International Journal of Applied Social Science
(An International Double Blind Peer Reviewed / Refereed Research Journal of Social Science)
Volume 11 (11 & 12), November & December (2024) : 761-769
Received : 30.10.2024; Revised : 15.11.2024; Accepted : 30.11.2024

RESEARCH ARTICLE
ISSN : 2394-1405 (Print)
DOI: 10.36537/IJASS/11.11&12/761-769

Impact of Temperature Change on Sub-National Output: Evidence from Indian Districts using a Linear Model

SUDIKSHA JHA
M.A. (Economics), South Asian University, Delhi (India)

ABSTRACT

Growth and development are the highly coveted goals for an industrialised world. Since Climate Change imposes additional costs on economic models of growth, it is pertinent to ask, "By how much does climate change dampen growth?" This paper examines the linear relationship between district gross domestic product (GDP) and temperature change for nine states within India between 2001 and 2010. This paper adopts the framework of Dell, Jones and Olken (2008, 2012), which analyses the correlation using a log-linear fixed effects model. The findings of the paper suggest that temperature changes are not the primary variable determining district GDP variation; within-district differences are more statistically potent. The results suggest that temperature changes do not hold prominent explanatory power over the short-run, especially in a linear relationship.

Keywords: Impact of temperatre, Linear model, Growth, Climate change, GDP

INTRODUCTION

The primary questions asked within Economics, especially in the Anthropocene age, are tantamount to dilemmas. This is essentially due to the rising costs that climate change and environmental damage impose on the "business as usual" models. Global Warming is the most visible way in which changes are being witnessed across the globe. In fact, many of the catastrophic events and weather phenomena are the direct result of a warmer planet.

Global warming is the rise in the average surface temperature of the Earth. A change in heating patterns alters many physical, chemical, and natural processes on the planet, including rainfall patterns, ocean salinity and temperature, cryosphere melting, biodiversity, and nutrient cycling. Despite knowing this, the possible effects on human life, economy, and society are still marred with uncertainty. Since any prescriptive policy will begin by weighing the costs and benefits of an action, itis essential to have a thorough understanding of how global warming may impact economies and societies.

Temperature changes have not generally been part of empirical research within Economics. Although New-Institutional Economics has used temperature differences to describe differences among countries in terms of the institutions they develop. This is rooted in the observation that the majority of developed countries are in temperate regions of the world. (Acemoglu *et al.*, 2002; Nordhaus, 2006) Hence, temperature differences do not feature directly or prominently in studies analysing economic activity. Although the temperature rise since the 1960s has led to a change in this trend, where temperature and extreme climatic events, such as cyclones, are becoming an important variable for consideration in economic studies. Recent trends indicate that the temperature rise is continuing and is likely to exceed the limits feasible, as per our current technology, to adapt and mitigate. Therefore, an increasing number of studies are examining the potential direct relationship between temperature and economic variables. This can help us better gauge the future costs that would emerge from breaching self-imposed control mechanisms to abate Climate change.

The relationship between temperature and aggregate

How to cite this Article: Jha, Sudiksha (2024). Impact of Temperature Change on Sub-National Output: Evidence from Indian Districts using a Linear Model. *Internat. J. Appl. Soc. Sci.,* **11** (11 & 12) : 761-769

economic activity has traditionally been quantified using two approaches. "*One approach, emphasised in the growth and development literature, has examined the relationship between average temperature and aggregate economic variables in cross-sections of countries. The second approach relies on micro-.*

Evidence to quantify various climatic effects and then aggregate these to produce a net effect on national income. This approach is embedded within Integrated Assessment Models (IAM), which are utilised extensively in the climate change literature to model climate-economy interactions and form the basis of many policy recommendations regarding greenhouse gas emissions (Olken *et al.,* 2012).

The latter system poses a significant constraint in terms of the extensive data requirements for an IAM model, like the Nordhaus DICE model. In addition to this, many complexities and interlinkages arise when climate variables are treated as endogenous. Even a model where aggregate variables are regressed on average temperature and rainfall is a difficult endeavour. Since climate is a long-term distribution of weather patterns over a space, it implies that studying the impact of climate on the economy requires a method to capturea specific climate variable from a continuum of processes. Additionally, weather is often used as a proxy for climate in such studies, as climate is a long-term phenomenon. This implies that the climate over a geographical space can remain unchanged over a certain amount of time. Therefore, studies have used weather patterns (mainly surface temperature and precipitation) as a good proxy for Climate Change. Additionally, the temperature or precipitation on a particular day is highly random, even though it is derived from the distribution of climate variables in the region, which are endogenous and depend on many factors. This makes the daily observation of these weather variables a random observation. This allows us to consider them as exogenous variables, at least over a short time span.

This study aims to study the relationship between temperatures and aggregate output at the sub-national level for India. Many studies have looked at this using panel data for countries, and also at the sub-national level for some countries. However, these sub-national studies have been more focused on the countries in the Western Hemisphere. Evidence of the adverse impacts of global warming on South Asia has been growing; moreover, there is a need for more extensive studies across different states and regions. The central question for this research is: What is the change in district aggregate product when temperature increases by 1 °C, controlling for rainfall in the short term?

A Glance at the Literature:

Dell *et al.* (2009) have provided evidence for a negative cross-country relationship between temperature and income, and also found similar results within countries. The sub-national study was done for 12 countries from the Western Hemisphere. However, the within-country cross-sectional relationship was substantially weaker than the cross-country relation, though it remained statistically significant. The sub-national study indicated a 1.2-1.9% decline in municipal per capita income for a 1 °C temperature rise. The study suggested that the presence of a statistically significant correlation at the sub-national level indicates that the idea that temperature only impacts through the institutional endowment mechanism

Acemoglu *et al.,* (2002) is not supported. Rather, there can be a direct correlation between economic output and temperature. The study also suggested that these results hold for long-term panels (10-15 years), indicating the existence of both growth and level effects of temperature rise on per-capita income. They expanded the theoretical framework to suggest that adaptation can reduce some of the negative impacts in the long run.

Dell *et al.* (2012) used a linear model to analyse the impact of temperature on the GDP of 125 countries, using panel data for these countries, including India, for the period 1950-2003. They found that a 1 °C increase in temperature had a significant impact on poorer Countries, where the GDP for these countries fell by 1.3 per cent. No significant effect was found on the GDP of the richer countries. This was achieved by considering the subset of panels in terms of GDP level using a cut-off. They also studied the impact of temperature on the growth rates of these same 125 countries and found the results to be significant. The paper employed a linear specification; however, the differences in the effects among countries are indicative of the existence of non-linearity in the relationship.

Burke *et al.* (2015) analysed the nonlinear impacts of temperature on a country's production using a panel of 166 countries from 1960 to 2010. They found that production peaks at an annual average temperature of 13 °C, and any further increase has a negative correlation. This holds for both non-agricultural and agricultural production. They found that the "*country-level economic production is a smooth, non-linear concave function in temperature with its peak at 13°C"* (Burke *et al.*, 2015). A higher impact on the non-agricultural sector compared to the agricultural sector was another finding in the paper.

Since the aim is to capture the impact of climate change on economic systems, it is also of significance to analyse the effects of climate shocks apart from the general trends in weather variables. Hsiang (2010) has studied the effect of temperature on the economic production of 28 Caribbean countries for the period 1970-2006. He controlled for the various climate shocks, such as cyclones and rapid winds, that these countries experience. His results showed that the losses in non-agricultural output (2.4%) exceed those in agricultural production (0.1%) for a 1 °C increase in temperature.

In India, various studies have attempted to assess the impact of temperature and precipitation on agricultural yield and output. Since agriculture is the activity that relies heavily on weather conditions, especially in developing and less developed countries. Gupta, Sen and Srinivasan (2012) analysed the regional incidence of climate change on the yields of rice and millets at the district level. Their findings indicate regional variation in the effects of higher temperatures and precipitation, as well as variation across crops, where rice and millet respond differently to temperature and precipitation.

Somanathan *et al.* (2018) have studied the impact of temperature and precipitation on labour productivity, manufacturing output and absenteeism. They used three levels of aggregation: Worker, manufacturing firm, and district-level manufacturing output. They found that the manufacturing output at the district level would decline by approximately 2% with 1°C rise in temperature.

Model:

The fundamental question that one needs to ask is: What is the direction of the relationship between output and temperature? The growing literature in the field suggests a statistically significant and robust negative relationship, which holds across various models and datasets. A more essential question is: why is it negative? Since the seminal work of Acemoglu *et al.* (2002), the notion that climate variables have influenced a country's institutions and, consequently, its growth trajectory, has been prevalent. Yet, Dell *et al.* (2009) have shown that if the institutions are represented by omitted variables in studies looking at the direct relationship between temperature and economic incomes, then these omitted variables should have a strong positive effect on specific countries and show differences in the coefficient values for the cross-sectional relationship between countries and for within-country studies. *Since "cross-sectional relationship holds within countries, as well as between countries, this suggests that omitted country-specific characteristics are not wholly driving the cross-sectional relationship between temperature and income"* (Dell *et al.*, 2009)

In Burke *et al.* (2015), the evidence of a non-linear relationship is even more telling. It explores how the rise in temperature doesn't affect economic variables unidirectionally, but rather would be driven by the level of temperature itself. This would mean that hotter countries would see a negative impact from temperature rise, while colder countries could benefit from it (at least for a certain range of temperature). Though why that is so remains unanswered. The evidence from Somanathan *et al.* (2018) on labour productivity in manufacturing has shown that rising temperatures affect human labour and productivity. It is well-accepted that people can only tolerate temperatures within a certain range, beyond which any heat exposure affects them both physically and cognitively. This can be suggestive for all labour, across sectors in the economy. Additionally, primary activities like agriculture and allied activities, such as animal husbandry, tend to have a more pronounced effect from a temperature rise, as not only labour is affected, but also a more direct impact on the crop production and animal health. Perhaps some of the non-linearity observed is due to colder countries having more scope to tolerate a temperature rise, which also has a positive impact on labour and agriculture. However, once these benefits are reaped, any further rise results in negatively impacting them as well.

Since aggregate economic output or income captures all sectors in the economy, it should reflect a similar correlation, as observed in studies conducted for particular sectors of the Economy. This paper adopts the framework from Dell *et al.* (2008, 2012)[1] to empirically examine the relationship between temperature and aggregate output for district-level data from India.

1. Dell, Jones, and Olken (2008, 2012) have mainly tried to analyse the cross-sectional impact. However, I aim to capture within-unit differences as well.

Previous sectoral works in India (Gupta *et al.*, 2012; Somanthan *et al.,* 2018) have found a statistically significant negative relationship between temperature and economic variables. In a similar vein, I wish to analyse the direction and statistical power of a similar empirical question, but at the level of Indian district data.

Mondal *et al.* (2014) have done a non-parametric study on trends in temperature for 107 years (1901-2007) and precipitation for 140 years (1871-2011) for sub-divisions of India and found decreasing annual rainfall in most of the regions along with temperature (minimum, maximum and mean) showing a significant increase, particularly in winter and post-monsoon period. The study gives the "*net impact of climate change on these factors and shows a net excess of temperature and net deficit of rainfall*". The trend in average yearly temperature, annual maximum temperature, and average yearly rainfall, along with general statistics for the nine states of India: Andhra Pradesh, Bihar, Kerala, Maharashtra, Odisha, Punjab, Rajasthan, Uttar Pradesh, and West Bengal, for the period 2001-2010, is provided in Appendix A[2].

Guided by the theoretical framework of Dell *et al.* (2008, 2012), I estimate a linear model to test the predicted effect of the yearly district temperature on gross domestic district product (gddp). Using panel data from Indian districts from 9 states of India for 2001-2010.[3]

The primary specification of the model is:

$$loggddp_{it}=\alpha+\beta_1 temp_{it}+\varepsilon_{it} \qquad \text{(I)}$$

- $loggddp_{it}$: district GDP in Rupees Croresat 2004-05 constant prices.
- $temp_{it}$: district yearly average (mean/max) temperature in degrees Celsius. Refer
- ε_{it}: error term

The linear specification, using the log-linear regression model (Dell *et al.*, 2008, 2012), tests for the percentage changes in GDDP due to a one-degree increase in average yearly temperature in the district. A linear model is used since many studies have found a significant linear relationship between the variables. Hence, the aim is to test for a similar specification in the case of India. Using the OLS model, the equation is tested for both the mean temperature and the maximum temperature. The maximum temperature can be used as an independent variable to prevent the loss of information due to averaging. Since the daily mean temperature itself is an average. The results are provided in Appendix B.

To prevent myself from committing the omitted variable bias and breaking the OLS assumption that error terms should not be correlated with the main regressor, rainfall needs to be controlled for.

Hence, Rainfall (in millimetres) is controlled for; the new regression equation is given below:

$$loggddp_{it}=\alpha+\beta_1 Temperature_{it}+\beta_2 Rainfall_{it}+\varepsilon_{it} \text{(III)}$$

I also estimate a fixed effects model to account for unobserved heterogeneity across districts as follows:

$$loggddp_{it}=\alpha+\beta_1 Temperature_{it}+\beta_2 Rainfall_{it}+ District\ fixed\ effects\ +Time\ fixed\ effect+\varepsilon_{it} \qquad \text{(III)}$$

Having panel data allows me to control for the unknown factors that differ between districts but remain constant over time (district fixed effects), as well as those that vary over time and are constant across districts. This is the Fixed Effects model. Alternatively, there is also the random effects model. The Hausman test provides evidence on which model fits better. Both these alternative specifications for the panel data need to be tested to see which fits better.[3] There can be district-specific factors that affect the GDP, but remain fixed over time. It is impossible to include all the factors that may be related to GDDP. Hence, these fixed effects in themodel have been tested using both dummy variables and categorical variables. Dummy variables are nothing but a special case of categorical variables, where they only take two values: 1 and 0, as opposed to any non-zero integer value in categorical variables. The results from both methods will be identical. Similarly, like the district fixed effects, there are time fixed effects, which capture all the factors that affect GDP and change over time but not across districts;

---

2. The data on weather comes from the Indian Meteorological Department's 1°×1° grid on daily maximum and minimum temperatures in degrees Celsius, as well as daily total rainfall in millimetres. The Census of India, 2001, shape file has been used to create area-weighted averages of daily maximum and minimum temperatures, as well as daily total rainfall, for all districts in the sample. The GDDP data at constant prices is available as part of the data sets compiled by the erstwhile Planning Commission of India. All values are based on 2004-05 price levels.

3. Total number of observations in the data set is 2.717.

   Hausman test results suggest that the fixed effects model is better. (p vaulue=0.008<0.05)This is further suggested later by the results, where the district fixed effects are responsible for explaining the majority of the variation in the gddp.

i.e., these changes are the same for all districts.[4]

Since dummy variable takes the value 1 for all observations for the ith district (or year t) and 0 otherwise. As STATA estimates OLS with an intercept, to avoid the dummy variable trap, I have dropped the year dummy for 2001 and the dummy for the first district from the model. Therefore, the coefficients on all other dummy variables need to be interpreted relative to the dropped group/year.[5]

RESULTS AND DISCUSSION

The results for equation (I) using ordinary least squares, where yearly maximum temperature is the main explanatory variable, are compiled under column (1) of Appendix B.1.1.[6] The coefficient on yearly maximum temperature is negative and statistically significant at five per cent. A 1°C increase in the yearly maximum temperature will decrease the GDDP by 0.798%. The fitted regression equation is given in Appendix B.1.2.

The results corresponding the equation (II) with maximum yearly temperature as the main regressor are given in column (2) of Appendix B.1. The coefficient on maximum yearly temperature remains negative and significant, but increases in magnitude; a 1°C increase in annual maximum temperature decreases GDDP by 1.01 per cent. The coefficient on rainfall is also statistically significant.[7]

When district fixed effects are included in the model with maximum yearly temperature as the main regressor, then the results are given under column (4) of Appendix B.1.The coefficient on temperature is positive, minimal and not statistically significant. Therefore, it suggests that temperature changes within districts do not have a substantial effect on changes in economic activity (GDP). When only time fixed effects are added and the results are presented in column (5), the results are very similar to those obtained from the regression model with only temperature and rainfall. It's statistically significant as well as almost the same in magnitude (1.19%). Whereas, adding both district fixed effects and time fixed effects provides us again with a statistically insignificant, positive and very small coefficient. What is telling is the F values, corresponding p-values, and the adjusted R^2 values, along with the standard errors of regression. The fitted line for equation (I) is statistically significant (F value and p value are substantial). Still, a low adjusted R^2 and a very high standard error of regression indicate that the model is not able to explain the variation in gddp very effectively. The results are identical when rainfall is added, as provided in equation (II). Therefore, temperature and rainfall are meaningful explanatory variables, but may be significant due to the large sample size rather than the actual strength of the model. The overall significance (as indicated by the adjusted R^2 and standard error) being low suggests that important variables are missing from the model, or the model needs a different specification, or quality data from all states of India.

To correct the omitted variable bias in regression equations (I) and (II), the regression analysis done using the District Fixed effects model provides the fitted line having very strong explanatory power (very high F values, adjusted R^2 sees a significant jump and explains 90% variation, and standard error is considerably small). This suggests that the model has very high explanatory power. However, a small, positive and statistically insignificant coefficient on temperature is indicative of district-specific factors having more explanatory power in explaining variation in gddp within districts over time. This is further justified by comparing it to the regression having only time fixed effects, where the adjusted R^2 is again very small, the standard error is high, but the temperature coefficient is negative and significant (which is very similar to the base model with no fixed effects).This also suggests that in panel studies, the impact of temperature may not be an important explanatory variable as compared to cross-sectional studies. Previous cross-sectional studies have found a significant linear relationship

4. Such as national policies.
5. In place of these dummy variables. I have also tested for categorical variables for both district and time, and the results are identical.
6. Max temp will be the main regressor here on, to avoid loss of information because of averaging twice-daily and yearly.
7. Climate (or weather in, short run) can affect many characteristics of the economy- choice of economic activity, type of agriculture, type of industries, etc. Hence, there are feedback loops in the climate-economy interface, which are difficult to isolate. Such panel and cross-sectional studies mainly aim to capture the nature of the relationship as per conventional econometric tools.

between the two variables (Dell *et al.,* 2008, 2012). This stands in contrast to the findings of this paper, which differences among districts have more explanatory power over the aggregate output than temperature.

The high explanatory power that district fixed effects have on the model, rather than temperature and rainfall (also time fixed effects), suggests that the district-specific factors were confounding the results in the base model due to omitted variable bias. A very high adjusted R^2 and low standard error indicate that the model fits well after considering district-specific factors, and perhaps also reflects the true relationship between the variables, where temperature doesn't explain much variation in aggregate output in districts over the years.[8]

Running OLS regression for a trimmed data set, where the observations that are two standard deviations away from the mean value of the variable are removed from the sample, gives some illuminating results, which are provided in Appendix C. Despite adding district fixed effects, the coefficient on temperature is negative and statistically significant. Additionally, the magnitude (1.98%) is very similar to estimates of previous studies. However, the overall fit of the model is not very high, yet significantly higher than the previous regression result. The coefficient loses its statistical power again when both district and time fixed effects are added together (though the sign on the coefficient remains negative). Hence, this suggests that the linear specification of the model with district fixed effects is very sensitive to data quality and outliers.

Conclusion:

Evidence of a negative linear relationship between output and temperature has been suggested, including level as well as growth effects, in the literature. This means that the relationship holds irrespective of whether the difference is between countries (or units), or within them. However, the findings of this paper suggest that the within-unit (districts) differences are more important determinants than temperature in explaining the variation in district outputs. Moreover, a non-linear specification may provide a better explanation of the results, as also suggested by Burke *et al.* (2015). The findings here indicate that the relationship between gross district domestic product and the yearly average of maximum temperature is negative; however, a more robust estimation, with a different model specification, and a larger sample is needed. Since removing outliers provided results which were much more comprehensive in terms of the sign on the coefficient, and also had a slightly better fit, it suggests that it would be desirable to replicate the study for a bigger sample covering all the districts in India for a longer time span.

Therefore, temperature doesn't remain the sole criterion in explaining the yearly and district-wise differences in output production, especially if the study is restricted in terms of coverage and duration. Any further attempt would require conducting a similar enquiry for a much larger data set, and preferably having information on more district-specific factors to capture them more explicitly. Also, it provided for investigating the presence of a relationship by accounting for agriculture and industrial activities separately in the model, since previous research has shown that the impact of temperature rise on these sectors is not the same. These differences might also distort some of the direct effects that temperature tends to have on aggregate output.

Appendix A

Appendix A.1: Maximum Yearly Average Temperature (in degrees Celsius)

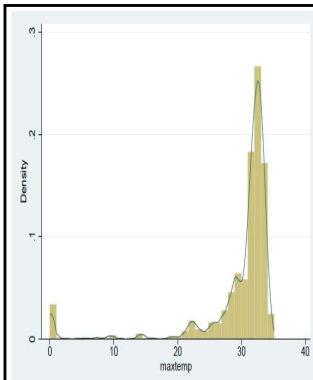


Fig. A1.1. : The Histogram and Density Function for Maximum Temperature

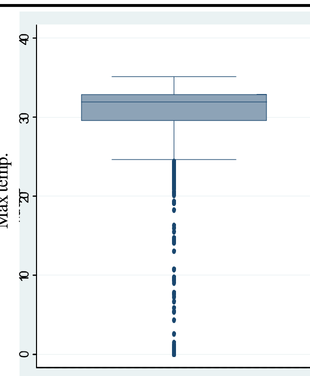


Fig. A1.2. : Box plot of maximum temperature

8. Cross-sectional studies analyse the differences across units, whereas district fixed effects capture differences within units over time. Since time fixed effects are small in the model, it suggests that the differences across districts are not that significant.

Table A.1.3 : Summary Statistics of Maximum Temperature

Variable	Mean	Standar dev	Min	Max	SKEWNESS	KURTOSIS
Max temp (in degrees Celsius)	29.68085	6.832374	0	35.10564	-3.281241	13.79748

Appendix A.2: Gross District Domestic Product (in Crores)

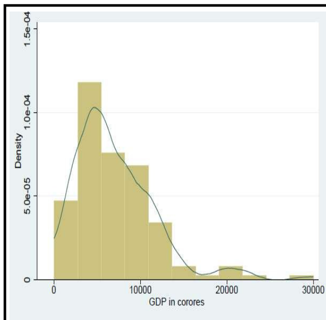


Fig. A2.1. : The Histogram and Density Function for gddp

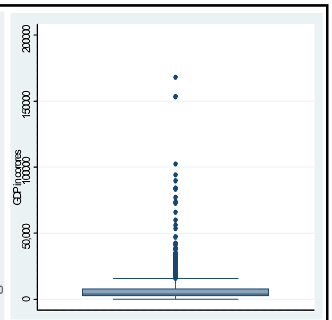
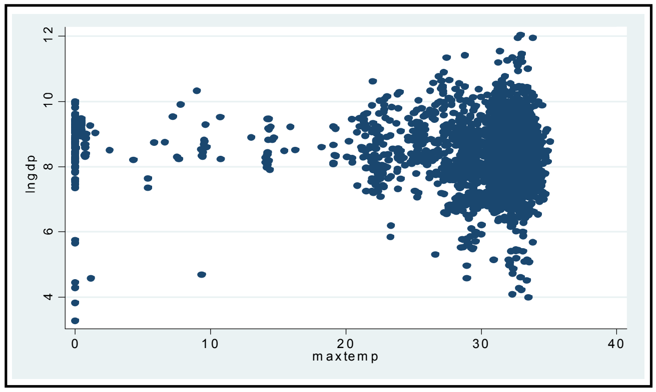


Fig. A2.2. : Box plot of gddp

Table A.2.3 : Summary Statistics of gddp

Variable	Mean	Standar dev	Min	Max	SKEWNESS	KURTOSIS
Gddp (in cr)	6505.606	9356.105	0	167914	7.679154	98.41096

Appendix A.3: The Scatter Plot for log gddp (in crores) and max temp (in Celsius)



Appendix B

TAB B.1.1: The Ordinary Least Square Regression Results

Dependent Variable: LOG OF GDDP IN RUPESS CRORES,2717 Observations

Regressor	(1)	(2)	(3)	(4)	(5)	(6)
Max. temp	-0.00798*	-0.0101*	0.0119**	0.00143	0.0001	0.0019
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.014)
Rainfall	–	-0.0267**	-0.0333**	0.0208**	0.0055	0.005
		(0.009)	(0.009)	(0.006)	(0.006)	(0.006)
Max temp²	–	–	–	–	–	-0.00005
						(0.0004)
District Fixed Effects	–	–	–	YES	YES	YES
Time Fixed Effects	–	–	YES	–	YES	YES
Intercept	8.548**	8.696**	8.521**	8.918**	8.7488**	8.742**
	(0.098)	(0.138)	(0.141)	(0.147)	(0.137)	(0.151)
Indicator Indicators for the Fit of the Model						
F Statistic	6.14	5.68	11.58	148.73	550.64	551.85
P-value	(0.013)	(0.003)	(0.00)	(0.00)	(0.00)	(0.00)
Adjusted R²	0.002	0.004	0.037	0.864	0.900	0.900
SER	0.975	0.966	0.950	0.356	0.307	0.307

Robust standard error are given in parentheses under the respective coefficients *p<0.05,"p<0.01

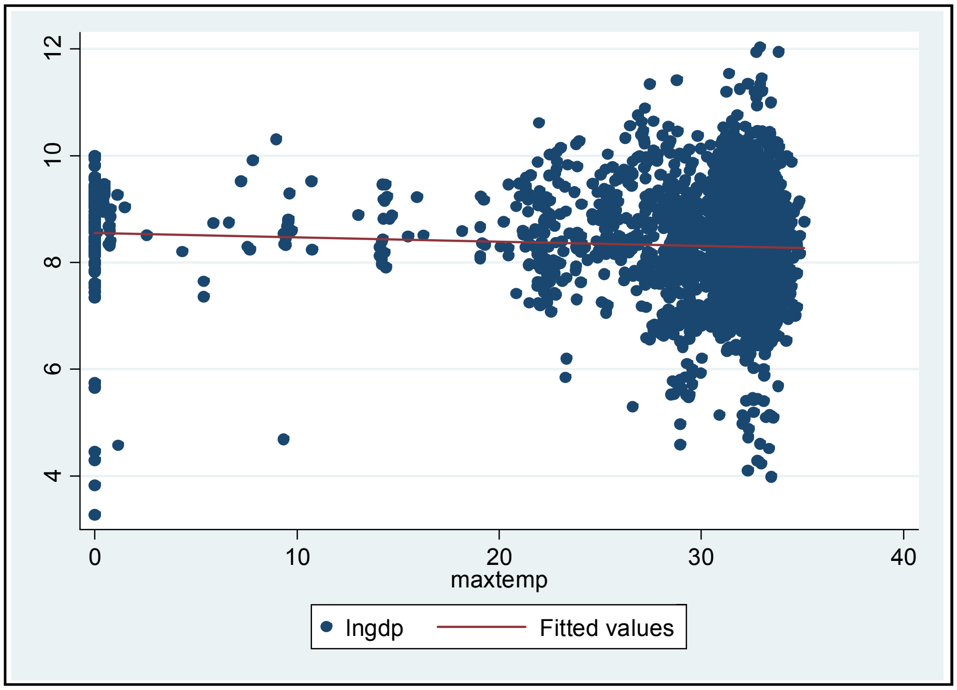
TAB B.2 : Regression Results When Mean Temperature is the Main Independent Variable

Dependent Variable: Log of District GDP in Rupees Crores, 2717 Observations

Regressors	(1)	(2)	(3)	(4)	(5)
Temp	-0.00672	-0.00836	0.003	-0.0108*	0.000
	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)
Rainfall	—	-0.0251**	0.020**	0.0320**	0.005**
		(0.009)	(0.006)	(0.009)	(0.006)
District Fixed Effects	NO	NO	YES	NO	YES
Time Fixed Effects	NO	NO	NO	YES	YES
Intercept	8.471**	8.588**	8.886**	8.420**	8.75**
	(0.092)	(0.125)	(0.157)	(0.130)	(0.140)

Robust standard error are given in parentheses under the respective coefficients *p<0.05,"p<0.01

Fig. B.1.2 : The Scatter Plot and the Fitted Regression Line for the Baseline OLS Model



Appendix C

Regression Results after Removing the Outliers

TAB 1: The Ordinary Least Square Regression Results

Dependent Variable: Log of District GDP in Rupees Crores, 2305 Observations

Regressor	(1)	(2)	(3)	(4)	(5)	(6)
Max. temp	-0.0125*	-0.0171**	-0.0176**	-0.0198**	0.0114	0.0760
	(0.005)	(0.006)	(0.005)	(0.008)	(0.008)	(0.108)
Rainfall	–	-0.0259**	-0.0330**	0.0201**	0.0396	0.0434
		(0.009)	(0.009)	(0.006)	(0.006)	(0.006)
Max temp²	–	–	–	–	–	-0.00116
						–
District Fixed Effects	NO	NO	YES	NO	YES	YES
Time Fixed Effects	NO	NO	NO	YES	YES	YES
Intercept	8.625**	8.848**	8.671**	9.463**	9.029**	9.929**
	(0.180)	(0.197)	(0.199)	(0.239)	(0.230)	(0.145)

Robust standard error are given in parentheses under the respective coefficients *p<0.05,"p<0.01

REFERENCES

Acemoglu, D., Johnson, S. and Robinson J. (2002). Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution. *The Quarterly Journal of Economics*, **117** (4) : 1231-1294

Burke, M., Hsiang, S. and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature*, **527** : 235-239.

Dell, M., Jones, B.F. and Olken, B.A. (2009). Temperature and Income: Reconciling New Cross-Sectional and Panel Estimates. *American Economic Review*, **99** (2) : 198-204.

Dell, M., Jones, B.F. and Olken, B.A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, **4** (3) : 66-95.

Dell, M., Jones, B.F. and Olken, B.A. (2014). What do we learn from the weather? The new climate-economy literature. *J. Econ. Lit.*, **52** (3) : 740-798.

Gupta, S., Sen, P. and Srinivasan, S.(2014). Impact of climate change on the Indian economy: evidence from food grain yields. *Climate Change Economics*, **5**(2) :

Hsiang, S.M. (2010). Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America. Proceedings of the National Academy of Sciences.

Mondal, A., Khare, D. and Kundu, S. (2015). Spatial and temporal analysis of rainfall and temperature trend of India. *Theoretical & Applied Climatology*, **122** : 143-158.

Somanathan, E., Somanathan, R., Sudarshan, A. and Tewari, M. (2018). The Impact of Temperature on Productivity and Labour Supply: Evidence from Indian Manufacturing.

****