be no firm-specific characteristics that can drive both the outcome and the measure of heat exposure. Hence, we do not include controls for time varying firm-level characteristics in the baseline analysis to avoid bad control problems[26] at the expense of the potentially unnecessarily high residual variance [Dell et al., 2014]. However, as we focus on common financial ratios with revenues and operating income scaled by assets, we implicitly account for variation in firm size over time.

Table 2 and Figure 3 show the estimates of the effect of extreme temperatures on financial performance in the current as well as the three subsequent financial quarters. In addition to the main regression model, columns 2, 4, 6, and 8 in Table 2 are augmented with controls for the number of days on which temperatures fall below 0, -5, or -10°C. Columns 1 to 4 refer to revenues, columns 5 to 8 to operating income over assets. We find that both quarterly revenues and income over assets decrease with the number of hot days. The effects on firms' income are more pronounced: Temperatures above 30°C have a statistically significant effect on operating income regardless of whether the temperatures are unusual (column 7-8 of Table 2) or not (column 5-6). As Figure 3 shows, the effects on revenues and income set in with a lag of one to two financial quarters. Observing such a lagged effect is plausible if extreme temperatures delay or distort operations in ways which only materialize when products are sold in subsequent financial periods. Moreover, observing lagged effects after environmental shocks is consistent with the related literature, e.g., Barrot and Sauvagnat [2016]. To understand the overall magnitude of the effect, we calculate the cumulative effects of heat over the directly affected and three lagged financial quarters. The size of the effect is both plausible and economically meaningful. First, with regard to the plausibility of the magnitude, we compare the estimates to the effects documented in the context of heat exposure and individual performance. Relative to the average revenue over assets in the sample divided by the days in the respective financial period (the quarterly ratio of 24.2% divided by 90 days), an additional day above 30°C and the 90^th percentile reduces firms' (daily equivalent of) revenue by 8.4% (column 4). Given a mean quarterly operating income over assets of 2.1%, an additional day of temperatures above 30°C corresponds to a reduction of about 21.9% in daily-equivalent operating income (column 6). Thereby, the relative response of operating income is not only statistically

[26]For instance, firm characteristics could be "bad controls" [Angrist and Pischke, 2008] if heat exposure affects potential control variables through its impact on financial performance, or if the strength of the effect depends on certain firm characteristics.

stronger, but also larger in magnitude compared to the effect of one additional day of high temperatures on revenues. The difference in the magnitude of the effects on revenues and income could indicate that there are both detrimental effects on revenues and expenses, which we investigate in the next section. According to Seppanen et al. [2003], worker exposure to temperatures above 25°C in the office environment decreases their task performance by 2% per additional degree – a daily temperature increase to 30°C would hence correspond to an expected output loss of 10%. The effects of revenues fall into a similar range[27] In addition, the effect size is similar to the estimates of Zhang et al. [2018]. Zhang et al. [2018] study a large sample of firms in China, and find that an additional day above 90° Fahrenheit (32.2°C) per year decreases annual output by 0.45%. Relative to the quarterly operating income over assets, we document a reduction of 0.28% per additional day above 30°C.

Second, the estimated effect is relevant in economic terms given that firms exert effort to optimize operational performance. A one standard deviation increase in the number of hot days (5.4 days above 30°C, 6.3 days above 30°C and above the 90^{th} percentile) compared to the average conditions results in a 0.025 percentage point (0.0047*5.4, column 6, >30°C) to 0.033 (0.0061*5.4, column 8, >30°C/90thP) reduction in operating income over assets over four financial quarters[28]. Relative to the average quarterly operating income over assets, a one standard deviation increase in days above 30°C (5.4 days) compared to average local conditions reduces operating income over assets by 1.8%[29] leading to an absolute decrease of 543,188 US dollars for an individual firm given the median (mean) total assets of the firms in our sample.

[27]Naturally, our results are likely to be driven by channels other than employee performance.

[28]To put a one standard deviation increase in short-run fluctuations in perspective, we obtain data from the fifth phase of the Coupled Model Intercomparison Project (CMIP5). Based on the average of all ensembles of the MPI-ESM-LR model), the mean projected increase in days above 30°C from 2006 to 2019 to mid-century (calculated based on daily temperatures projections from 2040-2059) is 7 days for a scenario assuming substantial policy intervention (RCP 2.6), and 22 days for a scenario closer to a business as usual approach to mitigation (RCP 8.5).

[29]As we focus on an increase of approximately one week in firms' exposure to heat, it is natural that this magnitude is much smaller than the performance response to large-scale environmental shocks. For instance, Barrot and Sauvagnat [2016] find that natural disasters (lasting less than 30 days with total estimated damages above $1 billion 2013 constant dollars) decrease sales growth by approximately 30 percent. Nevertheless, the observed 1.8% decrease in income is relevant, given the projection that the number of extreme temperature days might increase substantially. For instance, days above 30°C may increase by four standard deviations on average based on CMIP5 RCP 8.5 projections. Moreover, the dollar value of a 1.8% decrease by itself appears relevant from an operations management perspective.

3.1 Robustness Tests

We conduct a series of robustness tests. First, we compare our estimates to alternative regressions with different sets of fixed effects in Table A1. We find very similar results when we replace the combined firm times quarter with simple firm fixed effects, and test continent-year-quarter fixed effects as alternatives to country-linear trends. Second, to test if the results could be driven by spurious correlations as well as to provide alternative p-values, we conduct a permutation test. Following Fishman et al. [2019], Hsiang and Jina [2014], we randomly reassign heat exposures in three ways: (a) unconditionally, (b) between firms while preserving the ordering of years, and (c) within firms, but reshuffling observations over time. Approach (b) maintains the time structure within the data, and helps to test if regional trends generate spurious correlations. Approach (c) only affects the time structure of the observed heat exposure to test if time invariant cross-sectional patterns impose spurious correlations. Based on the random reassignment, we re-estimate the model in equation 1 5,000 times. As a substantial number of firms is likely to be be reassigned the heat exposure of firms in the same country when we reassign temperatures between firms, we expect the test statistic in Panel (b) to be conservative. Figure A1 shows the results. In support of the statistical model, we find that the average effects with randomly assigned heat exposures are centered around zero. Only for the distribution of the coefficients of the effect of heat on revenues in Panel (b), we obtain a mean slightly larger but close to zero (0.005). Further, we obtain p-values by calculating the share of estimation which yield coefficient sizes equal to or larger than the actual estimate. Most values are smaller than 0.01, with the exception of the left-hand side of Panel (b) with a p-value of 0.011. Therefore, it is unlikely that our findings are an outcome of chance, or driven by errors in the research design. Third, we test if the results could be confounded by the financial crisis as aggregate financial shocks could have coincided with particularly high temperatures. On the contrary, Table A3 shows that the magnitude of the estimates slightly increases after we exclude the years of 2008-2009 (2008-2010). Fourth, we estimate our results with ERA-Interim (ERAi) as well as country-level ERA5 average temperatures in A4. ERA5 and ERAi produce similar estimates, although the results are stronger in magnitude and significance when we use ERAi: For instance, we find that both revenues and operating income decrease significantly, and over two instead of only one financial quarter. In contrast, country-level averages yield wider confidence intervals compared to the estimates of the effects of more local temperature records. Fifth, we replace the temperature thresholds to define days as hot with a series of alternatives in Table A5.[30] Across all alternative thresholds, we find a negative sign. For revenues, days above 25°C and the 90^{th} percentile threshold (column 2) and 30°C and the 90^{th} percentile (P) (column 4) lead to significant decreases (10-% level). For operating income, we find significant decreases for days with temperatures above 25°C/$90^{th}P$, 25°C/95^{th}P, 30°C, 30°C/90^{th}P, and 30°C/95^{th}P.

We also estimate the effects of temperatures on firm performance using a bin specification. The coefficients are plotted in Figure A3. We find that for the average firm, operating income over assets peak between 20 and 25°C. Further, the main effects of days with temperatures above 30°C are not solely driven by the most extreme days, as the effects of temperatures from 30 to 35 and above 35°C are similar in magnitude and significance. In line with Brown et al. [2021] (Zhang et al. [2018]), we find that not only high but also low temperatures can reduce revenues and operating income. However, low temperatures occur much less frequently: The average firm experience temperatures below -5°C (-5 to 0°C) on 2.6 (5.3) days over four financial quarters, and temperatures between 30 and 35°C (above 35°C) on 78.4 (15.9) days. [31]

In addition, we test if firms compensate for the short-run performance shocks in later time periods, or whether the shocks persist beyond the horizon of one fiscal year. Figure A4 plots the effects of firms' heat exposure on annual revenues and operating income. The results are of a slightly larger magnitude and materialize after a longer lag compared to the main tests. We neither find evidence for the persistence of an effect beyond four financial quarters, nor a pronounced reversal in the long run. However, the individual effects are not statistically significant.[32]

[30] In this test, the observed effects may be attenuated as we estimate average effects of heat exposure across four quarters, despite the fact that previous tests have shown that the responses are heterogeneous across these lags.

[31] The coefficients of the temperature bins above 30°C are marginally significant. Given that we estimate the results across a global sample with heterogeneous average temperatures, the limited precision could be related to heterogeneity in what constitutes a high temperature. For instance, temperatures around 25-30°C may either be mild or unusually high depending on the location, leading to mixed magnitudes and signs of the estimate across space which we average by bin. Moreover, the support changes at the top of the temperature distribution. Whereas a few firm financial quarters are exposed to temperatures above 30°C on every day of the financial quarter, the occurrence of such temperatures is extremely rare in many other areas.

[32] The differences could arise due to several reasons: First, we normalize annual income and revenues instead of scaling the measures by assets, as there could be confounding shocks on assets (i.e., through inventories or cash). The longer time horizon makes it difficult to scale the dependent variable in ways in which the estimates would be unaffected. Second, requiring the existence of a longer series of observations decreases the size of our sample and potentially also affects the composition. Third, by testing the effects on annual revenues and income, we rely on observations at the end of the financial year. For most firms, the financial year ends in December, which means that the highest temperatures could be recorded with a lag of three instead of two quarters.

Moreover, we estimate the results for different levels of asset concentration in the firm's home country. If our estimates indeed capture the financial repercussions of heat, we might expect that the strength of the results increases with the quality of the match, which could increase with firms' concentration of assets. At the same time, different levels of asset concentration may be correlated with other covariates such as firm size, profitability and financial constraints, which could all directly influence the estimated magnitude. For firm performance (Figure A5a), we find the most negative but insignificant estimates in magnitude firms with 75-100%.

3.2 Firm Expenses

Our results so far indicate that firm performance is negatively affected by heat exposure. To better understand firms' responses, we investigate if heat exposure also affects expenses. For instance, the additional electricity consumption for cooling could increase utility bills. Moreover, firms could incur cost increases through heat-related hazard pay, or compensate performance increases by increasing labor inputs in order to meet contractual obligations. We observe three different outcomes related to these considerations: Firms' cost of goods sold (COGS), selling, general, and administrative expenses (SGA), and wages. Standard & Poor's defines the COGS as "all expenses directly allocated by the company to production, such as material, labor, and overhead". SGA comprise "all commercial expenses of operation (such as, expenses not directly related to product production) incurred in the regular course of business"[Standard & Poor's, 2004]. Both wages and electricity costs can in principle be attributed to the COGS or SGA. However, an attribution of utility costs to SGA is common [Robinson, 2020].

Table 3 shows the results for the effects of temperatures on expenses, and the coefficients are plotted in Figure 4. Whereas we find evidence for transitory increases in expenses in terms of individual lags, the significance of the cumulative effects of heat across four quarters is limited: The only significant cumulative impact of temperatures above 30°C affects the logarithm of wages (column 3, coefficient 0.0023, significant at the 5% level). Potentially, the insignificant cumulative effects could indicate that firms experience temporary increases and respond with measures to cut cost in later time periods. In terms of transitory effects, the log of the COGS increases when temperatures exceed 30°C (column 1, coefficient 0.0006, significant at the 5% level). When 30°C are unusual relative to the place- and season-specific distribution of temperatures, we find a small positive effect on the log of COGS (column 4, coefficient 0.0004, signficant at the 10% level) and the log of SGA (column 5, coefficient 0.0005, significant at the 1%-level). To put this magnitude of this transitory response into context, we have to make a series of assumptions. An immediate increase of 0.05 percent in SGA expenses corresponds to an increase of 1,854 US dollars per additional hot day (above both 30°C and the 90th percentile) at the median quarterly SGA expense of 3.708 million US dollars. According to the US Energy Information Administration, the average annual electricity costs of a sample of 2,391,000 fully cooled commercial buildings with an average of 15,757 square feet (1464m^2) is 27,162 US dollars [EIA, 2012]. Not taking different sources of electricity costs and usage into account, this number corresponds to a daily cost of cooling of 74 US dollars per building. We do not have information on the facilities of the firms in our sample at hand. If the increase in SGA would be exclusively attributable to electricity, the estimate for the increase in SGA under one additional day of 30°C would be equivalent to the daily costs of cooling 25 buildings. At a median number of 936 employees per firm, this number appears rather large for increased costs to be attributable to electricity use only.

As for wages, columns 3 and 6 indicate an increase after two financial quarters rather than an immediate effect. In principle, one could expect that heat-related hazard pay influences wages in the quarter in which workers are directly affected by heat. However, an increase after two quarters could arise with inter-temporal substitution, i.e., if firms increase labor inputs to compensate for a decrease in performance in earlier periods. Apart from that, the lagged effect is consistent with the finding that heat affects revenues and income beyond the current financial quarter, as well as with the estimates of related studies on firm performance and environmental shocks, e.g., Barrot and Sauvagnat [2016]. Depending on inventories or turnover times in production, it is possible that the performance shortfalls only become visible later in the financial year, and cause firms to respond with delay.[33] In terms of the magnitude of the effect on wages, we find that one additional day of 30°C increases wages by 0.1% after two quarters. To put this result into context, the increase corresponds to additional costs of 3,460 US dollars at the median value of quarterly wages of 3.46 million US dollars per firm in our sample. At the 2019 US median hourly wage of 19.33 US dollars,

[33] In comparing the effects of heat on COGS, SGA, and wages, we find that days of heat affect wages after two quarters, whereas COGS and SGA expenses respond immediately. Unfortunately, our empirical setting does not allow us to causally study how different outcomes interact, and we remain cautious in interpreting the differences between wages, SGA and COGS as wages are only reported by a subset of firms.

this effect corresponds to a loss of 179 worker hours, and a decrease in the time worked of 11.5 minutes per worker at the median number of 936 employees from Factset Fundamentals.

To put the magnitude of effect on wages into context, the increase corresponds to additional costs of 3,460US dollars at the median value of quarterly wages of 3.46 million US dollars per firm in our sample. At the 2019 US median hourly wage of 19.33 US dollars, this effect corresponds to a loss of 179 worker hours, and a decrease in the time worked of 11.5 minutes per worker at the median number of 936 employees from Factset Fundamentals.

3.3 Economic Channels and Heterogeneity

As these analyses show, the detrimental effects of heat are not solely driven by cost channels: the estimates are of mixed significance and do not match the magnitude of the decrease in operating income. Unrelated to costs, two different forces could affect firm performance: Heat exposure could delay or compromise firms' operations, or the decreases in performance could be demand-driven if firms' customers are simultaneously affected by heat. In Table 4, we use information on the geographic separation of firms' assets and sales and interact heat exposure with an indicator of whether firms' top geographic revenue segment is a foreign country. We find that shocks of heat are attenuated (positive and significant interaction terms in columns 1, 3, 5 and 7) when the largest geographic segment of corporate customers is not exposed to the same temperature shocks as the firm itself. However, the interaction term is insignificant and does not take a consistent sign when we measure the dependence on domestic demand with an indicator of whether less than 30% of firms sales are realized in the home country. In line with this mixed evidence, the recent literature indicates that both supply- and demand shocks may be relevant.[34] The distinction would have important managerial implications: If firms are subject to demand shocks through heat exposure, firm-level investment in adaptation can only partially mitigate the negative effects. In contrast, the differentiation is less focal in capital markets: analysts and investors have to assess the total

[34] Custodio et al. [2020] focus on distinguishing whether firm-level temperature shocks are demand- or supply driven, and find evidence in support of supply-side shocks based on within variation in shocks to firms with the same corporate customer. Pankratz and Schiller [2019] focus on customer firms' adaptation in response to changes in the frequency of climate-related shocks, but also show that transitory shocks in heat exposure lead to increases in the probability of corporate customers to end supply-chain relationships. Beyond corporate customers, there is evidence that consumer purchases respond to weather conditions, whereas consumers' adaptation (i.e., switching from outdoor to indoor shopping) appears limited (e.g. Bahng and Kincade 2012; Busse, Pope, Pope and Silva-Risso, 2014; Zwebner, Lee and Goldenberg, 2013; Roth Tran 2020; Tian, Cao and Song 2021).

effect of heat on firm performance, and are less concerned with the decomposition of the effect by channel.

If the observed decrease in financial performance is at least partially supply-related, the magnitude of the effect might vary with firms' operational sensitivity to heat. In Table 5, we test several hypotheses related to this idea.[35] First, the literature argues that reduced labor supply (e.g., Graff-Zivin and Neidell [2014]) and productivity may be an important economic channel through which extreme temperatures affect economic output. Therefore, we interact heat exposure with the several measures of the vulnerability of firms to temperatures: We calculate the share of labor expenses over total expenses, and lag labor and total expenses by one year to preempt confounding, direct shocks of heat to the share of labor costs.[36]. Consistent with the hypothesis that labor may be an important mechanism, we find a negative and significant coefficient for this interaction term for both the effect on revenues and operating income (column 1 and 8, significant at the 10% and 1%-level). Moreover, we use a proxy of firm-level average wages per worker as the total wage bill divided by the number of employees. In line with the idea that high-skilled workers may be less exposed to outdoor conditions, we find a positive interaction effect for revenues but not for operating income (column 2, 0.008, significant at the 1%-level). In addition, we use data from ONET on the percentage of time spent outdoors by industry, and following guidance of the Occupational Safety and Health Administration (OSHA) on occupational heat exposure, we classify firms in the agriculture, mining, construction, and transportation industry as particularly sensitive. The interactions of heat exposure with both measures take a negative sign. However, only the interaction on heat exposure and sensitive firms as defined by OSHA is statistically significant (column 11, significant at the 10%-level).

Another common view is that extreme temperatures could be economically harmful mainly through sectors in which output is a direct function of temperatures. For instance, there is a direct relation between agricultural returns and heat through the effects of temperatures on crop

[35]It is important to note that the cross-sectional setting does not allow a causal interpretation as individual firm characteristics may be correlated with other (un)observed characteristics that attenuate or reinforce the effect. We show the results for various interactions with the count of days on which temperatures exceeded both 30°C and the place- and time-contingent $90th$ percentile temperature. The results for the interactions with the 30°C threshold are shown in Table A6.

[36]Labor and total expenses are reported with error. To remove outliers, we trim the ratio of labor over total expenses at the 1st and 99th percentile. Further, we remove observations if labor expenses exceed total expenses. On average, the ratio of labor expenses to total expenses is 35%. For summary statistics, see Table 1a

yields. Hong et al. [2019] illustrate this relation using financial returns in the food industry. To test if the agricultural and food industry are major drivers of the observed effects, we interact heat exposure with an indicator for firms in agricultural and food industries. For revenues, the interaction effects are negative but insignificant(column 5). The estimate of the effect on operating income is robust (column 12, -0.0016, significant at the 1%-level) and consistent with the studies showing that extreme temperatures negatively affect agricultural and non-agricultural economic activities (Burke et al. 2015, Hsiang 2010).

In addition, we might expect that some industries benefit from extreme temperatures. For instance, firms in the utility sector could benefit from an increase in the number of high temperature days, as cooling increases the demand for electricity. We interact heat exposure with an indicator of utilities firms in column 7 and 14. The interaction terms are positive and insignificant. Joint tests of the coefficients indicate the overall effect of hot days on firm performance in the utility sector is indistinguishable from zero (p-values between 0.35 and 0.38).[37]

3.4 Geographic Heterogeneity

Further, we investigate differences in the estimates by average temperatures and economic development. On the one hand, hot days may be more disruptive when they are unusual compared to local climate conditions. On the other hand, hotter countries tend to be less developed, and firms in those countries may face more fragile infrastructure and constraints to adaptation. We plot average marginal effects by average temperatures at firms' headquarters and gross domestic product (GDP) per capita in Figure 9.[38] Consistent with the idea that firms in less developed countries may be more vulnerable to climate risk, we find negative, significant effects on firms with average temperatures above 25°C at their headquarters. For revenues, the effects are insignificant across the temperature distribution. Concerning GDP, we find negative and significant average marginal effects on revenues (operating income) for firms the lowest two (three) quintiles. This observation is consistent with studies on heat, firm productivity, and the non-linear effects of temperatures on

[37] Consistent with this result, Addoum et al. [2020] find a significant, positive effect of cold days on the sales of energy companies, and no effect of hot days.

[38] Temperatures and economic growth are known to be endogenous (i.e, Dell et al. [2012], and the cross-sectional setting does not allow us to disentangle both effects.

economic output [Burke et al., 2015, Dell et al., 2012, Zhang et al., 2018].[39]

4 Heat Exposure and the Accuracy of Analyst Forecasts

The results of the first part of the analysis indicate that heat exposure reduces revenue and operating income. Hence, information on extreme temperature days is relevant for financial projections of firm performance. At the same time, policy-makers voice concerns that investors and financial analysts might not be prepared to take climate-related information into account when pricing securities. We empirically test if this policy assumption is justified in the context of temperatures.

To do so, we collect data from IBES on analyst forecasts as well as data on stock returns from Compustat Global Security Daily. Both databases cover subsamples of the universe of firms in Compustat Global Fundamentals, which results in important differences in their composition. Out of the full sample, we obtain analyst forecasts (returns) for up to 8.1% (9.7%) of the firms. For a geographic comparison, we map the difference between the sample in Figure 5a (analysts) and 5b (returns). The maps visualize that both subsamples comprise fewer firms in Southern areas, leading to an increased share of firms in cold areas (Scandinavia: 18.2/18.4% compared to 4.1% in the full sample; lowest temperature quintile: 27.8/25.2% compared to 19.9%). The average temperature at firm locations is 19.9°C (Table 1c). Further, the sub-samples cover fewer countries (64/61 compared to 93 countries). In terms of the industry composition, the share of utilities firms, which may be subject to positive performance shocks, is relatively similar across all samples and ranges from 4.1 to 4.5%. Moreover, firms covered by analysts and with return data available appear to be more profitable. The mean operating income over assets of 3.4 instead of 2.1% for the full sample. The mean revenue over assets is 26.1 instead of 24.2 percent. If heat exposure is less detrimental in colder areas, and if more profitable firms face reduced financial constraints to adapt, these differences could attenuate the subsequent results.

Analogous to the first analysis, we use the randomly distributed and exogenous variation in the number of extreme temperature days[40] around the average number of days at the firm's location

[39] We also interact heat exposure with an indicator for firms located in Scandinavia in Table 5. In line with the evidence that effects are attenuated in wealthier and colder countries, we find economically large positive but insignificant coefficients for the interaction terms. Joint tests of the main effect and the interaction term indicate that heat exposure on revenues and operating income does not significantly affect firm performance in Scandinavia.

[40] The assumption that the variation is quasi-random is conditional on spatial and temporal fixed effects.

to identify the effect of heat exposure on the accuracy of analyst forecasts. In this test, we aim to understand whether analysts understand the financial repercussions of heat for firm performance. The null hypothesis is that analysts respond to available information on firms' exposure to heat, and that no systematic changes to forecast errors occur when firms are exposed to prolonged periods of high temperatures. However, if analysts do not sufficiently incorporate information on the realized heat exposure in their predictions, then surprises in financial performance should become systematically more negative in periods when firms experience heat-driven repercussions. Hence, we focus on deviations of forecasts from the actual performance ($Performance\ Surprise$). To align the tests with the previous analyses, we focus on analysts' projections of revenues and income. We obtain these projections from IBES, and scale both forecast types by the firms' total assets. Due to few forecasts on operating income in IBES, we substitute them with forecasts of pre-tax income.[41]

Instead of understanding the cumulative effect of heat over time, we focus on the magnitude of the deviation of expectations and realizations per financial quarter in this set of tests. This difference is important: investors might take corrective actions quarter-by-quarter and errors could net out if investors (incorrectly) adjust their expectations after a negative surprise, i.e., by assuming that a performance shocks persists longer than it actually does. Further, we construct the tests in a way that ensures quarter by quarter that information on heat exposure is publicly available, and that allows us to assume that analysts have sufficient time to incorporate this information in their projections. Figure A2 illustrates this timing. Analysts forecast the performance of firms for any given financial quarter, and the quarter which the forecast refers to is labeled $Affected\ Fiscal\ Period$ (t) in the figure. During this period, the firm is exposed to a certain number of hot days, labelled $Heat\ Exposure$ (t). The financial performance of the firm is then announced at the $Announcement\ Date$, which follows the affected financial quarter with a certain time lag. Precisely this time lag gives analysts time to update their projections toward the end or after the closing of the fiscal period when the realized number of days of heat exposure is known. Moreover, lagged effects over several quarters give analysts additional time to update their forecasts. If heat exposure affects firms particularly with a lag of one to two quarters, analysts have time until the announcement of the earnings of the fiscal quarter t+2. At the same time,

[41]Conceptually, this difference should not be problematic. The main difference between both values lies in the firms' interest expenses, which should be orthogonal to the firms' exposure to high temperatures, since this exposure is exogenous and varies from year to year.

the lag of the effect might make it harder for analysts to discern that firms are negatively affected by heat. Table 1f and 1g document how often analysts update forecasts in this time frame. Per firm- and financial quarter-specific forecast of revenues (income), analysts change their forecast 0.6 (0.59) times after the close of the financial period and before the announcement date (window a in Figure A2). Between the affected financial quarter and the point in time when the effects of heat materialize, analysts update revenue and income forecasts 3.6 times on average. Equation 3 shows the regression specification:

$$Performance\ Surprise_{iskt} = \sum_{t=-3}^{0} \beta\ Heat\ Exposure_{ist} + \kappa_{is} + \theta_{mt} + \delta\ Trend_{ct} + \epsilon_{ist} \qquad (3)$$

where i stands for the firm, s stands for the season of each firm that is based on its financial reporting schedule ($s = 1, ..., 4$), κ_{is} represents the firm $\times$ financial quarter-fixed effect to absorb firm-location and firm-season-specific levels of heat exposure. n stands for the firm's industry; t for the observed time period and θ_{nt} for industry $\times$ time fixed effects to absorb the average forecast errors that analysts make systematically due to industry-specific economic dynamics. $\delta\ Trend_{ct}$ indicates country linear trends, with c as an index for $c = 1, ..., C$ countries determined by the location of i. k stands for the forecast measure, either revenues or pre-tax income. We calculate the $Performance\ Surprise_{it}$ by deducting the expected from the actual revenue or pre-tax income (k) and scale the difference by firms' total assets. $Heat\ Exposure$ refers to the number of hot days, which we count during the affected financial period. Earnings are announced with some delay, at the point in time labeled t. The timing of the test is illustrated in Figure A2. To ensure that our results are driven by heat and not by changes at the other extreme end of temperature distributions, we control for the number of cold days between -5 and 0 and below -5°C. We cluster standard errors two-way by country and year-quarter.

The analyses have three objectives. First, we estimate the effect of heat on revenues (operating income) to test if the main result holds for this subsample of firms. Second, we test whether analyst forecast errors become more negative with firms' exposure to heat, which we would expect if analysts do not anticipate the effects on firm performance. Third, we compare the magnitude of actual shocks on firm performance to the magnitude of the change in analysts' surprises to help us understand the meaning and plausibility of the results (Actual−Surprise, p-Value). If analysts do not respond altogether, the magnitude of the increase in surprises should correspond to the magnitude of the repercussions caused by high temperatures.

In line with the three objectives, the main results are threefold and (graphically) presented in Table 6 (Figure 6). We focus on analysts' responses after two and three quarters in particular, as the previous analysis shows that heat reduces operating income significantly in these time periods. First, we find that the effects of heat on firm performance hold for this subset of firms. We find similar magnitudes, although some of the effects decrease in significance.[42] Second, we turn to the potential deviation of analysts' expectations and actual financial performance. For the most pronounced heat-related repercussions after two quarters, the negative coefficients (Column 3, 4, 7 and Column 8) indicate that increases in firms' heat exposure indeed come with more negative revenue and income surprises.[43] Surprisingly, we also find a positive and significant coefficient for the effect of heat on analysts' forecast errors after three quarters. In principle, this effect could occur when analysts are negatively surprised in the period in which the shock occurs (q-2) and extrapolate the weak financial results to the next period (q-3).

Third, we contrast the effects on firm performance and the size of the surprises to interpret the observed magnitude with formal tests of the difference of the coefficients in the rows between the coefficients of the lags of heat exposure. If analysts do not respond altogether, the magnitude of the increase in surprises should correspond to the repercussions caused by high temperatures. Consistent with this view, the joint tests indicate that the most pronounced effects after two quarters are not statistically different for revenues. In contrast, there is a statistical difference between the effect of heat exposure on income and analysts errors after two quarters (column 7, significant at the 10%-level), and after three quarters.

This gap could indicate that some analysts adjust their forecast in response to firms' exposure, or that analysts generally do so, but to an insufficient extent. We test if increased exposure

[42] This deviation from the estimates for the full sample could be due to the fact that a larger share of firms in this subsample located in cold areas and more profitable. Both revenues and operating income decrease in response to heat, although the effect on revenues is less precisely estimated than in the first set of tests. Alternatively, the less pronounced effects in column 2 and 6 could be explained by the fact that the number of hot days alone is much lower in the areas of these subsamples, leading the a negligible number of observed hot days under the absolute-relative definition.

[43] This result is robust when we estimate the effects on median instead of mean surprises, and when we lag assets by one year before scaling the dependent variable in Table A7. In the main tests, assets are contemporaneous as the lag substantially reduces the sample size.

to heat leads to more updates or adjusted estimates. As Figure 7a shows, we do not find that forecast updates increase with firms' exposure to heat. Further, mean analyst estimates are not systematically adjusted downwards (Figure 7b).

Taken together, we find that heat exposure leads to more negative earnings responses, while the difference between the actual shock and the change in the forecast error is at times positive and significant. This finding would be consistent with the idea that analysts do not sufficiently take heat into account, however, the interpretation is complicated by the much smaller sample and the less precisely estimated results.

4.1 Robustness Tests

Mirroring the analysis on heat exposure and firm performance, we conduct a series of robustness tests. First, we test whether the results could be confounded by the financial crisis. However, Table A8 shows that the results remain similar after excluding the crisis years. Second, we compare our estimates using ERA5 temperature data with estimates based on ERA-Interim as well as country-level average temperatures in A9. ERA5 and ERA-Interim data produce similar results. Based on both temperature data sources, we find that errors in forecasts of revenues (income) over assets are significantly affected by the number of days above 30°C in q-2 (quarters q-3 and q-3). However, the results are different for country-level averages: For revenues, column 3 shows that forecasts errors are significantly affected by days above 30°C in both the current and preceding two quarters. For forecasts of operating income, we do not find any significant effects of days of heat derived from country-level average temperatures. The deviation between country-level and downscaled temperatures is notable, and much more pronounced than the differences estimates of the effects of heat on firm performance for the full sample. Third, we replace the temperature thresholds to define days as hot with a series of alternatives in Table A5. We find that a wide range of alternative thresholds produces similar results (significant effects on revenues: 25°C/90thP, 25°C/95thP, 30°C, 30°C/90thP, 30°C/90thP, 35°C). Fourth, in line with our robustness tests on performance, Panels (c) and (d) of Figure A5b shows the effects of heat exposure after two quarters by asset concentration. The effect of heat after two quarters is more negative and significant for firms that have most assets in their home country (75%-100%) compared to firms that have the least domestic concentration (0-25%). While this difference is consistent with the idea that improved spatial matching of assets and temperatures better captures the effect of heat on unanticipated revenues and profits, we do not see the magnitude of coefficients increase significance monotonically across the samples with different ranges of asset concentration.

5 Heat Exposure and Announcement Returns

The attention that analysts can devote to assessing the performance of each individual firm is likely to be limited. Therefore, we test whether the conclusion that market participants do not fully anticipate the repercussions of heat for performance holds beyond the case of analysts. As another common[44] and more general test on market surprises, we study whether investors react more negatively to earnings announcements in periods when firms have been exposed to heat.

Once again, we construct the test as illustrated in Figure A2 and use the quasi-random variation in the number of heat days at firms' locations for identification. If investors lower their expectation of firm profitability in response to observable firm-level heat shocks sufficiently – before these effects become apparent as earnings surprises at earnings announcement dates, the negative effects of heat exposure on firm profit should not lead to negative abnormal returns. In contrast, when market participants do not immediately and adequately factor heat exposure effects into stock prices based on publicly available information on firms' heat exposure, we expect valuation adjustments to occur on dates when investors learn about their incorrect expectations of profits, not having taken the full repercussions of heat into account.

For this test, we obtain daily share prices from Compustat Global, convert the time series into US dollars[45], and calculate daily returns. As a proxy for expected returns and the benchmark for the market model, we calculate equal (market capitalization-weighted) returns of all firms in the sample.[46] We calculate 3-, 5-, 7- and 11-day announcement returns for the announcement date subsequent to the affected fiscal period. The summary statistics[47] are shown in Table 2i and 2h.

[44] For instance, see La Porta et al. [1997], Core et al. [2006], and Edmans [2011].

[45] We lag exchange rates by one year to ensure that our results are not confounded by potential macro-financial effects of heat on aggregate economic output. We also estimate the results without this adjustment, and do not find that this choice affects our results (see Figure A6)

[46] We trim the returns below the 1^{st} and above the 99^{th} percentile. This approach is common in the finance and accounting literature, as accounting-based financial variables often exhibit extreme values (see Chen and Yang [2019] and Hsu et al. [2021] for recent examples).

[47] Similar to the analysis in Section 4, firms with return data available are more profitable. The mean operating income over assets is 3.4% (instead of a 2.1% mean for the full sample). The mean revenues over assets is 25.9% (instead of 24.2%).

Equation 4 shows the regression specification

$$c(a)r_{ist_{-d,+d}} = \sum_{t=-3}^{0} \beta \; Heat \; Exposure_{ist} + \gamma_{mt} + \kappa_{is} + \delta Trend_{ct} + \epsilon_{ist} \tag{4}$$

where i stands for the firm, s stands for the season for each firm that is based on its reporting schedule ($S = 1, ..., 4$). t stands for the announcement date; κ_{is} for firm×season fixed effects; γ_{mt} for industry-year fixed effects; and $\delta Trend_{ct}$ for country linear trends. d indicates the length of the window over which we calculate announcement returns cr. The timing of the test and the matching of fiscal periods and $Heat \; Exposure$ are analogous to the second analysis, as illustrated in Figure A2. To ensure that our results are driven by heat and not by changes at the other extreme end of temperature distributions, we control for the number of cold days between -5 and 0 and below -5°C. Standard errors are clustered two-way at the country and year-quarter level.

Panel A of Table 7 shows the main result for this test based on the raw and abnormal returns (market model, equal weighted returns) for the 11-day event window.[48] In line with the previous analyses on analyst forecasts, we focus on the magnitude of earnings surprises quarter by quarter and find a negative relation between increases in hot days during the financial period and announcement returns at the respective announcement date. As Figure 8 shows, the effects are most pronounced after two quarters (q-2). This lag structure matches the previous tests as well as the estimations of the effects of heat on operating income for this subsample in particular (see Figure A6, top-left corner). For every additional day with temperatures exceeding the 30°C, the raw announcement returns become 0.0358 percentage points more negative over the 11-day window around the announcement date (column 2, significant at the 5% level). The effect is slightly weaker when we focus on abnormal returns over an equal-weighted benchmark (coefficient -0.0361, column 6, significant at the 10% level). We do not find larger magnitudes when the realized temperatures are unusual given the place and time-specific distribution of temperatures (e.g., column 4 and 8).

Given the standard deviation in the number of days per quarter by which heat exposure varies over time (5.4 days for the 30°C threshold), the effect of a one standard deviation increase in heat exposure would induce a 0.1976 percentage point more negative announcement return. We compare

[48]For the expected returns, we estimate the market model out of sample based on a maximum of 365 days ending 46 days before the announcement date. We require at least 20 observations per firm and announcement date, and winsorize daily stock rates of return at –2 and +4 times the market rate of return following Welch [2019].

this magnitude to two related studies. First, Edmans [2011] investigates a portfolio composed of firms that are on America's Best Companies to Work (BC) for list. The study finds that BC firms generate more positive earnings surprises, and that the three-day abnormal returns of BC firms are on average 0.28 higher compared to non-BC firms. While the event in Edmans [2011] is in nature different from ours, the interpretation is related: The findings indicate that employee satisfaction contributes to firm performance through increased worker performance, but that the market does not fully understand this relation until the effects become visible in earnings announcements. Given that the literature associates heat with lower worker performance, the potential mechanism behind our finding that high temperatures lead to lower earnings announcement returns is similar. In comparison, we estimate that a one standard deviation in hot days leads to earnings announcement returns of about -0.18 percentage points (q-2, 6.3 days $\times$ 0.0292, Table 7, column 4). Second, Barrot and Sauvagnat [2016] study how firms' and their suppliers' revenues and returns are affected by natural disasters. The authors report that the returns of the directly affected supplier firms decrease by -0.5 percentage points over 10 days after the event. Considering that Barrot and Sauvagnat [2016] find these effects for large-scale natural disasters, our estimates for heat are sizeable.

5.1 Robustness Tests

We test the robustness of the results to alternative calculations of abnormal returns. First, Figure A6a shows that the results remain similar when we convert stock prices using contemporaneous instead of lagged exchange rates. The effects after two quarters are marginally significant, with stronger effects visible after three quarters compared to the main test. Second, we test six different approaches to calculate abnormal returns. The results hold when we use returns adjusted by equal weighted average market returns (Figure A6b), and returns adjusted using a benchmark derived from the market model with equal and market capitalization weighted returns (Figure A6c). Further, we estimate tests using 3-factor and 4-factor returns (Figure A6d) using Fama-French international research returns of developed countries excluding the United States [French, 2021].[49] The results slightly increase in magnitude. Only for market capitalization weighted average mar-

[49]For the main specification, we rely on raw returns. In a multi-country setting, the choice of a benchmark can induce bias if individual countries load differently on the benchmark returns, depending on how well the aggregate factor returns represent the conditions in local financial markets. For a firm-level analysis, this heterogeneity could potentially raise questions about whether the results are driven by country exposures. For the market model, we estimate factor loadings out of sample based on a maximum of 365 days ending 46 days before the announcement date. The coefficients for the 7-day window are plotted in Panel C and consistent with the main results.

ket returns and days which exceed both 30°C and the historical benchmark, the effect after two quarters becomes insignificant (Figure A6b).

Further, we test whether the results could be confounded by the financial crisis as in the previous analyses. Again, Table A11 shows that the results do not change substantially when we exclude the crisis years. We also compare our estimates using ERA5, ERA-Interim, as well as country-level average temperatures in Table A12. ERA5 and ERA-Interim estimates both indicate a significantly negative effect of heat in the current and after two quarters (q and q-2) on the 5-day earning announcement return. For the 3-day announcement returns, only the results based on ERA5 are significant, in contrast to the results of the firm performance tests, where we find stronger results using ERA-Interim. As with the analysis of analyst forecasts, we only find insignificant or counter-intuitive positive and significant results using country-level averages. Next, we replace the temperature thresholds to define days as hot in Table A13, and find that a wide range of alternative thresholds produces similar results. In addition, we estimate the effects of heat on the 5-day return around earnings announcements for different levels of asset concentration, analogous to previous tests in Sections 3.1 and 4.1. As Panel e of Figure A5c shows, the estimated coefficients on our measures of heat exposure are close to zero for firms with the lowest fraction of assets (0-25%) concentrated in their home country, but more negative based on samples of firms with greater domestic asset concentration. However, both the point estimates and the standard errors do no consistently change from one range of asset concentration to another.

6 Conclusion

In this study, we use an international sample of more than 13,000 listed firms with regionally concentrated assets in 93 countries in the period from 1995 to 2019 to test if heat exposure has a negative effect on financial performance, and if analysts and investors anticipate this effect.

We find that quasi-random increases in the number of extremely hot days per financial quarter at firms' locations decreases revenues and operating income. Further, the prolonged exposure to heat increases firms' cost of goods sold and selling, general, and administrative expenses. Total wages per firm increase with a lag of two quarters, consistent with the idea that heat decreases worker performance, and that firms compensate for losses increasing labor inputs in later periods. Based on the observed effects of heat on firm performance, we conduct two tests to understand whether analysts and investors anticipate this negative financial effect: If extremely high temperature days are financially material but not anticipated, expectations on revenue and operating income should be too high in periods when firms are exposed to more extremely warm days than usual. Moreover, expectations on firm performance should similarly be systematically higher than the actual performance and lead to negative announcement returns. Indeed, we find that both revenue and operating income surprises and announcement returns become more negative with increasing heat exposure at the firms' locations. This finding indicates that analysts and investors do not fully take into account information on high temperatures.

An open question relates to the timing of the observed effects. For the full sample, we find that the detrimental consequences on firm performance are most visible after one quarter. For the subset of firms with information on earnings surprises and announcement returns available, the effects are strongest after two financial quarters. Further, we find increases in wage expenses after two quarters, as well as immediate responses two broader expense categories. These differences in timing could be explained by heterogeneity in firms' production processes: Depending on turnover times and inventories, performance shocks could materialize at different points in time. Dissecting these dynamics is an important area for future research, as the timelines over which these effects play out are crucial both for managers concerned with adaptation to rising temperatures and investors who want to assess these shocks to firm performance.

Further, our findings raise the question why do firms remain sensitive to costly temperatures shocks. In principle, the observed sensitivity of firms to temperature fluctuations does not imply a divergence from profit maximization or a lack of awareness of the problem. As long as the average conditions allow the firm to maximize the value of its production or services, firms might find not investing in adaptation to be optimal, accepting that some years are more productive than others depending on environmental conditions. However, once temperature distributions shift persistently due to climate change, firms' production and adaptation might no longer be optimally matched to the new average exposure to heat. Still, such a shift in temperatures would have to be large enough to financially incentivize firms to make adjustments. For instance, these investments could require firms to consistently use cooling technology, and potentially require substantial renovations of plant, property and equipment. To what extent temperature changes going forward will be apparent enough to justify such investment is an empirical question that our study leaves open.

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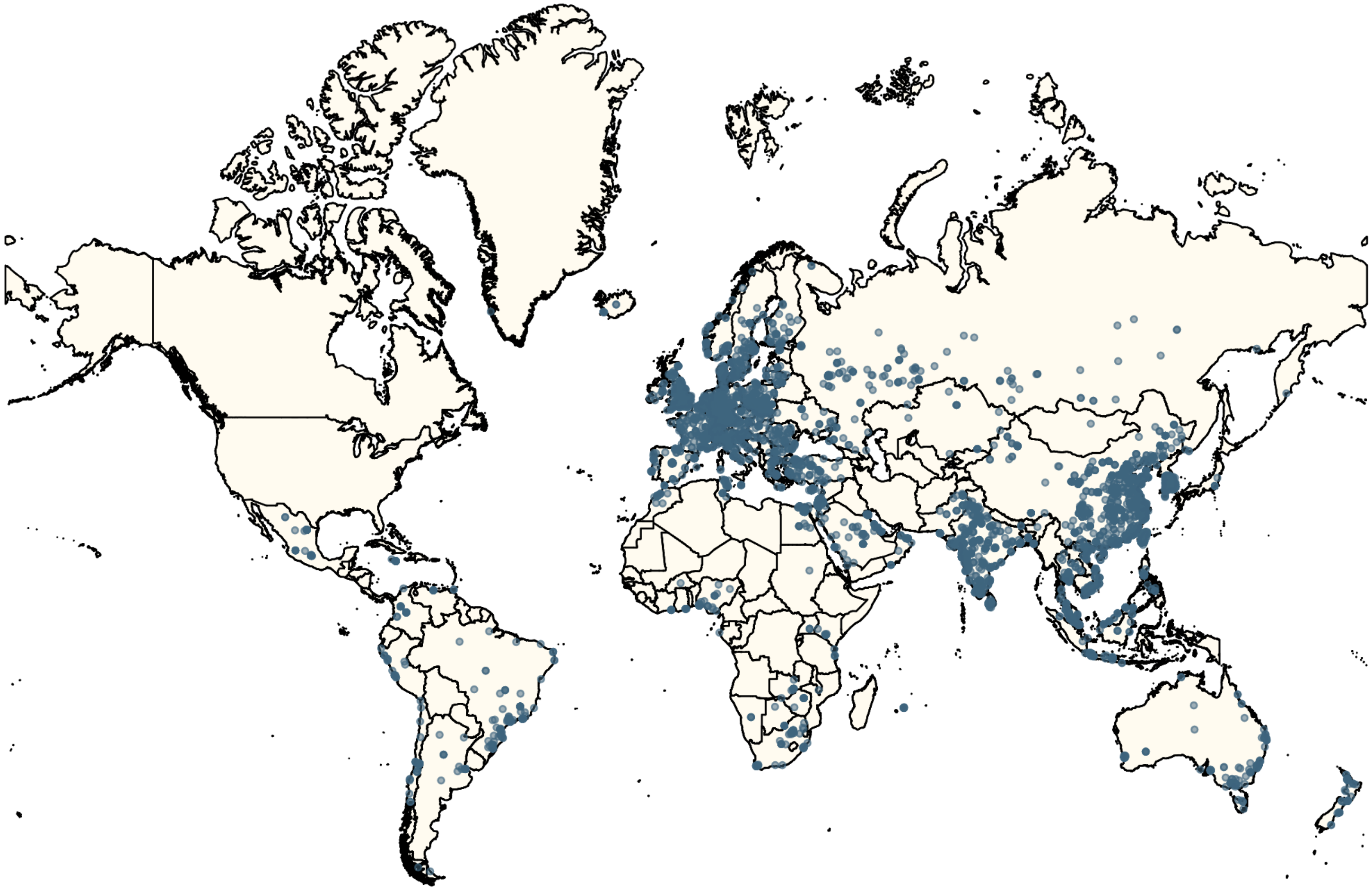
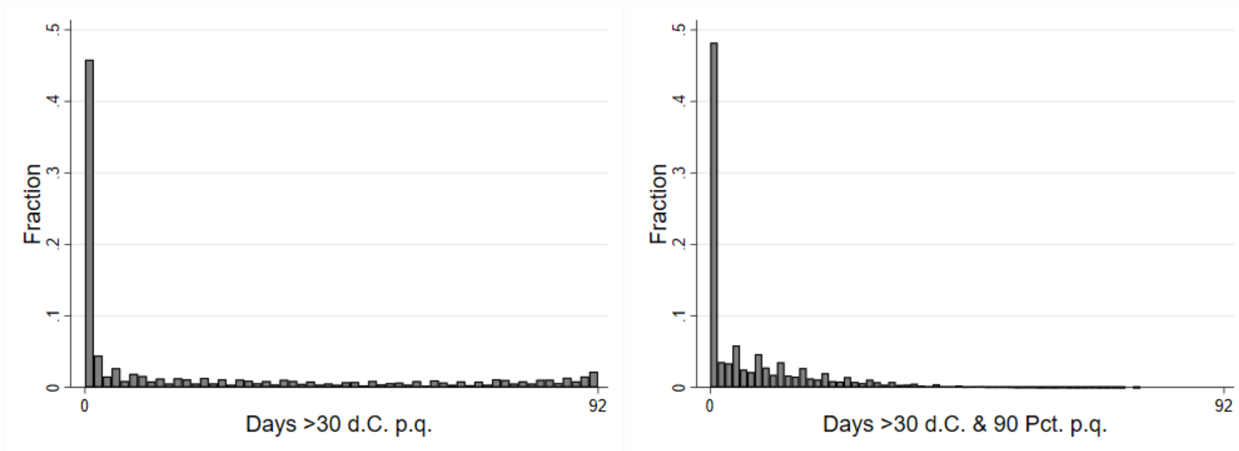
Tables and Figures

Figure 1: Geographic Distribution of the Sample



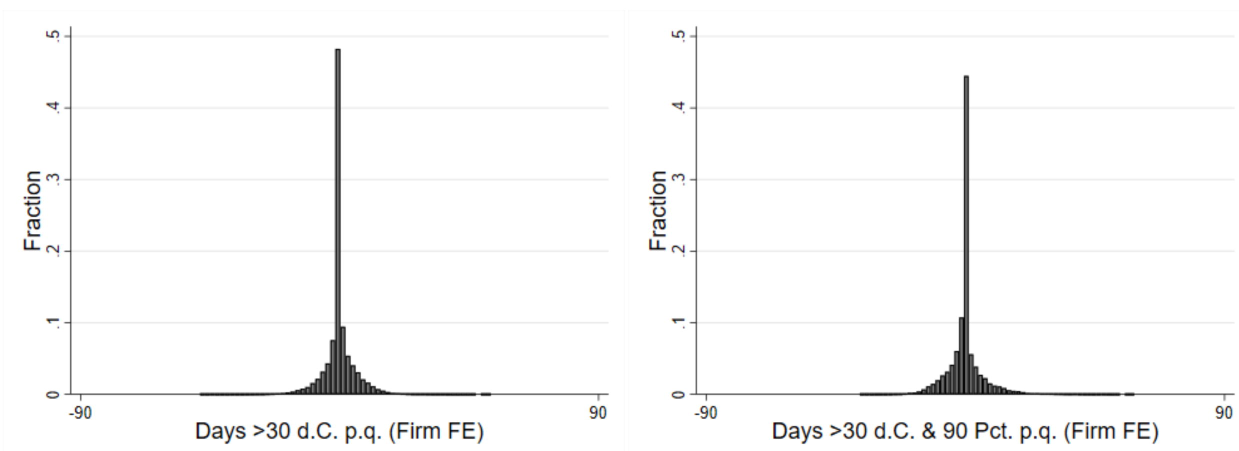
Notes: This figure shows the geographic distribution of the firms in the sample. To determine a firm-specific measure of heat exposure, we use the location of firms' headquarters combined with information on asset concentration from FactSet Revere records on geographic segments. We exclude firms from the sample which hold less than 10% of their assets in their home country.

Figure 2: Identifying Variation



(a) Cross-Sectional Variation in Heat Exposure

Notes. Figure 2a shows the cross-sectional variation in quarterly heat exposure. When absolute temperature thresholds are used to classify days as extremely warm (above 30°C at a firm's location), some firms are either never or always "treated" (see image on the left), or in other words, located in climate zones were the thresholds are always or never crossed. Figure 2a (image on the right) shows the distribution of quarterly heat exposure, measured by days on which temperatures exceed not only 30°C but also the 90^{th} percentile of the historic (1980-1999) distribution of temperatures that the firm experienced on the same day as well as on the five preceding and subsequent days.

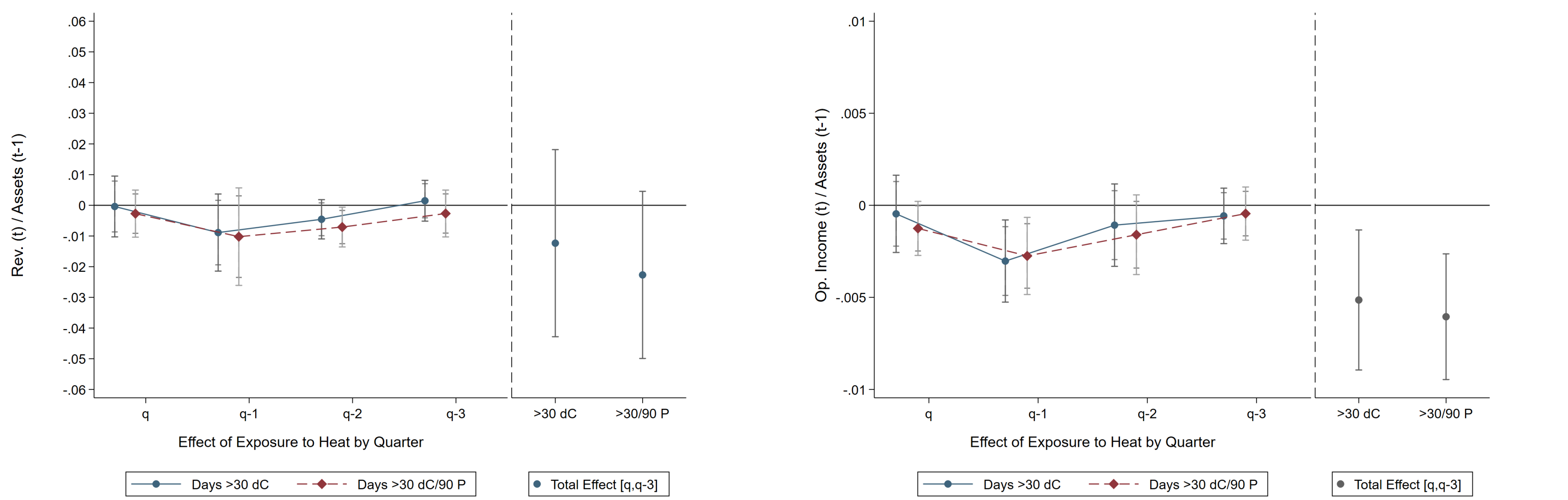


(b) Within Variation in Heat Exposure

Notes: Figure 2b shows *within variation* in quarterly heat exposure. This variation is the number of days in a fiscal quarter on which firms were exposed to extreme temperatures minus the average number of days of heat exposure in the same quarter over the years in the sample period.

Figure 3: Heat Exposure and Firm Performance

(a) Revenues/Assets (b) Operating Income/Assets



Notes. This figure reports the effects of high temperatures on quarterly revenues as percentage of assets, and on operating income as percentage of total assets; see specifications (1) and (2) in Table 2. *Heat Exposure* refers to the number of days in a quarter on which the firm experiences a temperature which exceeds the threshold level indicated by the legend of the figure. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. The specifications include heat exposure in the directly affected quarter (q) as well as exposures in three lagged quarters (q-1, q-2, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends and controls for days below 0°C. Two-way standard errors are clustered at the country and year-quarter level. 90 and 95% confidence intervals are indicated by small bars.

Figure 4: Heat Exposure and Firm Expenses

Notes. This figure shows the effect of high temperatures on log expenses. We observe three different outcomes related to these considerations: Firms' cost of goods sold (COGS), selling, general, and administrative expenses (SGA), and wages. Standard & Poor's defines the COGS as "all expenses directly allocated by the company to production, such as mate-rial, labor, and overhead". SGA comprise "all commercial expenses of operation (such as, expenses not directly related to product production) incurred in the regular course of business". *Heat Exposure* refers to the number of days in a quarter on which the firm experiences a temperature above the threshold level indicated by the legend of the figure. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. The specifications include heat exposure in the directly affected quarter (q) as well as exposures in three lagged quarters (q-1, q-2, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends and controls for days below 0°C. Two-way standard errors are clustered at the country and year-quarter level. 90 and 95% confidence intervals are indicated by small bars.

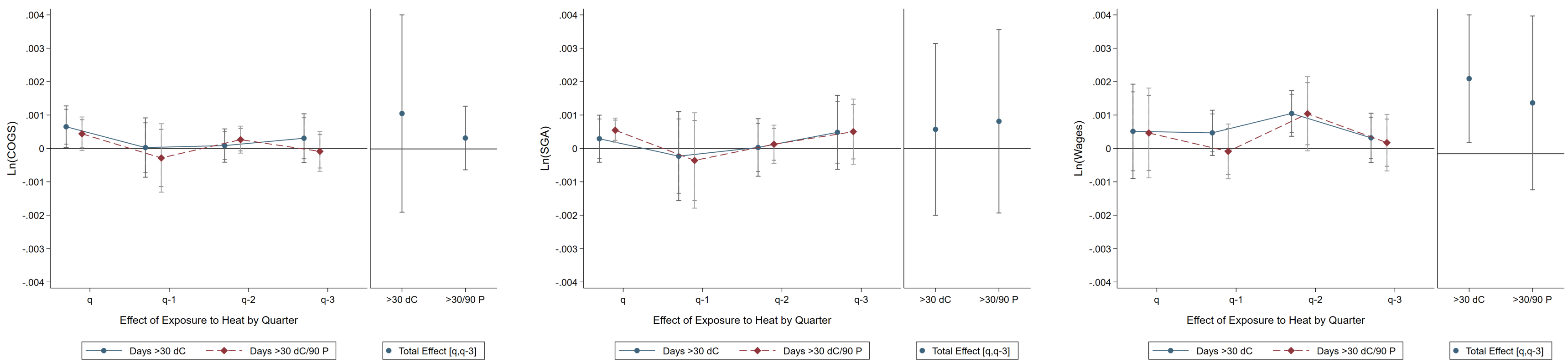
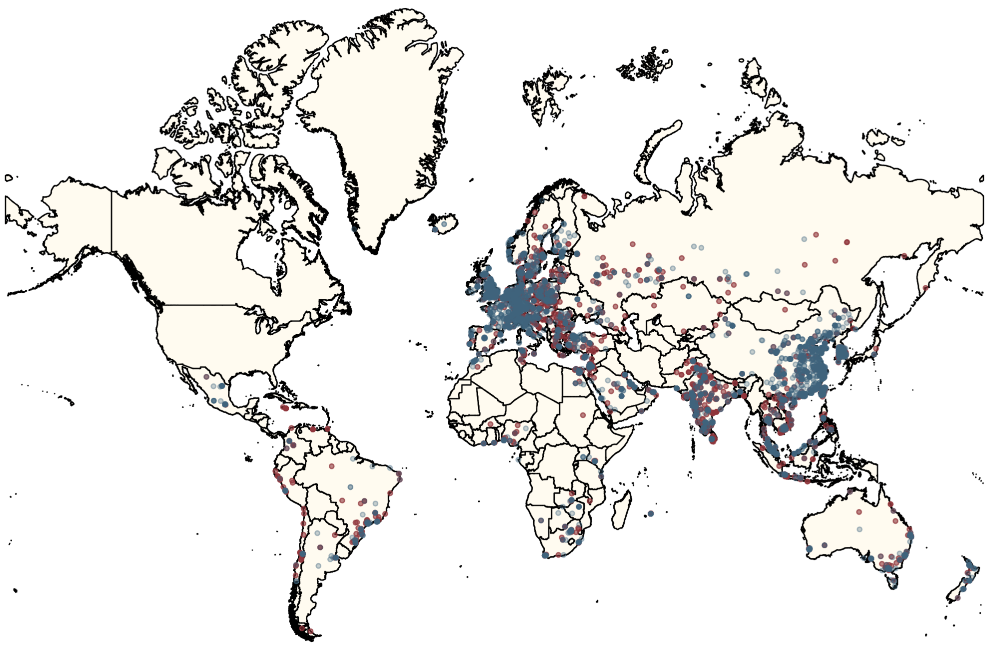


Figure 5: Comparison of Samples

Notes. Figure 5a (5b) shows the geographic distribution of firms with data available on analyst forecasts (announcement returns). Firms in blue are included both in the analyst (return) sample and the firm performance sample, points in red are firms only included in the firm performance sample and not in subsequent analyses.

(a) Geographic Distribution — Firm Performance and Analyst Forecasts



(b) Geographic Distribution — Firm Performance and Announcement Returns

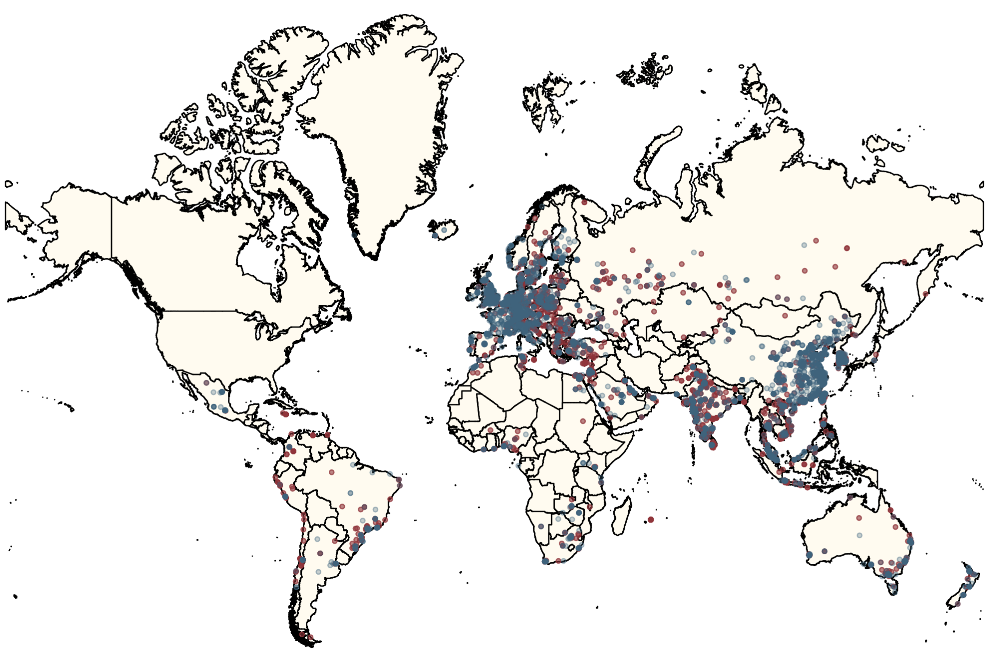
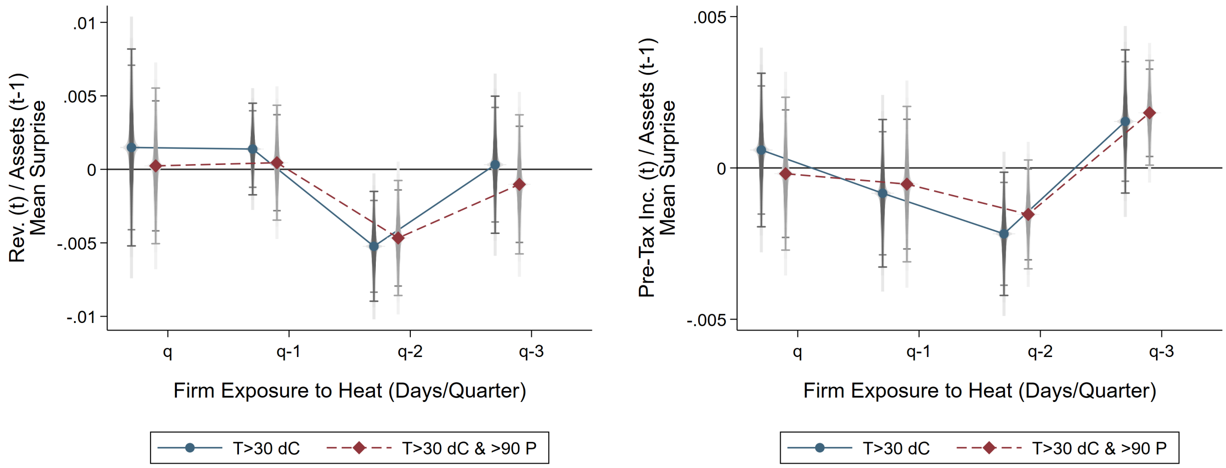
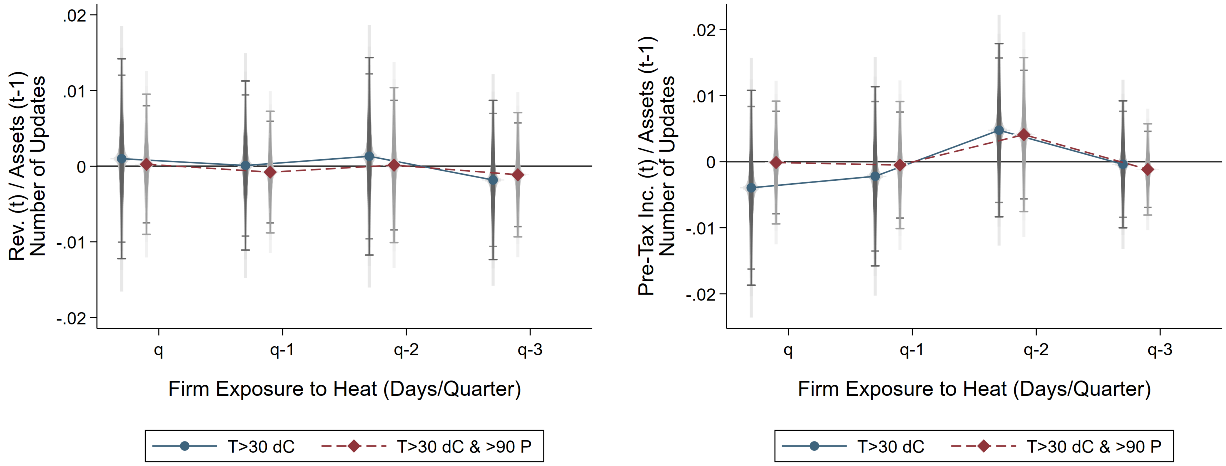


Figure 6: Heat Exposure and Analyst Forecast Errors

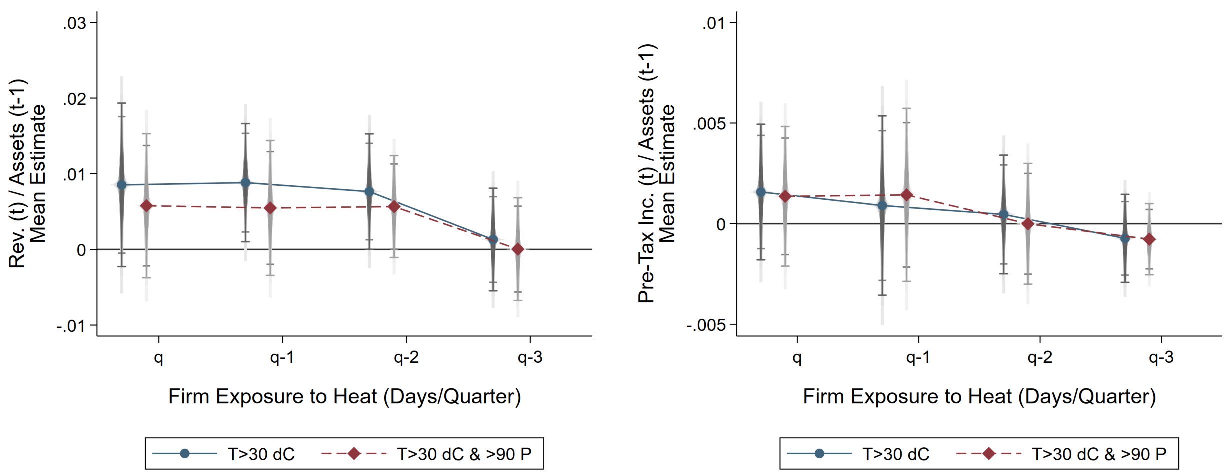


Notes. Shown are the effects of heat exposure on the error in the mean analyst forecasts of revenues, scaled by lagged assets (left figure), and on the mean analyst forecast of pre-tax income, scaled by assets (right figure). The first measure of heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (T> 30°C). The second measure is based on the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic (1980-1999) distribution of temperatures that occurred at the firm's location on the same day as well as the five preceding and subsequent days (T>30°C & 90 P). The specifications include heat exposure in the directly affected quarter (q) as well as exposures in three lagged quarters (q-1, q-2, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends and controls for days below 0°C. 90 and 95% confidence intervals are indicated by small bars.

Figure 7: Heat Exposure and Analyst Forecasts — Additional Tests



(a) Effects on the Number of Updates



(b) Effects on Mean Estimates

Notes. In this figure, Panel (a) shows the effect of heat exposure on the number of updates of analyst forecasts of revenues (left) and pre-tax income (right figure). Panel (b) reports the effects of heat exposure on analysts' mean estimates of revenues (left) and pre-tax income (right figure). 90 and 95% confidence intervals are indicated by small bars. The first measure of heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (T> 30°C). The second measure is based on the number of days on which temperatures exceeded not only 30°C but also the 90th percentile of the historic (1980-1999) distribution of temperatures that occurred at the firm's location on the same day as well as the five preceding and subsequent days (T>30°C & 90 P). The specifications include heat exposure in the directly affected quarter (q) as well as exposures in three lagged quarters (q-1, q-2, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends and controls for days below 0°C. 90 and 95% confidence intervals are indicated by small bars.

Figure 8: Heat Exposure and Earnings Announcement Returns

Notes. Reported are the effects of high temperatures on quarterly earnings announcement returns. Announcement returns are measured over either three days (left figure), 7 days (middle figure), or 11 days (right figure) surrounding the announcement date. Heat exposure indicated by T > 30 dC is measured by the number of days in a financial quarter on which temperatures exceeded 30°C. Heat exposure indicated by T > 30 dC & >90P is the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days. The specifications include heat exposure in the directly affected quarter (q) as well as exposures in three lagged quarters (q-1, q-2, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends and controls for days below 0°C. Two-way standard errors are clustered at the country and year-quarter level. 90% and 95% confidence intervals are indicated by small bars.

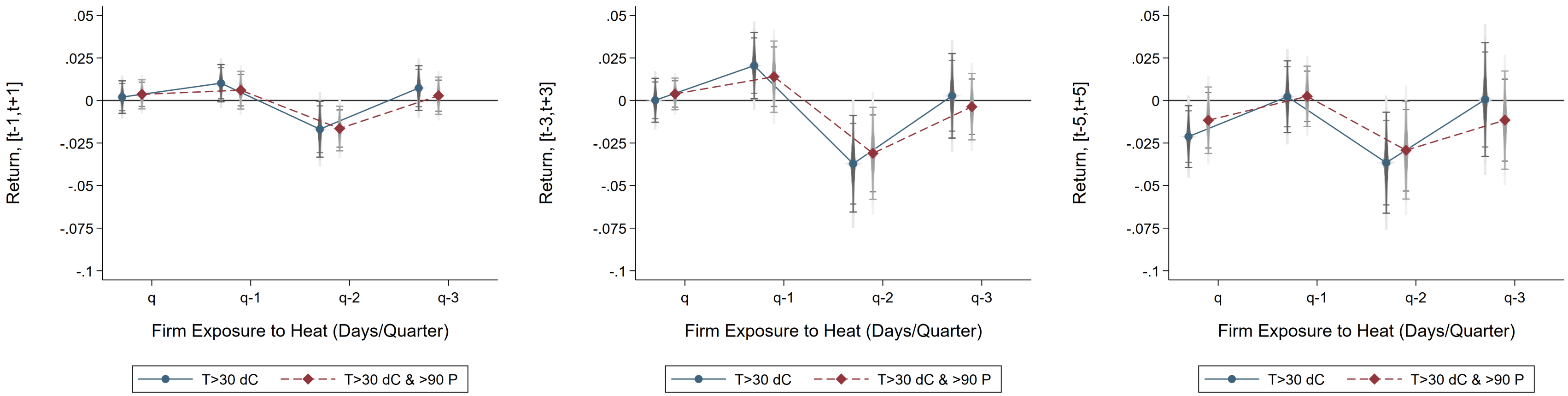


Figure 9: Heat Exposure and Regional Heterogeneity

Notes. This figure shows the average marginal effects of high temperatures on revenues and operating income by average temperatures and gross domestic product (GDP) per capita. *Heat Exposure* refers to the number of days in a quarter on which the firm experiences a temperature above the threshold level indicated by the legend of the figure. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. The specifications include heat exposure in the directly affected quarter as well as exposures in three lagged quarters, firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends and controls for days below 0°C. Two-way standard errors are clustered at the country and year-quarter level. 90 and 95% confidence intervals are indicated by small bars.

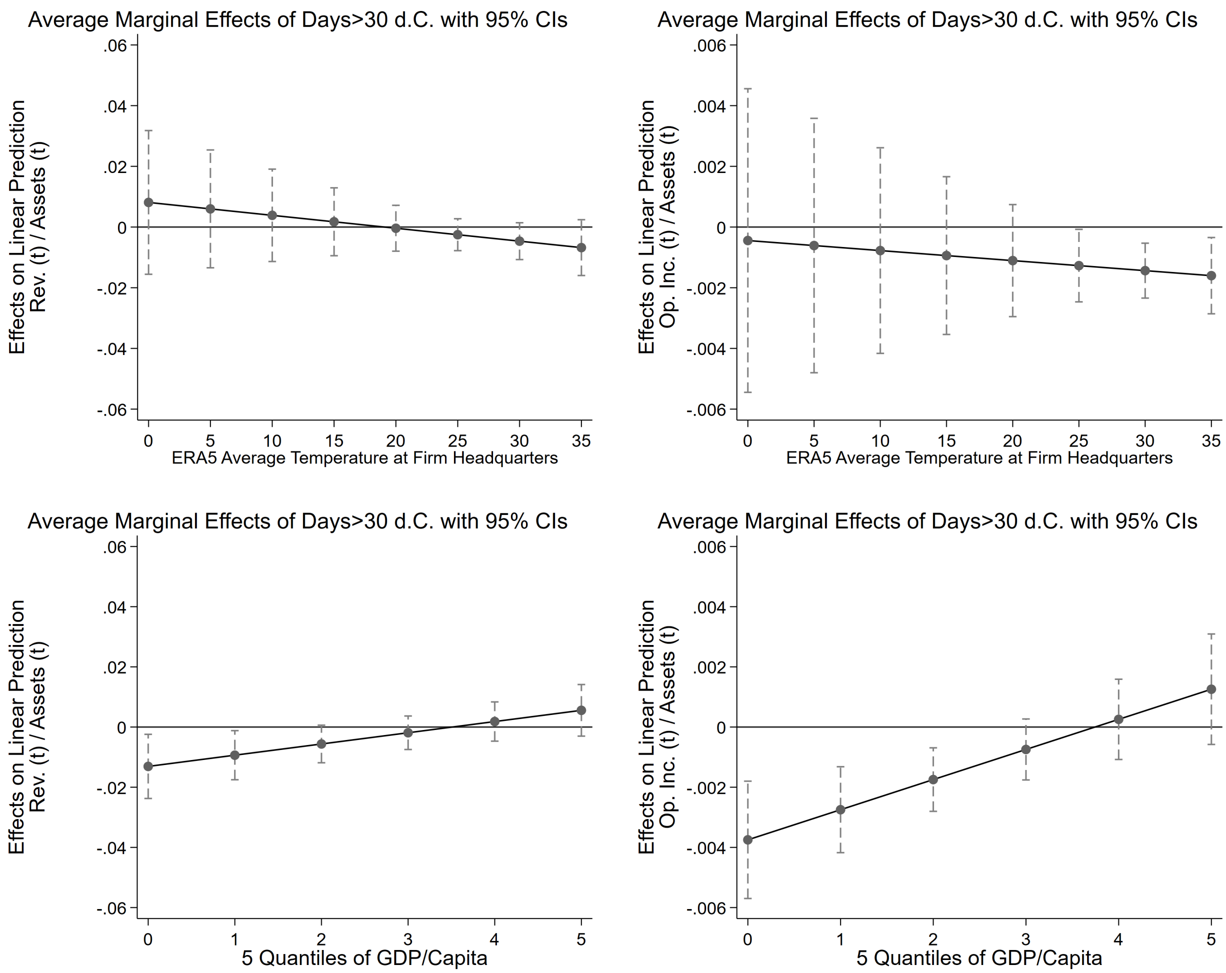


Table 1: Summary Statistics

	(1) (N)	(2) (mean)	(3) (sd)	(4) (p25)	(5) (p50)	(6) (p75)
Total Assets mUSD	599,347	1,704.92	10,879.70	43.60	153.79	581.37
Revenues mUSD p.q.	592,281	158.29	432.92	7.04	26.20	99.31
Operating Income (bef. Depr.) mUSD p.q.	587,994	21.04	63.64	0.26	2.27	11.12
Revenues mUSD p.a.	590,359	366.88	1,018.64	14.67	57.05	225.07
Operating Income (bef. Depr.) mUSD p.a.	586,321	50.07	150.67	0.76	5.45	26.45
Revenues (t)/Assets (t-1) p.q. (%)	599,347	24.23	18.90	10.93	19.96	32.32
Operating Income (t)/Assets (t-1) p.q. (%)	599,347	2.10	3.50	0.53	2.03	3.80
Labor/Total Expenses (%)	566,448	34.70	111.13	11.84	24.01	43.26

(a) Firm Performance

	(1) (N)	(2) (mean)	(3) (sd)	(4) (p25)	(5) (p50)	(6) (p75)
Days>30 d.C. p.q	599,347	22.47	30.42	0.00	3.00	41.00
Days>30 d.C. & 90 Pct. p.q	599,347	7.53	10.88	0.00	2.00	12.00
Days >30 d.C. p.q. (Firm FE)	599,347	0.06	5.36	-1.06	0.00	1.00
Days >30 d.C. & 90 Pct. p.q. (Firm FE)	599,347	0.10	6.31	-1.57	0.00	0.75
Average Temperature at Firm Location	599,347	21.91	8.70	16.24	23.35	29.49

(b) Heat Exposure

Notes. Panel (a) shows descriptive statistics on firm performance. Reported are the mean, standard deviation (sd) and the 25^{th}, 50^{th} and 75^{th} percentiles (p25, p50, p75) for, respectively, current-quarter (t) revenue (operating income) as percentage of one-year-lagged (t-1) total assets, and for total assets, revenues, and operating income before depreciation (in millions U.S. dollars). All variables in Panel (a) are obtained from Compustat Global and trimmed at the 1st and 99th percentiles to remove outliers. Panel (b) shows statistics on firms' heat exposure, based on two alternative measures of the number of days a firm's headquarter location experiences heat. To determine a firm-specific measure of heat exposure, we use the location of firms' headquarters combined with information on asset concentration from FactSet Revere records on geographic segments. We exclude firms from the sample which hold less than 10% of their assets in their home country. The first measure of heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (Days > 30 d.C. p.q). The second measure is based on the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic (1980-1999) distribution of temperatures that occurred at the firm's location on the same day as well as the five preceding and subsequent days (Days > 30°C & 90^{th} Pct. p.q.). Firm FE indicates that the respective variable has been demeaned with the firm-specific average across the sample period. Reported is also the average temperature observed at the firm's locations. N refers to firm-quarters.

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Days >30 d.C. p.q.	55,927	16.83	26.71	0	1	24
Days >30 d.C. & 90 Pct. p.q.	55,927	6.51	10.26	0	0	10
Average Temperature at Firm Location	55,927	19.87	9.27	12.15	21.54	27.37
Revenues (t)/Assets (t-1) p.q.	55,927	26.08	16.65	14.63	22.52	33.31
Operating Income (t)/Assets (t-1) p.q.	55,781	3.42	2.79	1.81	3.10	4.76
Total Assets mUSD	55,927	4,004.39	7,989.02	301.79	1,025.60	3,495.47

(c) Heat Exposure and Performance of Firms with Data on Analyst Forecasts Available

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Revenues Mean Surprise/Assets p.q.	55,927	-0.15	2.13	-0.79	-0	0.58
Revenues Median Surprise/Assets p.q.	55,890	-0.14	2.10	-0.75	-0	0.56

(d) Analyst Forecast Errors - Revenues

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Pre-Tax Income Mean Surprise/Assets p.q.	40,590	-0.15	0.90	-0.44	-0.01	0.24
Pre-Tax Income Median Surprise/Assets p.q.	40,573	-0.15	0.89	-0.44	-0.01	0.23

(e) Analyst Forecast Errors - Pre-Tax Income

Notes. Panel (c) shows summary statistics on the two alternative measures of firms' heat exposure based on the sample firms used in analysis of analysts' forecast errors, along with the average temperature observed at the firms' locations. Panel (d) presents summary statistics on the measures of analysts' revenue forecast errors while Panel (e) shows statistics on errors in analysts' forecasts of pre-tax income. The quarterly error in forecast of a firm's revenue (pre-tax income) is computed by deducting either the mean or the median of forecasts (that analysts in the IBES universe reported for the firm) from the actual revenue (pre-tax income) and then scaling this difference by total assets lagged by four financial quarters. All variables in Panels (d) and (e) are obtained from IBES and trimmed at the 1st and 99th percentiles to remove outliers. N refers to firm-quarters.

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Number of Revenue Forecast Changes [window (a)]	55,927	0.61	1.24	0	0	1
Number of Revenue Forecast Changes [window (b)]	55,927	2.50	4.19	0	1	3
Number of Revenue Forecast Changes [window (c)]	55,927	3.57	6.12	0	1	4

(f) Revenue Forecast Changes Before the Earnings Announcement Date

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Number of Pre-Tax Income Forecast Changes [window (a)]	40,590	0.59	1.17	0	0	1
Number of Pre-Tax Income Forecast Changes [window (b)]	40,590	2.48	3.87	0	1	3
Number of Pre-Tax Income Forecast Changes [window (c)]	40,590	3.57	5.67	0	2	4

(g) Income Forecast Changes Before the Earnings Announcement Date

Notes. Panel (d) and (e) show how often forecasts are updated. The tables correspond to the windows shown in Figure A2. The variable show the number of changes in revenue (d) and income (e) forecasts. All variables are obtained from IBES, N refers to firm quarters.

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Days >30 d.C. p.q.	40,209	18.84	28.09	0	1	31
Days >30 d.C. & 90 Pct. p.q.	40,209	7.05	10.61	0	1	11
Average Temperature at Firm Location	40,209	20.39	9.40	13.45	21.77	28.17
Revenues (t)/Assets (t-1) p.q.	38,913	25.94	16.88	14.38	22.24	33.04
Operating Income (t)/Assets (t-1) p.q.	38,843	3.39	2.74	1.81	3.08	4.69
Total Assets mUSD	40,209	7,375.81	26,486.40	321.70	1,136.14	4,165.28

(h) Heat Exposure of Firms with Data on Earnings Announcement Returns Available

VARIABLES	(1) N	(2) mean	(3) sd	(4) p25	(5) p50	(6) p75
Cum. Return, 3 Days	40,209	-0.11	4.78	-2.77	-0.20	2.47
Cum. Benchmark-Adj. Return (EW), 3 Days	40,209	0.01	4.60	-2.59	-0.11	2.49
Cum. Abnormal Return (MM, EW), 3 Days	40,209	0	4.63	-2.61	-0.10	2.49
Cum. Return, 5 Days	40,209	-0.17	5.84	-3.45	-0.28	3.03
Cum. Benchmark-Adj. Return (EW), 5 Days	40,209	-0.01	5.56	-3.15	-0.15	3.03
Cum. Abnormal Return (MM, EW), 5 Days	40,209	-0.02	5.60	-3.19	-0.16	3.05
Cum. Return, 7 Days	40,209	-0.23	6.58	-3.95	-0.31	3.44
Cum. Benchmark-Adj. Return (EW), 7 Days	40,209	-0.01	6.25	-3.58	-0.15	3.45
Cum. Abnormal Return (MM, EW), 7 Days	40,209	-0.03	6.30	-3.59	-0.17	3.44
Cum. Return, 11 Days	40,209	-0.36	7.76	-4.73	-0.37	4.05
Cum. Benchmark-Adj. Return (EW), 11 Days	40,209	-0.01	7.34	-4.24	-0.10	4.12
Cum. Abnormal Return (MM, EW), 11 Days	40,209	-0.04	7.40	-4.30	-0.13	4.13

(i) Announcement Returns

Notes. Panel (f) shows summary statistics on the two alternative measures of firms' heat exposure based on the sample firms used in analysis of quarterly earnings announcement returns, along with the average temperature observed at the firms' locations. Panel (g) presents summary statistics on the accumulated daily stock returns that a firm experiences during the 3 (5, 7, 11) days surrounding the earnings announcement date (Cum. Return, 3 Days), statistics on earnings announcement returns relative to a benchmark return, and statistics on abnormal returns derived from estimating firms' equity betas in market models (MM) of their stock returns. The benchmark used in computation of benchmark-adjusted and abnormal returns is an equal-weighted average of all firms in the global sample. Stock returns are from Compustat Global Security Daily, converted to U.S. dollars, and trimmed at the 1st and 99^{th} percentiles.

Table 2: Heat Exposure and Firm Performance

Notes. This table reports the effects of high temperatures on quarterly revenues as a percentage of assets (Revenues/Assets, columns 1 to 4) and operating income as a percentage of total assets (Op. Income/Assets, columns 5 to 8); see specifications in equations (1) and (2). *Heat Exposure* refers to the number of days in a quarter on which the firm experiences a temperature which exceeds a threshold level, based on headquarter location. To determine a firm-specific measure of heat exposure, we match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. All specifications include heat exposure augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends. Columns 2, 4, 6 and 8 additionally control for the number of days when temperatures were below 0°C. In addition, the sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

(a) Average Effects

	Revenues/Assets				Op. Income/Assets			
	30° C		30° C/90thP		30° C		30° C/90thP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Heat Exp. (q)	-0.0005	-0.0004	-0.0031	-0.0027	-0.0004	-0.0005	-0.0013**	-0.0013*
	(0.0048)	(0.0050)	(0.0035)	(0.0039)	(0.0010)	(0.0011)	(0.0006)	(0.0007)
Heat Exp. (q-1)	-0.0087	-0.0089	-0.0104	-0.0102	-0.0030***	-0.0030***	-0.0028***	-0.0028**
	(0.0065)	(0.0063)	(0.0082)	(0.0080)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Heat Exp. (q-2)	-0.0031	-0.0046	-0.0061**	-0.0071**	-0.0008	-0.0011	-0.0014	-0.0016
	(0.0035)	(0.0032)	(0.0030)	(0.0033)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Heat Exp. (q-3)	0.0025	0.0015	-0.0022	-0.0027	-0.0004	-0.0006	-0.0004	-0.0004
	(0.0036)	(0.0033)	(0.0037)	(0.0038)	(0.0008)	(0.0008)	(0.0007)	(0.0007)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	No	Yes	No	Yes	No	Yes	No	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\sum$ Heat Exposure	-0.0098	-0.0123	-0.0219	-0.0227*	-0.0047**	-0.0051**	-0.0059***	-0.0061***
Joint P-Value	(0.38)	(0.25)	(0.10)	(0.09)	(0.03)	(0.01)	(0.00)	(0.00)
R-Squared	0.7511	0.7512	0.7511	0.7512	0.5780	0.5782	0.5781	0.5782
Mean Dep. Variable	24.23	24.23	24.23	24.23	2.10	2.10	2.10	2.10
Number of Observations	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347
Number of Firms	14,736	14,736	14,736	14,736	14,736	14,736	14,736	14,736
Number of Countries	93	93	93	93	93	93	93	93

Table 3: Heat Exposure and Firm Expenses

Notes. This table reports the effects of high temperatures on different measures of firm expense: selling, general and administrative expenses (SGA), cost of goods (COGS) and wages. The dependent variables refer to U.S. dollar-denominated expenses taken in natural logarithm. Heat Exposure refers to the number of days in a quarter that the firm experiences a temperature which exceeds a threshold level, based on headquarter location. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. In results columns 1-3, heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (Days > 30 d.C. p.q). In columns 4-6, heat exposure is the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days (Days > 30 d.C. & 90 Pct. p.q.). All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C (Cold Day Controls). In addition, the sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Ln(COGS)	Ln(SGA)	Ln(Wages)	Ln(COGS)	Ln(SGA)	Ln(Wages)
	30° C			30° C/90^{th}P		
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	0.0006**	0.0003	0.0005	0.0004*	0.0005***	0.0005
	(0.0003)	(0.0004)	(0.0007)	(0.0003)	(0.0002)	(0.0007)
Heat Exp. (q-1)	0.0000	-0.0002	0.0005	-0.0003	-0.0004	-0.0001
	(0.0004)	(0.0007)	(0.0003)	(0.0005)	(0.0007)	(0.0004)
Heat Exp. (q-2)	0.0001	0.0000	0.0010***	0.0003	0.0001	0.0010*
	(0.0003)	(0.0004)	(0.0003)	(0.0002)	(0.0003)	(0.0006)
Heat Exp. (q-3)	0.0003	0.0005	0.0003	-0.0001	0.0005	0.0002
	(0.0004)	(0.0006)	(0.0004)	(0.0003)	(0.0005)	(0.0004)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
$\sum$ Heat Exposure	0.0011	0.0006	0.0023**	0.0003	0.0008	0.0016
Joint P-Value	(0.28)	(0.64)	(0.03)	(0.71)	(0.31)	(0.17)
R-Squared	0.9190	0.9369	0.9119	0.9190	0.9370	0.9119
Mean Dep. Variable	7.44	6.06	5.86	7.44	6.06	5.86
Number of Observations	532,598	532,598	291,870	532,598	532,598	291,870
Number of Firms	12,991	12,991	7,511	12,991	12,991	7,511
Number of Countries	92	92	92	92	92	92

Table 4: Heat Exposure and Firm Performance – Geographic Sales-Assets-Separation

Notes. This table reports the effects of high temperatures on revenues as percentage of assets (Revenues/Assets, columns 1 to 4) and operating income as percentage of total assets (Op. Income/Assets, columns 5 to 8) in interaction with indicators of revenue earned abroad. Reported are the sum of coefficients on the four quarterly heat exposures (q, q-3) along with standard errors. In columns 1, 2, 5 and 6 heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (Heat Exp.> 30°C). In columns 3, 4, 7 and 8, heat exposure is the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days (Heat Exp. > 30°C. & 90^{th} Pct). #1 Revenue Abroad indicates that the firm's top-ranked revenue country is not the country of headquarters. The indicator <30% Domestic sales is a dummy variable which indicates that less than 30% is sales is earned in the firm's home country. Test Difference indicates the joint significance of the coefficients on heat exposure and the interaction variable. All specifications additionally include firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°(Cold Day Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Revenues/Assets				Op. Income/Assets			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\sum$ Heat Exp. >30° C	-0.0079*	-0.0020			-0.0026***	-0.0013***		
	(0.0041)	(0.0030)			(0.0006)	(0.0005)		
$\sum$ Heat Exp. >30° C & 90^th Pctl			-0.0100**	-0.0053			-0.0024***	-0.0015***
			(0.0044)	(0.0034)			(0.0006)	(0.0005)
$\sum$ Heat Exp. >30° C × #1 Revenue Abroad	0.0096**				0.0024***			
	(0.0045)				(0.0009)			
$\sum$ Heat Exp. >30° C × <30% Domestic Sales		-0.0053				0.0003		
		(0.0063)				(0.0011)		
$\sum$ Heat Exp. >30° C & 90^th Pctl × #1 Revenue Abroad			0.0076*				0.0015*	
			(0.0042)				(0.0009)	
$\sum$ Heat Exp. >30° C & 90^th Pctl × <30% Domestic Sales				-0.0031				-0.0003
				(0.0044)				(0.0008)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test Difference (p-Value)	(0.63)	(0.21)	(0.54)	(0.13)	(0.71)	(0.39)	(0.14)	(0.07)
R-Squared	0.7489	0.7488	0.7489	0.7489	0.5676	0.5676	0.5676	0.5676
Mean Dep. Variable	24.49	24.49	24.49	24.49	2.18	2.18	2.18	2.18
Number of Observations	588,974	588,974	588,974	588,974	588,974	588,974	588,974	588,974
Number of Firms	13,521	13,521	13,521	13,521	13,521	13,521	13,521	13,521
Number of Countries	92	92	92	92	92	92	92	92

Table 5: Heat Exposure and Firm Heterogeneity

Notes. This table reports the effects of heat exposure on revenues as percentage of assets and operating income as percentage of total assets in interaction with, respectively, the firm-level average share of labor expenses relative to total expenses, the average wage per employee, the ratio of labor to total expenses lagged by one year, the percentage of time spent outdoors by industry, an indicator of heat sensitive industries derived from the Occupational Safety & Health Administration (OSHA, a dummy variable indicating firms from agricultural industries, and a dummy variable that identifies utilities firms. Reported are the sum of coefficients on the four quarterly heat exposures (q, q-3), and their interaction effects. Heat exposure is measured by the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days (Heat exp. > 30°C. & 90^{th} Pct). For indicator variables, the joint significance of the coefficient on heat exposure and the interaction variable are shown below the table (*Joint P-Value*). All specifications additionally include firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C (Cold Day Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Revenues/Assets							Op. Income/Assets						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
∑ Heat Exp. >30° C & 90^th Pctl	-0.0026	-0.0222***	-0.0029	-0.0056	-0.0055	-0.0064*	-0.0059*	-0.0000	-0.0033***	-0.0013	-0.0013***	-0.0016***	-0.0016***	-0.0016***
	(0.0049)	(0.0060)	(0.0091)	(0.0037)	(0.0034)	(0.0035)	(0.0034)	(0.0008)	(0.0010)	(0.0009)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Labor/Total Expenses $_{it}$	-0.0031							-0.0000						
	(0.0033)							(0.0002)						
∑ Heat Exp. >30° C & 90^th Pctl × Labor/Total Expenses $_{it}$	-0.0002*							-0.0000***						
	(0.0001)							(0.0000)						
∑ Heat Exp. >30° C & 90^th Pctl × Wages/Employees		0.0008***							0.0000					
		(0.0002)							(0.0001)					
∑ Heat Exp. >30° C & 90^th Pctl × Pct Outdoors			-0.0178							-0.0023				
			(0.0372)							(0.0040)				
∑ Heat Exp. >30° C & 90^th Pctl × OSHA Definition				-0.0016							-0.0012*			
				(0.0055)							(0.0007)			
∑ Heat Exp. >30° C & 90^th Pctl × Food					-0.0112							0.0042		
					(0.0232)							(0.0026)		
∑ Heat Exp. >30° C & 90^th Pctl × Agriculture					-0.0083							-0.0029		
					(0.0093)							(0.0019)		
∑ Heat Exp. >30° C & 90^th Pctl × Utilities						0.0194							0.0001	
						(0.0144)							(0.0014)	
∑ Heat Exp. >30° C & 90^th Pctl × Scandinavia							0.1285							0.0684
							(0.1104)							(0.0552)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Joint P-Value				(0.16)		(0.35)	(0.26)				(0.00)		(0.28)	(0.23)
R-Squared	0.7855	0.8180	0.7647	0.7512	0.7512	0.7512	0.7512	0.6441	0.6744	0.5955	0.5782	0.5782	0.5782	0.5782
Mean Dep. Variable	24.23	24.23	24.23	24.23	24.23	24.23	24.23	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Number of Observations	295,750	161,610	322,619	599,347	599,347	599,347	599,347	295,750	161,610	322,619	599,347	599,347	599,347	599,347
Number of Firms	7,672	3,861	7,929	14,768	14,768	14,768	14,768	7,672	3,861	7,929	14,768	14,768	14,768	14,768
Number of Countries	90	87	85	93	93	93	93	90	87	85	93	93	93	93

Table 6: Heat Exposure and Analyst Forecast Errors — Formal Comparison

Notes. This table compares the effect of heat exposure on firms' revenue and income over assets based on the sample of firms that receive analyst forecasts with the effects of heat exposure on errors in analyst forecasts. The forecast error in columns 3-4 is the difference between the actual revenue and the mean forecast revenue from IBES, scaled by lagged total assets. In columns 1 and 3 (2 and 4), heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (30°C and $> 90^{th}$ percentile of place- and time-specific temperature distribution). For each of lags of $Heat\ Exposure$, the effect on revenues (income) over assets is compared with their effect on forecast errors (Actual - Surprise) together with a test of the significance of the difference (p-Value) The separate panels show the results for revenue and pre-tax income forecasts as indicated by the table headers. All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends, and a control for the number of days when temperatures were below 0°C (Cold Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Revenues/Assets			
	Actual Effect		Mean Surprise	
	30°C	30°C/90$^{\text{th}}$P	30°C	30°C/90$^{\text{th}}$P
	(1)	(2)	(3)	(4)
Heat Exp. [q]	0.0048	0.0007	0.0015	0.0002
	(0.0140)	(0.0133)	(0.0034)	(0.0026)
Actual − Surprise			0.0033	0.0005
p-Value			.802	.9656
Heat Exp. [q-1]	0.0055	0.0006	0.0014	0.0005
	(0.0094)	(0.0096)	(0.0016)	(0.0020)
Actual − Surprise			0.0045	0.0005
p-Value			.6158	.9584
Heat Exp. [q-2]	-0.0074	-0.0124	-0.0052***	-0.0047**
	(0.0080)	(0.0090)	(0.0019)	(0.0020)
Actual − Surprise			-0.0020	-0.0077
p-Value			.7773	.3301
Heat Exp. [q-3]	0.0086	0.0010	0.0003	-0.0010
	(0.0060)	(0.0059)	(0.0023)	(0.0024)
Actual − Surprise			0.0082	0.0019
p-Value			.2481	.7662
R-Squared	0.8662	0.8662	0.2648	0.2648
Number of Observations	55,927	55,927	55,927	55,927
Number of Firms	1,122	1,122	1,122	1,122
Number of Countries	64	64	64	64
Mean Dependent Variable	26.1345	26.1345	-.162	-.162
Firm-Qtr FE	Yes	Yes	Yes	Yes
Ind-Year-Qtr FE	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes
Cold Controls	Yes	Yes	Yes	Yes

	Pre-Tax Income/Assets			
	Actual Effect		Mean Surprise	
	30°C	30°C/90$^{\text{th}}$P	30°C	30°C/90$^{\text{th}}$P
	(5)	(6)	(7)	(8)
Heat Exp. [q]	-0.0010	-0.0013	0.0006	-0.0002
	(0.0021)	(0.0029)	(0.0013)	(0.0013)
Actual − Surprise			-0.0016	-0.0011
p-Value			.4927	.6472
Heat Exp. [q-1]	-0.0014	-0.0011	-0.0008	-0.0005
	(0.0024)	(0.0027)	(0.0012)	(0.0013)
Actual − Surprise			-0.0005	-0.0005
p-Value			.8198	.842
Heat Exp. [q-2]	-0.0055**	-0.0033	-0.0022**	-0.0015*
	(0.0021)	(0.0025)	(0.0010)	(0.0009)
Actual − Surprise			-0.0036*	-0.0020
p-Value			.078	.4234
Heat Exp. [q-3]	-0.0038***	-0.0017	0.0015	0.0018**
	(0.0014)	(0.0011)	(0.0012)	(0.0009)
Actual − Surprise			-0.0053***	-0.0035***
p-Value			.0004	.0028
R-Squared	0.7144	0.7143	0.2995	0.2995
Number of Observations	40,590	40,590	40,590	40,590
Number of Firms	737	737	737	737
Number of Countries	52	52	52	52
Mean Dependent Variable	3.4463	3.4463	-.1573	-.1573
Firm-Qtr FE	Yes	Yes	Yes	Yes
Ind-Year-Qtr FE	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes
Cold Controls	Yes	Yes	Yes	Yes

Table 7: Heat Exposure and Earnings Announcement Returns

Notes. This table reports the effects of high temperatures on quarterly earnings announcement returns. In Panel A, the first (last) four columns pertain to cumulative stock returns (abnormal returns relative to the market model using equal weighted returns as the market portfolio) over 11 days surrounding the earnings announcement date [-5,+5 days]. In Panel B, the first (last) four columns pertain to abnormal returns relative to the three (four) factor model using Fama-French factor returns for developed markets excluding the United States over 11 days surrounding the earnings announcement date [-5,+5 days]. In results columns 1, 2, 5, and 6 heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (Days > 30 d.C. p.q). In columns 3, 4, 7, and 8, heat exposure is the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days (Days > 30 d.C. & 90 Pct. p.q.). All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends. Columns 2, 4, 6 and 8 additionally control for the number of days when temperatures were below 0°C (Cold Day Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Return, [t-5,t+5]				Return MM/EW [t-5,t+5]			
	(30° C)		(30°C/90^thP)		(30° C)		(30°C/90^thP)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Heat Exp. (q)	-0.0259***	-0.0241***	-0.0162**	-0.0141*	-0.0097	-0.0078	-0.0029	-0.0008
	(0.0078)	(0.0084)	(0.0069)	(0.0079)	(0.0106)	(0.0103)	(0.0046)	(0.0055)
Heat Exp. (q-1)	0.0059	0.0045	0.0095	0.0086	-0.0020	-0.0028	-0.0024	-0.0028
	(0.0108)	(0.0104)	(0.0093)	(0.0101)	(0.0109)	(0.0106)	(0.0062)	(0.0072)
Heat Exp. (q-2)	-0.0331**	-0.0358**	-0.0259	-0.0277*	-0.0345*	-0.0361*	-0.0296	-0.0306
	(0.0161)	(0.0152)	(0.0159)	(0.0151)	(0.0204)	(0.0204)	(0.0196)	(0.0194)
Heat Exp. (q-3)	0.0019	0.0008	-0.0107	-0.0109	0.0151	0.0144	0.0044	0.0042
	(0.0157)	(0.0157)	(0.0124)	(0.0126)	(0.0136)	(0.0132)	(0.0121)	(0.0120)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	No	Yes	No	Yes	No	Yes	No	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2474	0.2524	0.2473	0.2523	0.2447	0.2468	0.2446	0.2467
Mean Dep. Variable	-0.40	-0.40	-0.40	-0.40	-0.10	-0.10	-0.10	-0.10
Number of Observations	40,209	40,209	40,209	40,209	40,209	40,209	40,209	40,209
Number of Firms	1,382	1,382	1,382	1,382	1,382	1,382	1,382	1,382
Number of Countries	64	64	64	64	64	64	64	64

A Appendix

Figure A2: Construction of the Analyst Forecast & Announcement Returns Test

Notes: This figure shows how we match temperatures, firm performance, as well as analyst forecast errors and announcement returns. In all tests, the measure *Heat Exposure* is the number of days on which temperatures exceed a certain threshold in a given quarterly fiscal period t, labeled *Affected Fiscal Period*. The earnings of the respective fiscal period are announced with a lag, so that every *Affected Fiscal Period* is associated with a subsequent *Announcement Date* in the future. The maximum length of these lags differs by jurisdictions, the exact timing of earnings announcements is hence firm- and time-specific. To correctly match all components, we calculate earnings surprises and announcement returns for the announcement date, and match this information with the heat exposure over the associated preceding fiscal period. The time window available to analysts and investor to adjust their expectations depends on how quickly the effects of heat on firms' financial performance materialize. If there is an instant effect of temperatures in t on firm performance in t, analysts and investors have the opportunity to update forecasts in the time between the end of the fiscal period and the announcement date (*Adjustment Time* (a)). Even in this most extreme case, temperatures are realized and publicly available to analysts and investors. If there is a longer lag between temperatures and consequences for firm performance, the window widens and investors have more time to acquire information on heat. For instance, if temperatures in $t-1$ affect firm performance in t, the adjustment time window grows to *Adjustment Time* (b). If temperatures in $t-2$ affect firm performance in t, the adjustment time window grows to *Adjustment Time* (c).

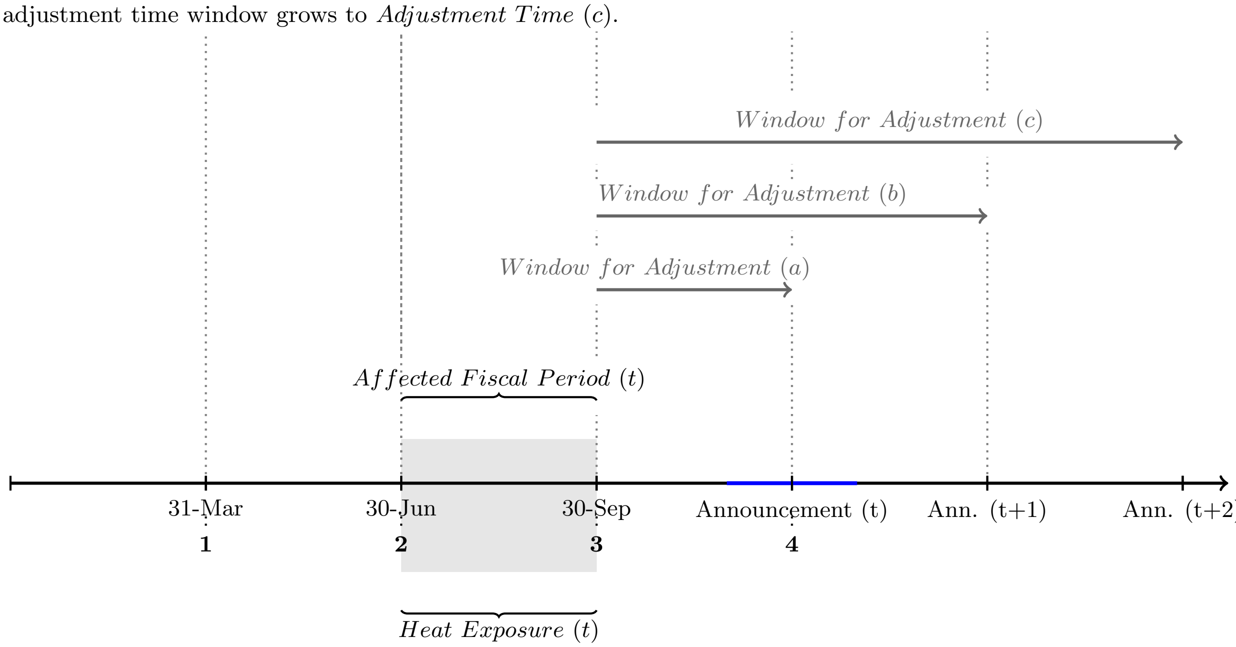
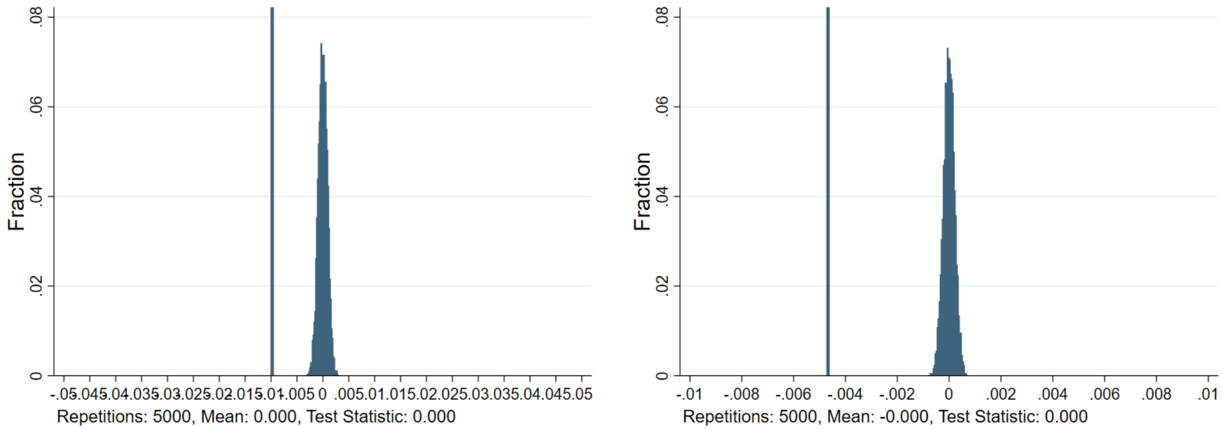
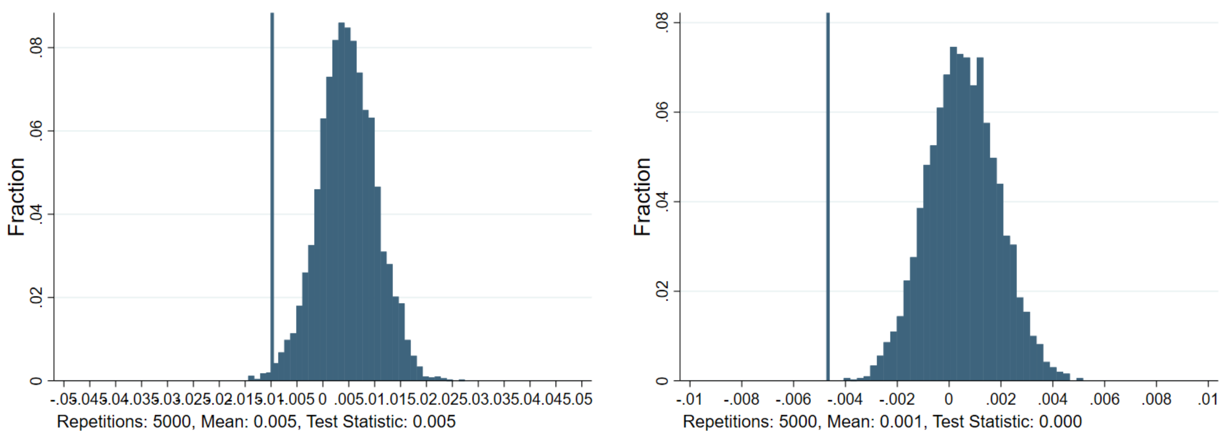


Figure A1: Temperatures and Firm Performance — Permutation Test

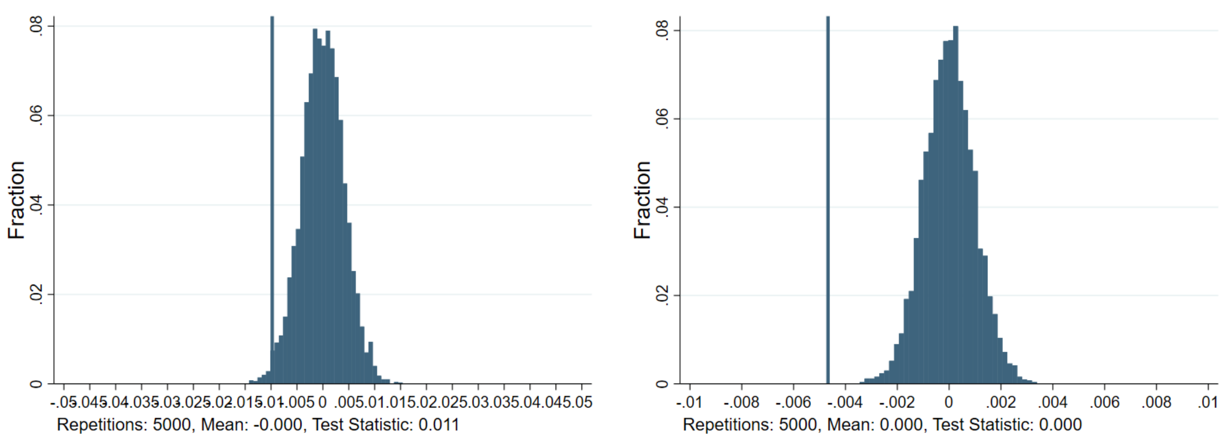
Notes. As a falsification test, this figure reports the distribution of point estimates of the effect of heat on revenues and operating income by re-estimating equation 1 on randomized placebo datasets. Each histogram shows the distribution of the effects on revenues (left) and operating income (right) for one of three different randomization schemes (panels), in which we re-assign heat exposure unconditionally (a), between firms (b), and within firms over time (3). Based on this re-assignment, we re-estimate Equation 1 5,000 times. The actual coefficient estimates are shown as blue vertical lines. P-values ('Test Statistic') are calculated as the fraction of coefficients from randomized regressions which exceed the actual estimate.



(a) Random Reassignment of Heat Exposure



(b) Random Reassignment of Heat Exposure Between Firms



(c) Random Reassignment of Heat Exposure Within Firms

Figure A3: Temperatures and Firm Performance — Bin Specification

Notes. This figure reports the effects of temperature bins on quarterly revenues as percentage of one-year lagged assets (Revenues/Assets, left) and operating income as percentage of lagged assets (Op. Income/Assets, right). Each temperature bin variable represents a temperature range and counts the number of days on which a firm experienced a temperature within that range. As the baseline, the temperature bin of 20 to 25°C is omitted. Coefficients on the temperature bin variables are presented along with 90 and 95% confidence intervals. All specifications include firm-financial quarter fixed effects, industry-year fixed effects, controls for cold days, and country linear trends.

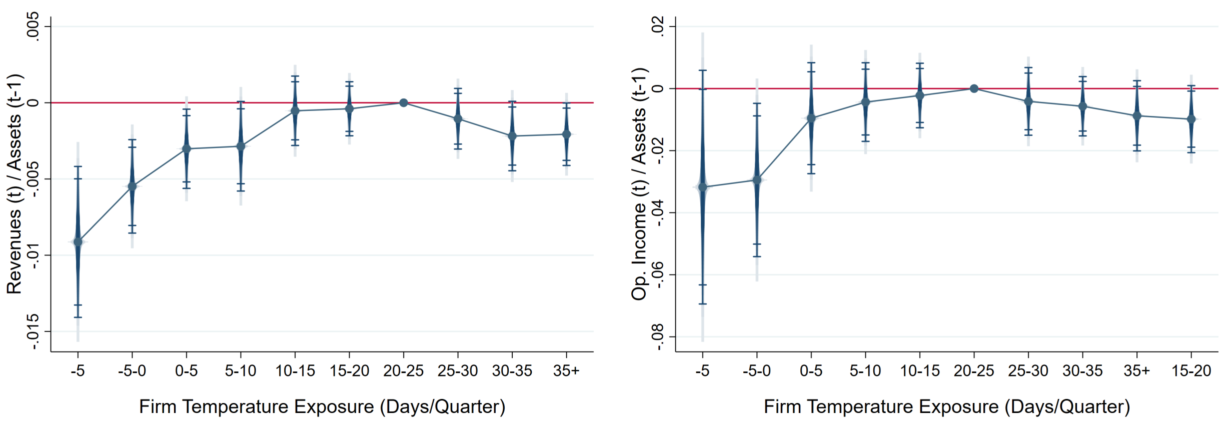
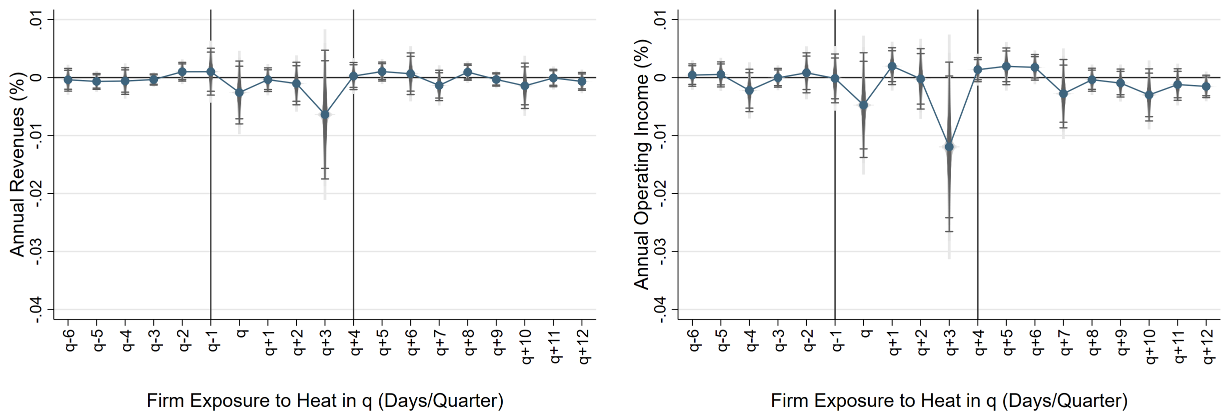


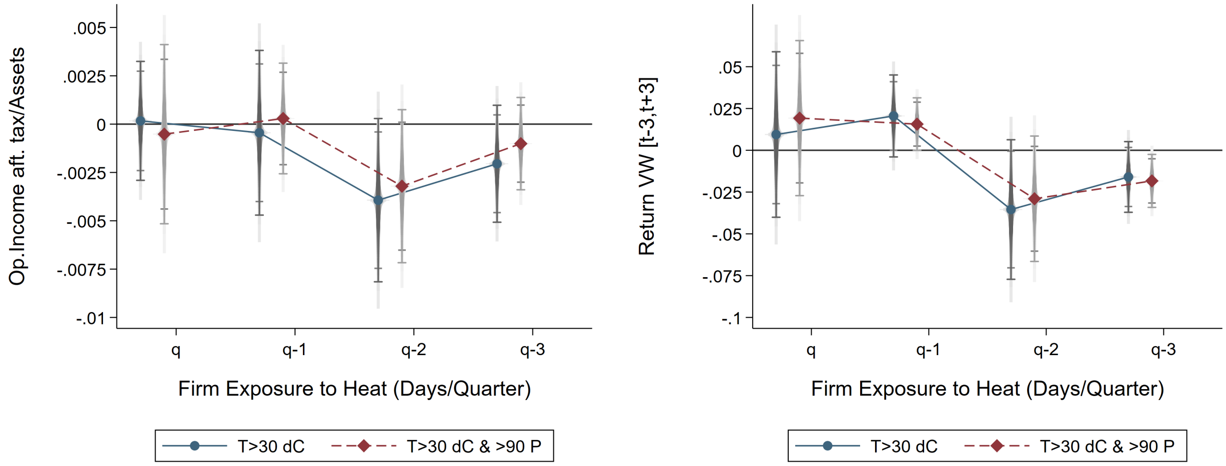
Figure A4: Temperatures and Firm Performance — Lags

Notes. This figure reports the effects of heat exposure on annual revenues and operating income in percent. The effects are estimated based on equation 1 and 2 but augmented with lags to encompass one financial year before, and two financial years after firms' exposure to heat. Standard errors are clustered two-way at the country and year-quarter level. Coefficients on the effects of (lagged heat exposure) are presented along with 90 and 95% confidence intervals. All specifications include firm-financial quarter fixed effects, industry-year fixed effects, controls for cold days, and country linear trends.

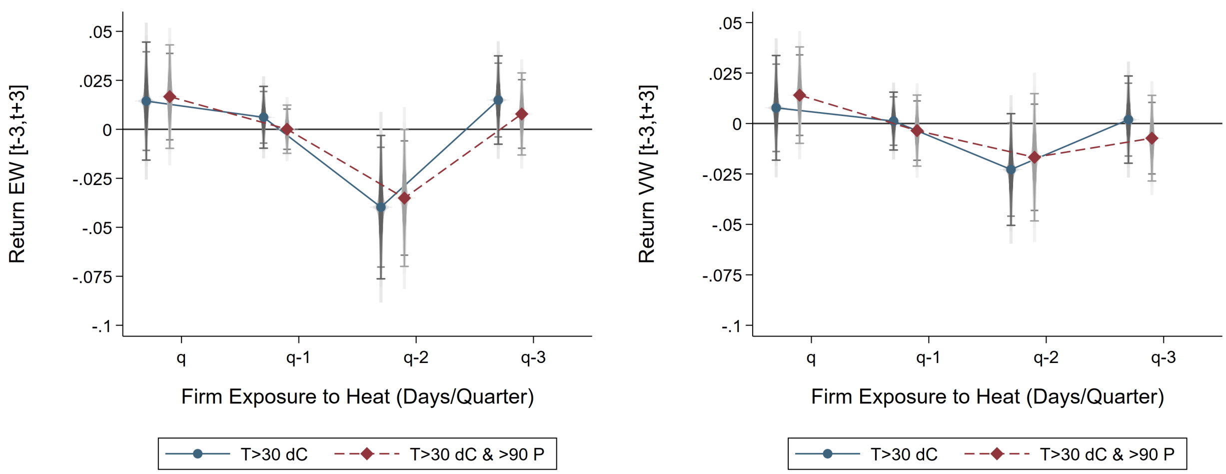


(a) Number of Days Above 30°C

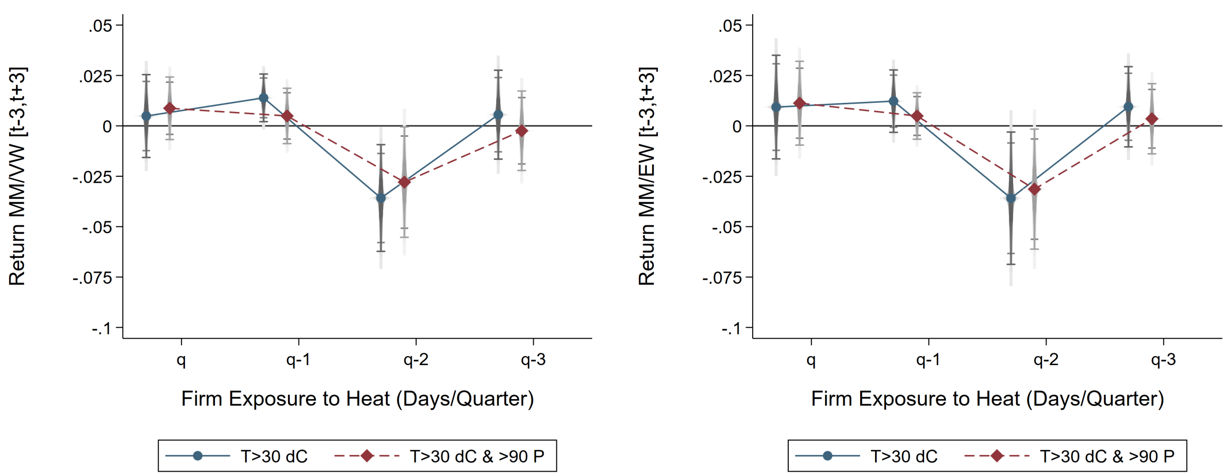
Figure A6: Heat Exposure and Announcement Returns — Additional Specifications



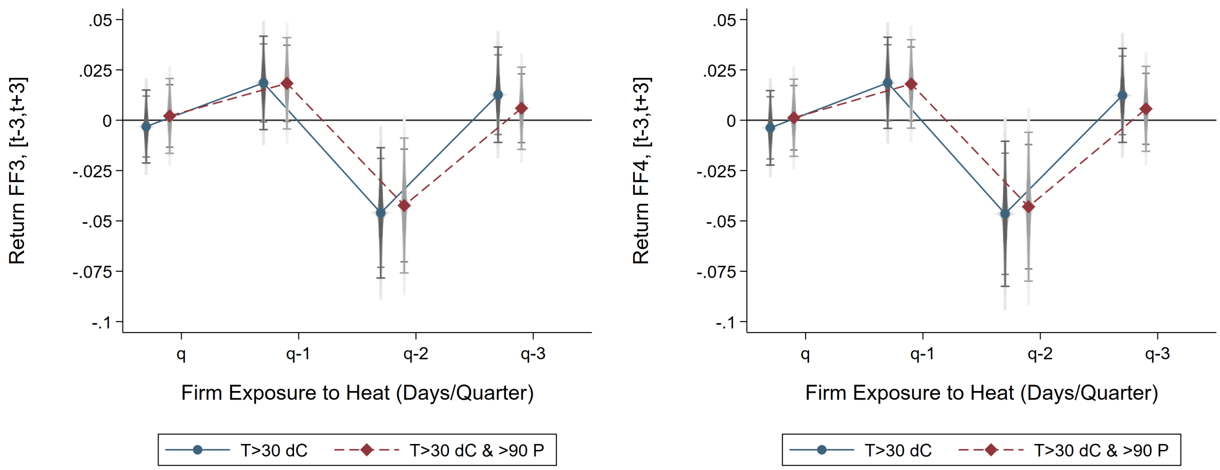
(a) Effects on Operating Income and Alternative Exchange Rate Conversion



(b) Effects on Abnormal Returns over Equal Weighted-, and Value Weighted Benchmark



(c) Effects on Abnormal Returns over Market Model Using Equal Weighted- and Value Weighted Benchmark



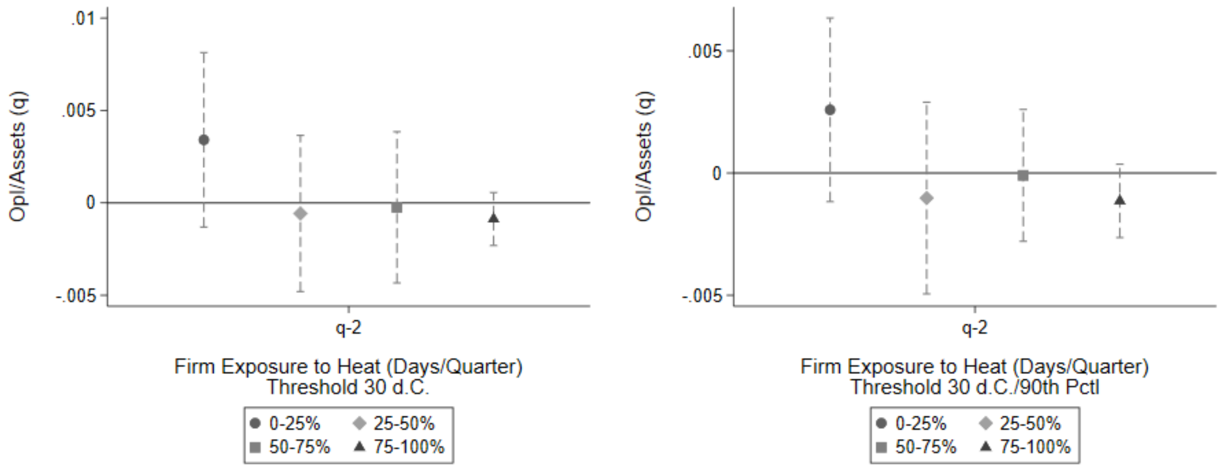
(d) Effects on Abnormal Returns over 3-Factor, and 4-Factor Returns

Notes. This figure reports additional tests related to the effects of heat exposure on announcement returns. In Panel A, the figure shows the effects of heat exposure on operating income over assets for the subsample of firms with information on earnings announcement returns available (left). Further, Panel A shows the 7-day return relative to the return on a value-weighted (VW) benchmark but after converting stock prices using the contemporaneous exchange rate. Panel B shows the effects of heat on 7-day announcement return [-3,+3 days] relative to the return on an equal-weighted (EW) and value-weighted (VW) benchmark composed of all stocks in the sample. Panel C shows 7-day abnormal returns [-3, +3] derived from estimating firms' equity betas in market models (MM, using EW and VW as market portfolio) of their stock returns. Panel D shows 7-day announcement returns using 3-factor and 4-factor models. Market and factor models of returns are estimated based on a maximum of 365 daily returns, ending 46 days before the announcement date. Stock returns are from Compustat Global Security Daily, converted to U.S. dollars with the exchange rate lagged by one year, and trimmed at the 1^{st} and 99^{th} percentiles. Heat exposure indicated by T > 30 dC is measured by the number of days in a financial quarter on which temperatures exceeded 30°C. Heat exposure indicated by T > 30 dC & >90P is the number of days on which temperatures exceeded not only 30°C but also the 90^{th} percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days. Reported are coefficients on heat exposures up to three lagged quarterly exposures (q, q-3). Two-way standard errors are clustered at the country and year-quarter level. 90% and 95% confidence intervals are indicated by small bars.

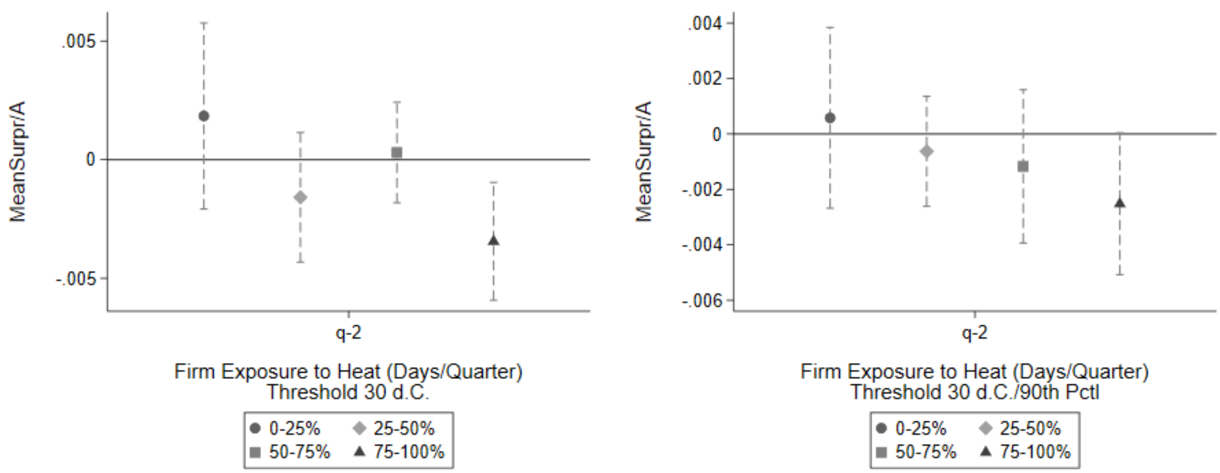
Figure A5: Sensitivity of the Results to Different Asset Concentration Thresholds

Notes. Reported are the estimated effects of heat exposure on operating income scaled by one-year lagged assets (equation 2), on errors in analysts' forecasts of pre-tax income (equation 3), and on 5-day earnings announcement returns (equation 4), after restricting the sample to firms that are within a specific range regarding percentage of domestic asset concentration: : 0-25%, 25-50%, 50-75% and 75-100%.

(a) Firm Performance — Operating Income/Assets



(b) Analyst Forecast Errors — Pre-Tax Income



(c) Earnings Announcement Returns — 5-Day Cumulative Returns

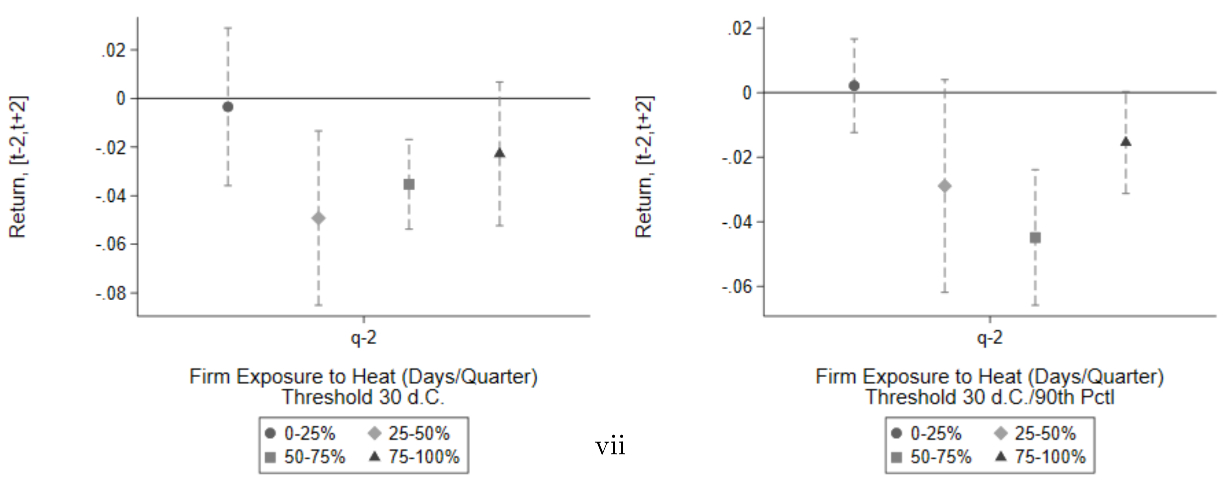


Table A1: Robustness: Heat Exposure and Firm Performance — Fixed Effects

Notes. This table reports the effects of high temperatures on quarterly revenues as percentage of assets (Revenues/Assets, columns 1 to 4) and operating income as percentage of total assets (Op. Income/Assets, columns 5 to 8); see specifications (1) and (2) in Section 3. Panel (a) [(b)] shows the effects for temperatures exceeding 30°C (Days > 30 d.C. p.q and >90^{th} percentile of the time- and location-specific distribution of temperatures). All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3). FE refers to firm fixed effects. Firm-Qtr FE indicates firm-financial quarter fixed effects. Ind-Year FE indicates industry-year fixed effects. Continent-Year-Qtr FE indicates continent-year-quarter fixed effects. Cold Days Controls indicates the number of days when temperatures were below 0°C. In addition, the sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Columns 4 and 8 also include country linear trends. Two-way standard errors in parentheses are clustered at the country and year-quarter level. Asterisks indicate significance * at 10% level, ** at 5% level, *** at 1% level.

	Revenues/Assets				Op. Income/Assets			
	30° C		30° C/90^{th}P		30° C		30° C/90^{th}P	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Heat Exp. (q)	-0.0115	-0.0025	0.0018	-0.0004	-0.0059	-0.0016	-0.0021	-0.0005
	(0.0075)	(0.0067)	(0.0069)	(0.0050)	(0.0038)	(0.0013)	(0.0017)	(0.0011)
Heat Exp. (q-1)	0.0073	-0.0114	-0.0077	-0.0089	-0.0010	-0.0041***	-0.0030**	-0.0030***
	(0.0108)	(0.0086)	(0.0065)	(0.0063)	(0.0021)	(0.0012)	(0.0015)	(0.0011)
Heat Exp. (q-2)	-0.0159*	-0.0065	-0.0038	-0.0046	-0.0050**	-0.0020	-0.0030	-0.0011
	(0.0086)	(0.0059)	(0.0049)	(0.0032)	(0.0021)	(0.0014)	(0.0021)	(0.0011)
Heat Exp. (q-3)	0.0034	-0.0000	0.0041	0.0015	0.0026	-0.0015*	-0.0006	-0.0006
	(0.0065)	(0.0038)	(0.0050)	(0.0033)	(0.0026)	(0.0008)	(0.0011)	(0.0008)
Firm FE	Yes	No	No	No	Yes	No	No	No
Firm-Qtr FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent-Year-Qtr FE	No	No	Yes	No	No	No	Yes	No
Cold Days Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	No	No	No	Yes	No	No	No	Yes
$\sum$ Heat Exposure	-0.0167	-0.0205	-0.0057	-0.0123	-0.0093***	-0.0092***	-0.0087**	-0.0051**
Joint P-Value	(0.46)	(0.28)	(0.74)	(0.25)	(0.00)	(0.00)	(0.02)	(0.01)
R-Squared	0.7171	0.7485	0.7516	0.7512	0.5024	0.5755	0.5798	0.5782
Number of Observations	599,347	599,347	599,328	599,347	599,347	599,347	599,328	599,347

(a) Number of Days Above 30°C

	Revenues/Assets				Op. Income/Assets			
	30° C		30° C/90^{th}P		30° C		30° C/90^{th}P	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Heat Exp. (q)	-0.0013	-0.0050	-0.0013	-0.0027	-0.0042	-0.0023**	-0.0026**	-0.0013*
	(0.0087)	(0.0064)	(0.0063)	(0.0039)	(0.0040)	(0.0010)	(0.0013)	(0.0007)
Heat Exp. (q-1)	0.0128	-0.0127	-0.0096	-0.0102	-0.0035**	-0.0036***	-0.0028**	-0.0028**
	(0.0111)	(0.0094)	(0.0072)	(0.0080)	(0.0017)	(0.0010)	(0.0011)	(0.0011)
Heat Exp. (q-2)	-0.0229**	-0.0081	-0.0061	-0.0071**	-0.0043***	-0.0023*	-0.0037*	-0.0016
	(0.0091)	(0.0053)	(0.0038)	(0.0033)	(0.0015)	(0.0013)	(0.0019)	(0.0011)
Heat Exp. (q-3)	-0.0163**	-0.0038	-0.0015	-0.0027	0.0029	-0.0012*	-0.0007	-0.0004
	(0.0064)	(0.0046)	(0.0046)	(0.0038)	(0.0027)	(0.0007)	(0.0009)	(0.0007)
Firm FE	Yes	No	No	No	Yes	No	No	No
Firm-Qtr FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent-Year-Qtr FE	No	No	Yes	No	No	No	Yes	No
Cold Days Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	No	No	No	Yes	No	No	No	Yes
$\sum$ Heat Exposure	-0.0277	-0.0296	-0.0185	-0.0227*	-0.0091***	-0.0095***	-0.0099***	-0.0061***
Joint P-Value	(0.23)	(0.14)	(0.28)	(0.09)	(0.00)	(0.00)	(0.00)	(0.00)
R-Squared	0.7172	0.7485	0.7516	0.7512	0.5019	0.5756	0.5798	0.5782
Number of Observations	599,347	599,347	599,328	599,347	599,347	599,347	599,328	599,347

(b) Number of Days Above 30°C and the 90^{th} Percentile

Table A2: Robustness Test – Conley HAC Standard Errors

Notes. This table reports the effects of high temperatures on quarterly revenues as percentage of assets (Revenues/Assets, columns 1 and 2) and operating income as percentage of total assets (Op. Income/Assets, columns 3 and 4); see specifications (1) and (2) in Section 3. Panel (a) [(b)] shows the effects for temperatures exceeding 30°C (Days > 30 d.C. p.q and >90^{th} percentile of the time- and location-specific distribution of temperatures). All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3). The number of observations refers to firm-quarters. For comparison, we report two sets of standard errors below coefficient estimates. The first is calculated using two-way clusters at the firm and year-quarter level. The second uses standard errors adjusted for spatial correlation, following the method of Conley (1999). Asterisks indicate significance * at 10% level, ** at 5% level, *** at 1% level.

	Revenues/Assets		Operating Income/Assets	
	(1)	(2)	(3)	(4)
Heat Exp. (q)	-0.0005		-0.0004	
	(0.0048)		(0.0010)	
Heat Exp. (q-1)	-0.0087		-0.0030***	
	(0.0065)		(0.0011)	
Heat Exp. (q-2)	-0.0031		-0.0008	
	(0.0035)		(0.0011)	
Heat Exp. (q-3)	0.0025		-0.0004	
	(0.0036)		(0.0008)	
Heat Exp. (q) [Conley]		-0.0005		-0.0004
		(0.0044)		(0.0011)
Heat Exp. (q-1) [Conley]		-0.0087		-0.0030**
		(0.0054)		(0.0013)
Heat Exp. (q-2) [Conley]		-0.0031		-0.0008
		(0.0043)		(0.0010)
Heat Exp. (q-3) [Conley]		0.0025		-0.0004
		(0.0045)		(0.0011)
R-Squared	0.7511	0.0000	0.5780	0.0001
Number of Observations	599,347	599,347	599,347	599,347

(a) Days with Temperatures > 30°C

	Revenues/Assets		Operating Income/Assets	
	(1)	(2)	(3)	(4)
Heat Exp. (q)	-0.0031		-0.0013**	
	(0.0035)		(0.0006)	
Heat Exp. (q-1)	-0.0104		-0.0028***	
	(0.0082)		(0.0011)	
Heat Exp. (q-2)	-0.0061**		-0.0014	
	(0.0030)		(0.0011)	
Heat Exp. (q-3)	-0.0022		-0.0004	
	(0.0037)		(0.0007)	
Heat Exp. (q) [Conley]		-0.0031		-0.0013
		(0.0037)		(0.0009)
Heat Exp. (q-1) [Conley]		-0.0104**		-0.0028***
		(0.0046)		(0.0011)
Heat Exp. (q-2) [Conley]		-0.0062		-0.0014*
		(0.0038)		(0.0009)
Heat Exp. (q-3) [Conley]		-0.0022		-0.0004
		(0.0041)		(0.0009)
R-Squared	0.7511	0.0001	0.5781	0.0001
Number of Observations	599,347	599,347	599,347	599,347

(b) Days with Temperatures > 30°C and Above 90^{th} Percentile

Table A3: Robustness: Heat Exposure and Firm Performance — Financial Crisis

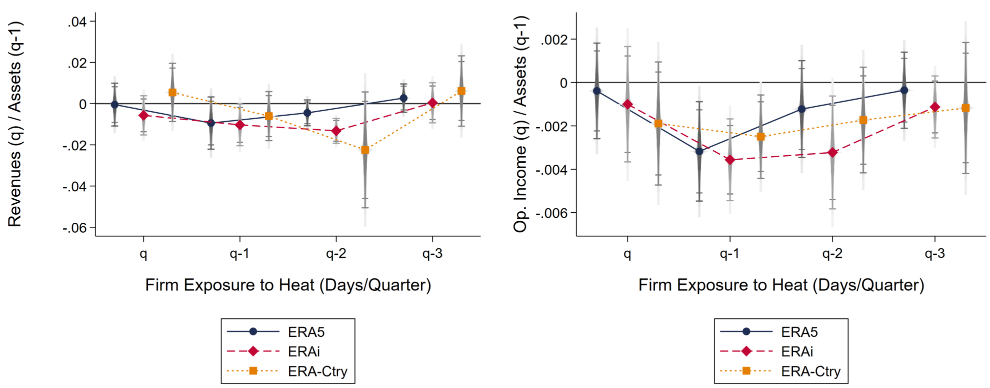
Notes. This table reports the effects of high temperatures on quarterly revenues as percentage of assets (Revenues/Assets, results columns 1 to 3) and operating income as percentage of total assets (Op. Income/Assets, columns 4 to 6) after excluding years of the financial crisis. Columns 1 and 4 refer to full-sample results, columns 2 and 5 report results after dropping years 2008 and 2009, columns 3 and 6 report results after omitting the period 2008-2010. Heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (Days > 30 d.C. p.q). All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C (Cold Day Controls). In addition, the sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Rev (t)/Assets (t-1)			OpI (t)/Assets (t-1)		
	Full Sample	Excl. 2008-09	Excl. 2008-10	Full Sample	Excl. 2008-09	Excl. 2008-10
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	-0.0004	-0.0016	-0.0023	-0.0005	-0.0011	-0.0018**
	(0.0050)	(0.0054)	(0.0061)	(0.0011)	(0.0010)	(0.0007)
Heat Exp. (q-1)	-0.0089	-0.0116*	-0.0113	-0.0030***	-0.0040***	-0.0029***
	(0.0063)	(0.0066)	(0.0069)	(0.0011)	(0.0011)	(0.0011)
Heat Exp. (q-2)	-0.0046	-0.0055	-0.0046	-0.0011	-0.0018*	-0.0032***
	(0.0032)	(0.0037)	(0.0036)	(0.0011)	(0.0010)	(0.0010)
Heat Exp. (q-3)	0.0015	0.0016	-0.0046	-0.0006	-0.0008	-0.0010
	(0.0033)	(0.0038)	(0.0028)	(0.0008)	(0.0007)	(0.0007)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
$\sum$ Heat Exposure	-0.0123	-0.0170	-0.0228	-0.0051**	-0.0077***	-0.0088***
Joint P-Value	(0.25)	(0.16)	(0.13)	(0.01)	(0.00)	(0.00)
R-Squared	0.7512	0.7598	0.7638	0.5782	0.5920	0.5985
Number of Observations	599,347	536,361	499,093	599,347	536,361	499,093
Number of Firms	14,783	13,368	12,542	14,783	13,368	12,542
Number of Countries	93	93	93	93	93	93

Table A4: Robustness: Heat Exposure and Firm Performance — Temperature Data

Notes. This table reports effects of high temperatures on quarterly revenues as a percentage of one-year lagged assets (Revenue/Assets), and on operating income as a percentage of lagged assets (Op. Income/Assets). To measure firms' heat exposure, we match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. Heat exposure is measured by the number of days in a financial quarter on which temperatures exceed 30°C. We obtain data on temperatures from the datasets ERA5 and ERA-Interim (ERAi), and calculate country-level average of temperatures from ERA5 in the firm's country of headquarters (ERA-Ctry). Specifications include heat exposure augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C. Panel (a) visualizes coefficients on quarterly heat exposures (q, q-3). 90 and 95% confidence intervals are indicated by small bars. The left (right) figure refers to effects of heat exposure on Revenues/Assets (Op. Income/Assets). Panel (b) tabulates effects of the quarterly heat exposures (q, q-3) on Revenue/Assets (columns 1-3) and Operating Income / Asset (columns 4-6). Columns 1 and 4 are based on ERA5, columns 2 and 5 are based on ERAi, columns 3 and 6 are based on ERA-Ctry. In addition, the sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

(a) Coefficient Plots



(b) Estimates

	Rev (t)/Assets (t-1)			OpI (t)/Assets (t-1)		
	ERA5	ERAi 9	ERA-Ctry	ERA5	ERAi 9	ERA-Ctry
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	-0.0005	-0.0057	0.0054	-0.0004	-0.0010	-0.0019
	(0.0052)	(0.0048)	(0.0071)	(0.0011)	(0.0013)	(0.0014)
Heat Exp. (q-1)	-0.0094	-0.0103**	-0.0061	-0.0032***	-0.0036***	-0.0025**
	(0.0064)	(0.0051)	(0.0060)	(0.0012)	(0.0009)	(0.0010)
Heat Exp. (q-2)	-0.0045	-0.0132***	-0.0225	-0.0012	-0.0032**	-0.0017
	(0.0032)	(0.0030)	(0.0141)	(0.0011)	(0.0013)	(0.0012)
Heat Exp. (q-3)	0.0027	0.0004	0.0061	-0.0004	-0.0011	-0.0012
	(0.0034)	(0.0049)	(0.0086)	(0.0009)	(0.0007)	(0.0015)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
$\sum$ Heat Exposure	-0.0117	-0.0288**	-0.0170	-0.0051**	-0.0089***	-0.0073**
Joint P-Value	(0.29)	(0.02)	(0.34)	(0.02)	(0.00)	(0.03)
R-Squared	0.7526	0.7526	0.7527	0.5811	0.5811	0.5812
Number of Observations	561,835	561,835	561,835	561,835	561,835	561,835
Number of Firms	13,811	13,811	13,811	13,811	13,811	13,811
Number of Countries	84	84	84	84	84	84

Table A5: Robustness: Heat Exposure and Firm Performance — Temperature Thresholds

Notes. This table reports the effects of high temperatures on quarterly revenues as percentage of assets (Revenues/Assets, columns 1 to 7) and operating income as percentage of total assets (Op. Income/Assets, columns 8 to 14); see specifications (1) and (2) in Section 3. Across column 1 to 7 (8 to 14) different measures of firm-level heat exposure are presented (the sum of coefficients on the four quarterly heat exposures (q, q-3)). Heat Exp. > 25°C (Heat Exp. > 30°C, Heat Exp. > 35°C,) indicates the number of days in a financial quarter on which temperatures exceeded 25°C (30°C, 35°C). Heat Exp. > 25°C & 90^{th} Pctl (Heat Exp. > 25°C & 95^{th} Pctl) indicates the number of days on which temperatures exceeded not only 25°C but also the 90^{th} (95^{th}) percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days. Heat Exp. > 30°C & 90^{th} Pctl (Heat Exp. > 30°C & 95^{th} Pctl) indicates the number of days on which temperatures exceeded not only 30°C but also the 90^{th} (95^{th}) percentile of the historic distribution of temperatures. All specifications include firm-financial quarter fixed effects, industry-year fixed effects, the number of days below 0°C (*Cold Days Control*), and country linear trends. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Revenues/Assets							Op. Income/Assets						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
$\sum$ Heat Exp. >25° C	-0.0019							-0.0011						
	(0.0059)							(0.0011)						
$\sum$ Heat Exp. >25° C & >90^th Pctl		-0.0051*							-0.0013***					
		(0.0028)							(0.0005)					
$\sum$ Heat Exp. >25° C & >95^th Pctl			-0.0041							-0.0016***				
			(0.0034)							(0.0005)				
$\sum$ Heat Exp. >30° C				-0.0032							-0.0013**			
				(0.0028)							(0.0005)			
$\sum$ Heat Exp. >30° C & >90^th Pctl					-0.0059*							-0.0016***		
					(0.0034)							(0.0005)		
$\sum$ Heat Exp. >30° C & >95^th Pctl						-0.0048							-0.0019***	
						(0.0038)							(0.0005)	
$\sum$ Heat Exp. >35° C							-0.0061							-0.0006
							(0.0055)							(0.0008)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.7512	0.7512	0.7512	0.7512	0.7512	0.7512	0.7512	0.5782	0.5782	0.5782	0.5782	0.5782	0.5782	0.5782
Number of Observations	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347	599,347
Number of Firms	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892	13,892
Number of Countries	93	93	93	93	93	93	93	93	93	93	93	93	93	93

Table A6: Heat Exposure and Firm Heterogeneity

Notes. This table reports the effects of heat exposure on revenues as percentage of assets and operating income as percentage of total assets in interaction with, respectively, the share of average labor expenses relative to total expenses, the average wage per employee, the percentage of time spent outdoors by industry, an indicator of heat sensitive industries derived from the Occupational Safety & Health Administration, a dummy variable indicating firms from agricultural industries, and a dummy variable that identifies utilities firms. Reported are the sum of coefficients on the four quarterly heat exposures (q, q-3), and their interaction effects. Heat exposure is measured by the number of days on which temperatures exceeded 30°C. For indicator variables, the joint significance of the coefficient on heat exposure and the interaction variable are shown below the table (*Joint P-Value*). All specifications additionally include firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C (Cold Day Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Revenues/Assets							Op. Income/Assets						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
$\sum$ Heat Exp. >30° C	0.0008	-0.0132*	0.0045	-0.0028	-0.0025	-0.0042	-0.0033	0.0004	-0.0018	-0.0012	-0.0012**	-0.0013***	-0.0014**	-0.0013**
	(0.0035)	(0.0075)	(0.0084)	(0.0031)	(0.0029)	(0.0028)	(0.0028)	(0.0008)	(0.0012)	(0.0011)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Labor/Total Expenses $_{it}$	-0.0026							-0.0001						
	(0.0026)							(0.0002)						
$\sum$ Heat Exp. >30° C × Labor/Total Expenses $_{it}$	-0.0001***							-0.0000***						
	(0.0000)							(0.0000)						
$\sum$ Heat Exp. >30° C × Wages/Employees		0.0002**							-0.0000					
		(0.0001)							(0.0000)					
$\sum$ Heat Exp. >30° C × Pct Outdoors			-0.0372							-0.0009				
			(0.0420)							(0.0047)				
$\sum$ Heat Exp. >30° C × OSHA Definition				-0.0024							-0.0009			
				(0.0074)							(0.0008)			
$\sum$ Heat Exp. >30° C × Food					-0.0286							0.0036		
					(0.0337)							(0.0025)		
$\sum$ Heat Exp. >30° C × Agriculture					-0.0044							-0.0062***		
					(0.0097)							(0.0024)		
$\sum$ Heat Exp. >30° C × Utilities						0.0278							0.0009	
						(0.0182)							(0.0017)	
$\sum$ Heat Exp. >30° C × Scandinavia							0.1264							0.0684
							(0.1120)							(0.0550)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Joint P-Value				(0.44)		(0.18)	(0.27)				(0.03)		(0.78)	(0.23)
R-Squared	0.7856	0.8179	0.7647	0.7512	0.7512	0.7512	0.7512	0.6441	0.6744	0.5955	0.5782	0.5782	0.5782	0.5782
Mean Dep. Variable	24.23	24.23	24.23	24.23	24.23	24.23	24.23	2.10	2.10	2.10	2.10	2.10	2.10	2.10
Number of Observations	295,750	161,610	322,619	599,347	599,347	599,347	599,347	295,750	161,610	322,619	599,347	599,347	599,347	599,347
Number of Firms	7,672	3,861	7,929	14,768	14,768	14,768	14,768	7,672	3,861	7,929	14,768	14,768	14,768	14,768
Number of Countries	90	87	85	93	93	93	93	90	87	85	93	93	93	93

Table A7: Robustness: Heat Exposure and Analyst Forecast Errors

Notes. This table reports robustness tests for the effects of high temperatures on errors in analyst forecasts of revenues and pre-tax income; see equation (3). The forecast error in columns 1-4 (5-8) is the difference between the actual revenue (pre-tax income) and the median forecast revenue from IBES, scaled by lagged total assets. In columns 1, 3, 5 and 7, heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C. In columns 2, 4, 6 and 8, heat exposure is the number of days on which temperatures exceeded not only 30 °C but also the 90^{th} percentile of the time- and place-specific historic distribution of temperatures. Panel (a) shows the effects on median instead of mean surprises, and Panel (b) shows the effects for surprises using lagged assets to scale the dependent variable. All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, and country linear trends. Columns 2, 4, 6 and 8 additionally control for the number of days when temperatures were below 0°C (Cold Day Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

(a) Median Forecasts

	Revenues/Assets				Pre-Tax Income/Assets			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Heat Exp. (q)	0.0019	0.0018	0.0004	0.0004	0.0003	0.0004	-0.0004	-0.0003
	(0.0033)	(0.0033)	(0.0026)	(0.0027)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
Heat Exp. (q-1)	0.0012	0.0011	0.0003	0.0002	-0.0008	-0.0009	-0.0004	-0.0005
	(0.0015)	(0.0015)	(0.0018)	(0.0019)	(0.0013)	(0.0012)	(0.0012)	(0.0013)
Heat Exp. (q-2)	-0.0048***	-0.0049***	-0.0042**	-0.0043**	-0.0022**	-0.0023**	-0.0016*	-0.0016*
	(0.0018)	(0.0017)	(0.0018)	(0.0019)	(0.0010)	(0.0010)	(0.0009)	(0.0009)
Heat Exp. (q-3)	0.0004	0.0005	-0.0010	-0.0010	0.0015	0.0014	0.0017**	0.0017**
	(0.0021)	(0.0021)	(0.0023)	(0.0023)	(0.0012)	(0.0012)	(0.0007)	(0.0008)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	No	Yes	No	Yes	No	Yes	No	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2650	0.2655	0.2650	0.2654	0.2977	0.2981	0.2977	0.2980
Mean Dep. Variable	-0.15	-0.15	-0.15	-0.15	-0.16	-0.16	-0.16	-0.16
Number of Observations	55,920	55,920	55,920	55,920	40,602	40,602	40,602	40,602
Number of Firms	1,125	1,125	1,125	1,125	737	737	737	737
Number of Countries	64	64	64	64	52	52	52	52

(b) Mean Forecasts of with Lagged Assets

	Revenues/Assets				Pre-Tax Income/Assets			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Heat Exp. (q)	0.0025	0.0025	0.0011	0.0012	-0.0009	-0.0009	-0.0013	-0.0012
	(0.0031)	(0.0030)	(0.0023)	(0.0024)	(0.0009)	(0.0010)	(0.0008)	(0.0009)
Heat Exp. (q-1)	-0.0013	-0.0013	-0.0010	-0.0009	-0.0002	-0.0003	-0.0002	-0.0002
	(0.0018)	(0.0019)	(0.0024)	(0.0025)	(0.0016)	(0.0015)	(0.0015)	(0.0015)
Heat Exp. (q-2)	-0.0051**	-0.0054**	-0.0050**	-0.0054**	-0.0018**	-0.0019**	-0.0018	-0.0019*
	(0.0023)	(0.0022)	(0.0024)	(0.0025)	(0.0007)	(0.0008)	(0.0011)	(0.0011)
Heat Exp. (q-3)	0.0003	0.0003	-0.0013	-0.0013	0.0027*	0.0027*	0.0023***	0.0023***
	(0.0026)	(0.0026)	(0.0020)	(0.0021)	(0.0015)	(0.0015)	(0.0006)	(0.0008)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	No	Yes	No	Yes	No	Yes	No	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.3028	0.3037	0.3028	0.3036	0.3396	0.3400	0.3396	0.3401
Mean Dep. Variable	-0.13	-0.13	-0.13	-0.13	-0.17	-0.17	-0.17	-0.17
Number of Observations	43,901	43,901	43,901	43,901	31,942	31,942	31,942	31,942
Number of Firms	843	843	843	843	555	555	555	555
Number of Countries	59	59	59	59	52	52	52	52

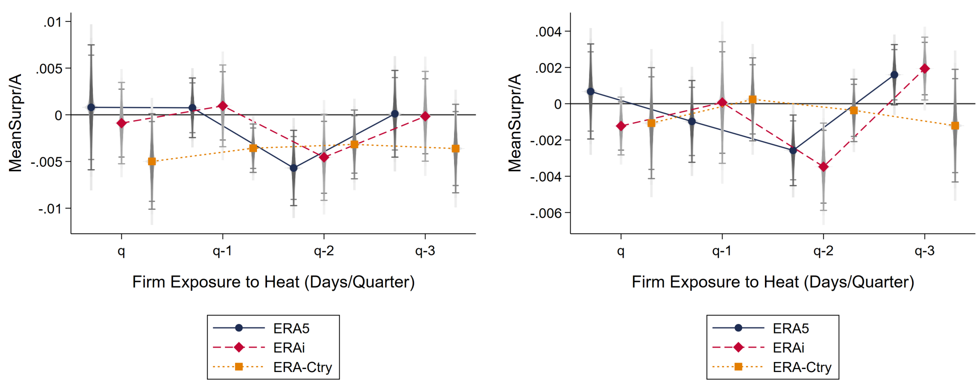
Table A8: Robustness: Analyst Forecast Errors — Financial Crisis

Notes. This table reports the effects of high temperatures on errors in analyst forecasts of revenues and pre-tax income after excluding years of the financial crisis. The forecast error in columns 1-3 is the difference between the actual revenue and the mean forecast revenue from IBES, scaled by lagged total assets. The forecast error in columns 4-6 is the difference between actual pre-tax income and the mean forecast pre-tax income IBES, scaled by lagged assets. Columns 1 and 3 refer to full-sample results, columns 2 and 5 report results after dropping years 2008 and 2009, columns 3 and 6 report results after omitting the period 2008-2010 Heat exposure is the number of days in a financial quarter on which temperatures exceeded 30°C (Days > 30 d.C. p.q). All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C (Cold Day Controls). In addition, the sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Rev (t)/Assets (t-1)			OpI (t)/Assets (t-1)		
	Full Sample	Excl. 2008-09	Excl. 2008-10	Full Sample	Excl. 2008-09	Excl. 2008-10
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	0.0015	0.0027	0.0035	0.0006	0.0002	-0.0002
	(0.0034)	(0.0031)	(0.0033)	(0.0013)	(0.0013)	(0.0014)
Heat Exp. (q-1)	0.0014	0.0011	0.0021	-0.0008	-0.0010	-0.0005
	(0.0016)	(0.0017)	(0.0017)	(0.0012)	(0.0012)	(0.0013)
Heat Exp. (q-2)	-0.0052***	-0.0051***	-0.0042**	-0.0022**	-0.0021**	-0.0017*
	(0.0019)	(0.0019)	(0.0016)	(0.0010)	(0.0010)	(0.0009)
Heat Exp. (q-3)	0.0003	-0.0001	-0.0001	0.0015	0.0016	0.0019**
	(0.0023)	(0.0021)	(0.0019)	(0.0012)	(0.0011)	(0.0009)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2648	0.2740	0.2820	0.2995	0.3097	0.3169
Number of Observations	55,927	52,358	49,603	40,590	38,249	36,192
Number of Firms	1,122	980	873	737	660	588
Number of Countries	64	63	63	52	52	51

Table A9: Robustness: Analyst Forecast Errors — Temperature Data

Notes. This table reports effects of high temperatures on errors in analyst forecasts of revenues and pre-tax income; see equation 3. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. Heat exposure is measured by the number of days in a financial quarter on which temperatures exceeded 30°C. Three ways to count days on which the temperature exceeds 30°C are considered: based on the ERA5 database (ERA5), based on the ERA-Interim temperature data (ERAi), and based on the average of temperatures from ERA5 in the firm's country of headquarters (ERA-Ctry). Specifications include heat exposure augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C. Panel (a) visualizes coefficients on quarterly heat exposures (q, q-3) for each of the alternative ways to count days of high temperatures. 90 and 95% confidence intervals are indicated by small bars. The left (right) figure refers to effects of heat exposure on the mean revenue forecast error (pre-tax income forecast error). Panel (b) tabulates effects of the quarterly heat exposures (q, q-3) on the mean revenue forecast error (columns 1-3) and pre-tax income forecast error (columns 4-6). Columns 1 and 4 are based on ERA5, columns 2 and 5 on ERAi, columns 3 and 6 on ERA-Ctry. The sum of coefficients on the four quarterly heat exposures (q, q-3) are presented along with p-values for tests of their joint significance (Joint P-Value). The number of observations refers to firm-quarters. Two-way standard errors in parentheses are clustered by country and year-quarter. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.



(a) Revenue/Assets (Sum)

	Rev (t)/Assets (t-1)			OpI (t)/Assets (t-1)		
	ERA5	ERAi 9	ERA-Ctry	ERA5	ERAi 9	ERA-Ctry
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	0.0008	-0.0009	-0.0050*	0.0007	-0.0012	-0.0011
	(0.0033)	(0.0022)	(0.0026)	(0.0013)	(0.0008)	(0.0015)
Heat Exp. (q-1)	0.0008	0.0010	-0.0036***	-0.0010	0.0001	0.0002
	(0.0016)	(0.0022)	(0.0013)	(0.0011)	(0.0017)	(0.0011)
Heat Exp. (q-2)	-0.0057***	-0.0046*	-0.0032*	-0.0026**	-0.0035***	-0.0004
	(0.0020)	(0.0023)	(0.0018)	(0.0010)	(0.0012)	(0.0009)
Heat Exp. (q-3)	0.0001	-0.0002	-0.0036	0.0016*	0.0019**	-0.0012
	(0.0023)	(0.0024)	(0.0024)	(0.0008)	(0.0009)	(0.0015)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2652	0.2652	0.2654	0.2966	0.2968	0.2963
Number of Observations	54,103	54,103	54,103	39,334	39,334	39,334
Number of Firms	1,693	1,693	1,693	1,129	1,129	1,129
Number of Countries	61	61	61	49	49	49

Table A10: Robustness: Analyst Forecast Errors — Temperature Thresholds

Notes. This table reports the effects of high temperatures on errors in analyst forecasts of revenues and pre-tax income; see equation (3). The forecast error in columns 1-7 is the difference between the actual revenue and the mean forecast revenue from IBES, scaled by lagged total assets. The forecast error in columns 8-14 is the difference between actual pre-tax income and the mean forecast pre-tax income IBES, scaled by lagged assets. Across columns 1 to 7 (8 to 14) different measures of firm-level heat exposure are presented (the sum of coefficients on the four quarterly heat exposures (q, q-3)). Heat Exp. $> 25°$C (Heat Exp. $> 30°$C, Heat Exp. $> 35°$C,) indicates the number of days in a financial quarter on which temperatures exceeded 25°C (30°C, 35°C). Heat Exp. $> 25°$C & 90^{th} Pctl (Heat Exp. $> 25°$C & 95^{th} Pctl) indicates the number of days on which temperatures exceeded not only 25°C but also the 90^{th} (95^{th}) percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days. Heat Exp. $> 30°$C & 90^{th} Pctl (Heat Exp. $> 30°$C & 95^{th} Pctl) indicates the number of days on which temperatures exceeded not only 30°C but also the 90^{th} (95^{th}) percentile of the historic distribution of temperatures. All specifications include firm-financial quarter fixed effects, industry-year fixed effects, the number of days below 0°C.(Cold Days Control), and country linear trends. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Revenues MeanSurpr/A							Pre-Tax Income MeanSurpr/A						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
$\sum$ Heat Exp. $>25°$ C	0.0001							-0.0008						
	(0.0025)							(0.0008)						
$\sum$ Heat Exp. $>25°$ C & $>90^{t}h$ Pctl		-0.0032**							-0.0019***					
		(0.0013)							(0.0006)					
$\sum$ Heat Exp. $>25°$ C & $>95^{t}h$ Pctl			-0.0040***							-0.0016**				
			(0.0012)							(0.0007)				
$\sum$ Heat Exp. $>30°$ C				-0.0058***							-0.0020**			
				(0.0017)							(0.0008)			
$\sum$ Heat Exp. $>30°$ C & $>90^{t}h$ Pctl					-0.0050***							-0.0018**		
					(0.0018)							(0.0008)		
$\sum$ Heat Exp. $>30°$ C & $>95^{t}h$ Pctl						-0.0056***							-0.0011	
						(0.0020)							(0.0011)	
$\sum$ Heat Exp. $>35°$ C							-0.0136***							-0.0006
							(0.0029)							(0.0021)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2617	0.2617	0.2617	0.2618	0.2618	0.2618	0.2619	0.2960	0.2961	0.2960	0.2960	0.2960	0.2960	0.2959
Number of Observations	58,017	58,017	58,017	58,017	58,017	58,017	58,017	42,187	42,187	42,187	42,187	42,187	42,187	42,187
Number of Firms	1,731	1,731	1,731	1,731	1,731	1,731	1,731	1,153	1,153	1,153	1,153	1,153	1,153	1,153
Number of Countries	65	65	65	65	65	65	65	52	52	52	52	52	52	52

Table A11: Robustness: Earnings Announcement Returns — Financial Crisis

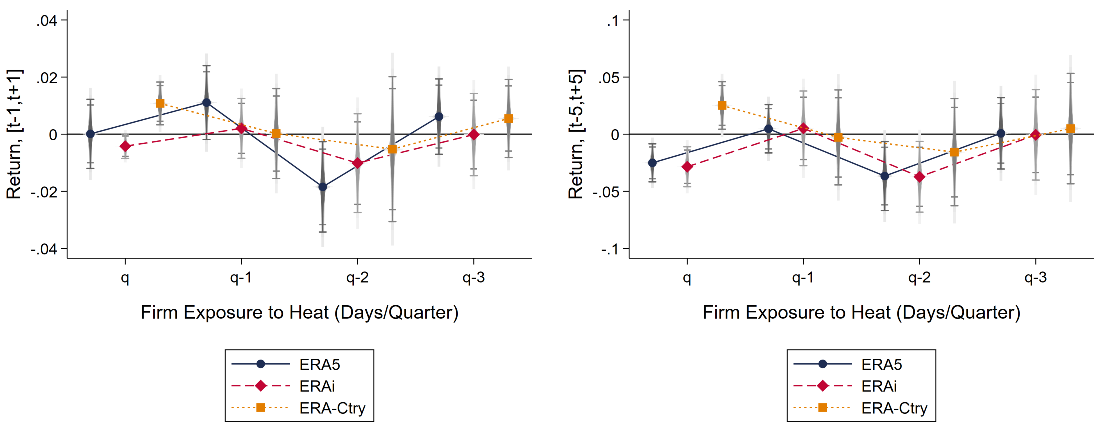
Notes. This table reports the effects of high temperatures on quarterly earnings announcement returns, measured over 3 [-1,+1] days and 11 [-5,+5 days] days surrounding the earnings announcement date. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. Heat exposure is measured by the number of days in a financial quarter on which temperatures exceeded 30°C. Columns 1 and 3 refer to full-sample results, columns 2 and 5 report results after dropping years 2008 and 2009, columns 3 and 6 report results after omitting the period 2008-2010. All specifications include heat exposures augmented with three lagged quarterly exposures (q, q-3), firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C (Cold Day Controls). The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Rev (t)/Assets (t-1)			OpI (t)/Assets (t-1)		
	Full Sample	Excl. 2008-09	Excl. 2008-10	Full Sample	Excl. 2008-09	Excl. 2008-10
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	0.0008	-0.0018	-0.0029	-0.0241***	-0.0259**	-0.0120
	(0.0059)	(0.0063)	(0.0056)	(0.0084)	(0.0099)	(0.0073)
Heat Exp. (q-1)	0.0111	0.0129*	0.0108	0.0045	0.0073	0.0121
	(0.0068)	(0.0068)	(0.0080)	(0.0104)	(0.0116)	(0.0155)
Heat Exp. (q-2)	-0.0180**	-0.0201***	-0.0181**	-0.0358**	-0.0341**	-0.0201
	(0.0078)	(0.0074)	(0.0079)	(0.0152)	(0.0166)	(0.0175)
Heat Exp. (q-3)	0.0062	0.0060	0.0097	0.0008	-0.0008	-0.0107
	(0.0067)	(0.0073)	(0.0075)	(0.0157)	(0.0169)	(0.0135)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2367	0.2504	0.2600	0.2524	0.2651	0.2727
Number of Observations	40,209	37,544	35,094	40,209	37,544	35,094
Number of Firms	1,382	1,199	1,073	1,382	1,199	1,073
Number of Countries	64	63	63	64	63	63

Table A12: Robustness: Earnings Announcement Returns — Temperature Data

Notes. This table reports the effects of high temperatures on quarterly earnings announcement returns, measured over 3 [-1,+1] days and 11 [-5,+5 days] days surrounding the earnings announcement date. We match firms and temperatures based on headquarter location, but require firms to hold at least 10% of their assets in their home country. Heat exposure is measured by the number of days in a financial quarter on which temperatures exceeded 30°C, and data on temperatures is obtained in three different ways: From ERA5 data, from ERA-Interim (ERAi), and based on ERA5, but averaging daily maximum temperatures over the firm's home country (ERA-Ctry). All specifications include firm-financial quarter fixed effects, industry-year fixed effects, country linear trends, and the number of days when temperatures were below 0°C. Panel (a) visualizes coefficients on quarterly heat exposures (q, q-3) for each of the alternative ways to count days of high temperatures. 90 and 95% confidence intervals are indicated by small bars. Panel (b) tabulates the effects of the heat exposures on earnings announcement returns. Columns 1 and 4 are based on ERA5, columns 2 and 5 on ERAi, columns 3 and 6 on ERA-Ctry. The number of observations refers to firm-quarters. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

(a) Heat exposures and Earnings announcement returns



(b) Heat exposures and Earnings announcement returns

	Rev (t)/Assets (t-1)			OpI (t)/Assets (t-1)		
	ERA5	ERAi 9	ERA-Ctry	ERA5	ERAi 9	ERA-Ctry
	(1)	(2)	(3)	(4)	(5)	(6)
Heat Exp. (q)	0.0001	-0.0042*	0.0108***	-0.0251***	-0.0285***	0.0252**
	(0.0060)	(0.0021)	(0.0037)	(0.0083)	(0.0087)	(0.0104)
Heat Exp. (q-1)	0.0111*	0.0020	0.0002	0.0047	0.0051	-0.0028
	(0.0065)	(0.0052)	(0.0079)	(0.0106)	(0.0163)	(0.0208)
Heat Exp. (q-2)	-0.0184**	-0.0101	-0.0052	-0.0367**	-0.0373**	-0.0157
	(0.0079)	(0.0086)	(0.0127)	(0.0151)	(0.0155)	(0.0234)
Heat Exp. (q-3)	0.0062	-0.0001	0.0055	0.0008	-0.0006	0.0049
	(0.0066)	(0.0072)	(0.0068)	(0.0156)	(0.0198)	(0.0242)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2354	0.2349	0.2353	0.2492	0.2494	0.2503
Number of Observations	39,744	39,744	39,744	39,744	39,744	39,744
Number of Firms	1,376	1,376	1,376	1,376	1,376	1,376
Number of Countries	60	60	60	60	60	60

Table A13: Robustness: Earnings Announcement Returns — Temperature Thresholds

Notes. This table reports the effects of high temperatures on quarterly earnings announcement returns. The first seven columns pertain to cumulative stock return measured over 3 days surrounding the earnings announcement date [-1,+1 days] while the last seven columns pertain to the cumulative return over 11 days surrounding the announcement date [-5,+5 days]. Across columns 1 to 7 (8 to 14) different measures of firm-level heat exposure are presented (the sum of coefficients on the four quarterly heat exposures (q, q-3)). Heat Exp. $>25°$C (Heat Exp. $>30°$C, Heat Exp. $>35°$C,) indicates the number of days in a financial quarter on which temperatures exceeded 25°C (30°C, 35°C). Heat Exp. $>25°$C & 90^{th} Pctl (Heat Exp. $>25°$C & 95^{th} Pctl) indicates the number of days on which temperatures exceeded not only 25°C but also the 90^{th} (95^{th}) percentile of the historic distribution of temperatures that occurred on the same day as well as the five preceding and subsequent days. Heat Exp. $>30°$C & 90^{th} Pctl (Heat Exp. $>30°$C & 9^{th} Pctl) indicates the number of days on which temperatures exceeded not only 30°C but also the 90^{th} (95^{th}) percentile of the historic distribution of temperatures. All specifications include firm-financial quarter fixed effects, industry-year fixed effects, the number of days below 0°C.(Cold Days Control), and country linear trends. Two-way standard errors are clustered at the country and year-quarter level, and reported in parentheses. Asterisks indicate significance * at the 10% level, ** at the 5% level, *** at the 1% level.

	Return, [t-1,t+1]							Return, [t-5,t+5]						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
$\sum$ Heat Exp. >25° C	-0.0112							0.0088						
	(0.0073)							(0.0256)						
$\sum$ Heat Exp. >25° C & $>90^{t}h$ Pctl		-0.0129***							-0.0145					
		(0.0048)							(0.0112)					
$\sum$ Heat Exp. >25° C & $>95^{t}h$ Pctl			-0.0187***							-0.0147				
			(0.0065)							(0.0160)				
$\sum$ Heat Exp. >30° C				-0.0169*							-0.0365**			
				(0.0093)							(0.0148)			
$\sum$ Heat Exp. >30° C & $>90^{t}h$ Pctl					-0.0156**							-0.0299**		
					(0.0067)							(0.0122)		
$\sum$ Heat Exp. >30° C & $>95^{t}h$ Pctl						-0.0214**							-0.0307**	
						(0.0094)							(0.0147)	
$\sum$ Heat Exp. >35° C							-0.0275**							-0.0629***
							(0.0120)							(0.0185)
Firm-Qtr FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cold Day Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Linear Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.2386	0.2388	0.2389	0.2388	0.2388	0.2388	0.2387	0.2519	0.2520	0.2520	0.2523	0.2522	0.2521	0.2523
Number of Observations	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386	40,386
Number of Firms	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359	1,359
Number of Countries	61	61	61	61	61	61	61	61	61	61	61	61	61	61