AMERICAN UNIVERSITY OF BEIRUT

THE AGGREGATE PRODUCTIVITY CONSEQUENCES OF CLIMATE CHANGE IN THE MIDDLE EAST AND NORTH AFRICA REGION

by

TIA HASSAN EL MOKDAD

A thesis
submitted in partial fulfillment of the requirements
for the degree of Master of Arts
to the Department of Economics
of the Faculty of Arts and Sciences at the
American University of Beirut

Beirut, Lebanon
April 2023

AMERICAN UNIVERSITY OF BEIRUT

THE AGGREGATE PRODUCTIVITY CONSEQUENCES OF CLIMATE CHANGE IN THE MIDDLE EAST AND NORTH AFRICA REGION

by

TIA HASSAN EL MOKDAD

Approved by:

Sumru Altug
Signature

_____

Dr. Sumru Guler Altug, Professor and Chairperson
Department of Economics

Advisor

Signature

Ali Abboud

_____

Dr. Ali Abboud, Assistant Professor
Department of Economics

Member of Committee

Nadine Yamout
Signature

_____

Dr. Nadine Yamout, Assistant Professor
Department of Economics

Member of Committee

Date of thesis defense: April 28, 2023

AMERICAN UNIVERSITY OF BEIRUT

THESIS RELEASE FORM

Student Name: El Mokdad Tia Hassan
Last First Middle

I authorize the American University of Beirut, to: (a) reproduce hard or electronic copies of my thesis; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes:

☒ As of the date of submission

☐ One year from the date of submission of my thesis.

☐ Two years from the date of submission of my thesis.

☐ Three years from the date of submission of my thesis.

02/05/2023

Signature Date

ACKNOWLEDGEMENTS

First, I would like to thank my advisor, Dr. Sumru Guler Altug, for her unwavering support and invaluable guidance throughout this research project. I would also like to thank my committee members Dr. Ali Abboud and Dr. Nadine Yamout for their constant support and guidance through all the stages of writing my thesis.

Moreover, I would like to express my gratitude to my family and friends for their support and encouragement throughout my academic journey. Their encouragement and support have been a source of strength and inspiration, and I could not have accomplished this feat without their support.

Finally, I would like to dedicate this work to my grandfather, who has been my greatest supporter, his unconditional faith in my abilities and his constant encouragement have been the driving force behind my academic achievements.

ABSTRACT
OF THE THESIS OF

Tia Hassan El Mokdad for Master's of Arts
Major: Economics

Title: The Aggregate Productivity Consequences of Climate Change in the Middle East and North Africa Region

This paper investigates the impact of climate change on the labor productivity of the manufacturing sector in six countries in the Middle East and North Africa region (Egypt, Jordan, Oman, Morocco, and Qatar). By analyzing the effect of temperature on labor productivity, this paper sheds light on the consequences of climate change on sectoral reallocation, welfare, and trade. The findings reveal that the deviation in temperature leads to a decrease in labor productivity and a subsequent negative effect on production. Furthermore, the research presents evidence of the adverse impact of climate change on sectoral reallocation and proposes policies that can mitigate the costs associated with climate change.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Climate change is an increasingly pressing global challenge that is affecting various aspects of human life, including the global economy. Among its various impacts, climate change is causing negative effects on labor productivity. Labor productivity is a crucial measure of the output of goods and services produced per unit of labor input, and it is essential for economic growth, employment, and living standards. Recent research indicates that climate change has a negative impact on labor productivity, particularly in manufacturing sectors.

The manufacturing sector is a critical component of the global economy, and it is one of the most affected by climate change due to its high energy consumption and emissions. Understanding the impact of climate change on the manufacturing sector's productivity is vital for policymakers and stakeholders to design relevant climate adaptation policies. The Middle East and North Africa (MENA) region, in particular, is one of the regions most vulnerable to the impacts of climate change, with extreme temperatures, water scarcity, and desertification, among others. Therefore, this study aims to evaluate the impact of climate change on aggregate productivity in the manufacturing sector in the MENA region. The MENA region's manufacturing sector is a critical contributor to the region's economy, providing jobs and income for millions of people. However, the sector is also one of the most energy-intensive and polluting industries, accounting for a significant proportion of the region's greenhouse gas emissions. The impact of climate change on the manufacturing sector in the MENA

region is, therefore, a crucial area of study, as it has implications for both the region's economy and the global climate.

In this context, this study aims to provide insights into the impact of climate change on the manufacturing sector in the MENA region by examining the relationship between climate change and aggregate productivity. By using a panel data analysis approach and considering other factors such as GDP per capita, this study aims to contribute to the existing literature on the impact of climate change on the manufacturing sector and provide policymakers with insights into the potential impacts of climate change on the region's economy.

CHAPTER II

LITERATURE REVIEW

A preliminary literature review shows that past studies focused on the impact of climate change on productivity. Cline (2007) argued that during the 21st century, climate change will cause significant and heterogenous changes in agricultural productivity across the world, such as the large declines in agricultural productivity of 30-60% in hot regions such as Sub-Saharan Africa and South Asia, with neutral or positive effects in cold regions including Canada and northern Europe. Thus, this pattern suggests large potential gains from shifting the geography of agricultural production.

Costinot et al. (2016) argue that changes in temperature and rainfall patterns could lead to significant shifts in comparative advantage, with some countries becoming more competitive in certain agricultural markets and others becoming less competitive. Furthermore, according to Tombe (2015), poor countries have much higher agricultural employment shares despite lower relative value-added per worker in agriculture compared to non-agriculture. The average person in the world's poorest quartile consumes 91% of their food from domestic sources, compared to 45% in the richest quartile. High agricultural production and labor shares result from the high consumption shares required for people with low incomes to meet subsistence food requirements in these relatively closed economies (Nath, 2020).

Furthermore, Somanathan et al. (2021) find that high temperatures have a negative impact on productivity and labor supply in the manufacturing sector in India, the study finds that a one-degree Celsius increase in temperature leads to a 0.7%

decrease in productivity and a 0.4% decrease in labor supply. The negative effects of temperature on productivity and labor supply are more pronounced in industries that require manual labor and have lower levels of automation. In the same vein, Liu et al. (2021) argue that Climate change-induced increases in temperature and humidity are likely to have significant negative impacts on labor productivity in China, particularly in sectors such as agriculture, construction, and manufacturing.

Dasgupta et al. (2021) claim that climate change is likely to have significant negative impacts on both labor productivity and labor supply in many regions of the world, particularly in low- and middle-income countries. The authors used a multi-model approach to estimate the impacts of climate change on labor productivity and supply, based on empirical data from a wide range of sources. The models predicted that heat stress and other climate-related factors are likely to reduce labor productivity and supply in many sectors, including agriculture, construction, and manufacturing. The authors found that the negative impacts of climate change on labor productivity and supply are likely to be most severe in tropical regions, where temperatures are already high and are expected to increase further.

Kjellstrom et al. (2009) argue that the economic costs of climate change on labor productivity are likely to be significant, with estimates ranging from 1.2% to 12% of global GDP by 2100, depending on the severity of climate change and the adaptation measures implemented. Day et al. (2019) claim that climate change is expected to have a significant impact on labor productivity negatively, particularly in hot and humid regions of the world, which may affect a range of sectors including construction, agriculture, and manufacturing. Also, Von Below and Persson (2008) claim that climate

change poses a significant threat to global economic growth, with the potential to cause widespread damage to physical capital and infrastructure, disrupt global supply chains, and reduce productivity and output.

However, the literature also showed that the effect of temperature on labor productivity is not always negative, knowing that are several factors that affect productivity, most importantly that firms quickly adapt to temperature change and take the necessary steps that can affect labor productivity. For example, Linnenluecke et al. (2013) indicate that firms and industries are adopting a wide range of adaptation measures, including risk management, infrastructure development, and changes in business practices and operations. The authors also found that the effectiveness of these adaptation measures depends on a range of factors, such as the type and level of climate risk, organizational capacity and culture, and stakeholder engagement. Furthermore, a study was conducted with 25 interviews with firms in the Netherlands across different industries to explore their perceptions and interpretations of physical climate impacts and how these shape their adaptation behavior. The authors analyzed the data using a grounded theory approach to identify key themes and patterns. The study's results indicate that firms' interpretations of physical climate impacts vary depending on their industry, location, and business model. Firms in highly vulnerable industries, such as agriculture and water management, were more likely to have a clear understanding of physical climate impacts and their potential implications for their business. In contrast, firms in less vulnerable industries, such as finance and insurance, were less likely to have a clear understanding of physical climate impacts and their potential implications. The authors found that firms' interpretations of physical climate impacts shape their adaptation behavior by influencing their risk perception, the degree of urgency to act,

and the types of adaptation strategies considered. Firms that perceived physical climate impacts as a significant risk were more likely to implement proactive adaptation strategies, such as investing in new technology or changing their business model. In contrast, firms that perceived physical climate impacts as a minor risk were more likely to implement reactive adaptation strategies, such as increasing insurance coverage or relocating assets (Gasbarro & Pinkse, 2019). Another study done in the UK by Berkhout et al. (2006) used a case study approach to investigate how seven UK organizations from different sectors are adapting to climate change impacts. The authors analyzed the data using a framework of organizational learning, which involves the process of knowledge creation, dissemination, and implementation. The study's results indicate that organizational adaptation to climate change impacts is a complex and dynamic process that involves multiple levels of learning. The authors found that successful adaptation requires the development of new knowledge, the creation of new networks and partnerships, and the implementation of new practices and technologies. The authors also identified several barriers to organizational adaptation, such as a lack of awareness and understanding of climate change impacts, uncertainty and complexity, and limited resources and capacity. The study found that the most successful adaptation strategies were those that involved collaboration and partnership between different stakeholders, such as industry associations, policymakers, and research institutions.

This paper presents a model that studies the relationship between temperature and labor productivity in the manufacturing sector in six countries in the Middle East and North African (MENA) countries region (Egypt, Jordan, Kuwait, Oman, Qatar, and Morocco) between 1995 and 2016, and discusses the effects and cost of adaption to climate change in these countries.

CHAPTER III

METHODOLOGY

We use macro-level sectoral data of the manufacturing sectors in the MENA region from INDSTAT[1] - 2 databases from the United Nations Industrial Development Organization website. For climate data, we use monthly average temperature time series data from the Berkeley Earth Climate Data guide. And we use purchasing power parity adjusted GDP per capita data from the Penn World Tables.

The following Ordinary Least Squares (OLS) model is utilized to examine the impact of temperature on labor productivity in the manufacturing sectors. Estimating the following equation allows us to evaluate the effects of β_1 temperature (taking the deviation from mean temperature), β_2 GDP per capita, and β_3 employment on labor productivity $\left(\frac{Y_i}{L_i}\right)$. Furthermore, labor productivity is defined by output (Y) divided by Labor units (L) at year i.

$$Ln\left(\frac{Y_i}{L_i}\right) = \beta_0 + \beta_1(temp)_i + \beta_2(gdppc)_i + \beta_3(emp)_i + \epsilon_i$$

CHAPTER IV

RESULTS

A. Empirical Results

Table 1. Effects of Temperature on Labor Productivity

	(1) *Output/Worker*	(2) *Output/Worker*	(3) *Output/Worker*
temp	-0.152*** (-7.15)	-0.0971*** (-5.86)	-0.0991*** (-6.62)
gdppc		0.0000135*** (32.62)	0.00000921*** (21.12)
emp			-0.000000930*** (-18.83)
N	1584	1584	1584

Marginal effects; *t* statistics in parentheses
(d) for discrete change of dummy variable from 0 to 1
* p<0.100, ** p<0.050, *** p<0.010

Table 1 presents the regression results indicating that temperature, GDP per capita, and employment are all significant predictors of labor productivity in the manufacturing sectors in the MENA region. Specifically, a one-degree deviation of temperature from the mean is associated with a statistically significant decrease in labor productivity of 0.152 units, with a highly significant t-statistic value of -7.15. On the other hand, a oneunit increase in GDP per capita is associated with a statistically significant increase in labor productivity of 0.0000135 units, with a highly significant t-statistic value of 32.62. In addition, a one-unit increase in employment is associated with a statistically significant decrease in labor productivity of 0.000000930 units, with a highly significant t-statistic value of -18.83. These findings underscore the importance

of considering temperature, GDP per capita, and employment as critical factors in understanding labor productivity.

B. Validity Checks

There is a problem associated with the existence of a correlation between the independent variables since it increases the variance of regression coefficients, resulting in inaccurate statistical significance. Thus, it is essential to test whether there is a collinearity problem. Accordingly, our testing method is based on the Variance Inflator Factor (VIF), one of the most used diagnostic tests. According to Hair et al. (1995), the VIF level should not exceed 10. That is because a VIF value above 10 indicates the presence of multicollinearity. In Table 2, we can observe that all the VIF values are below 10. Moreover, the value of our VIF mean is 1.254, implying that we do not have any multicollinearity problem among our explanatory variables.

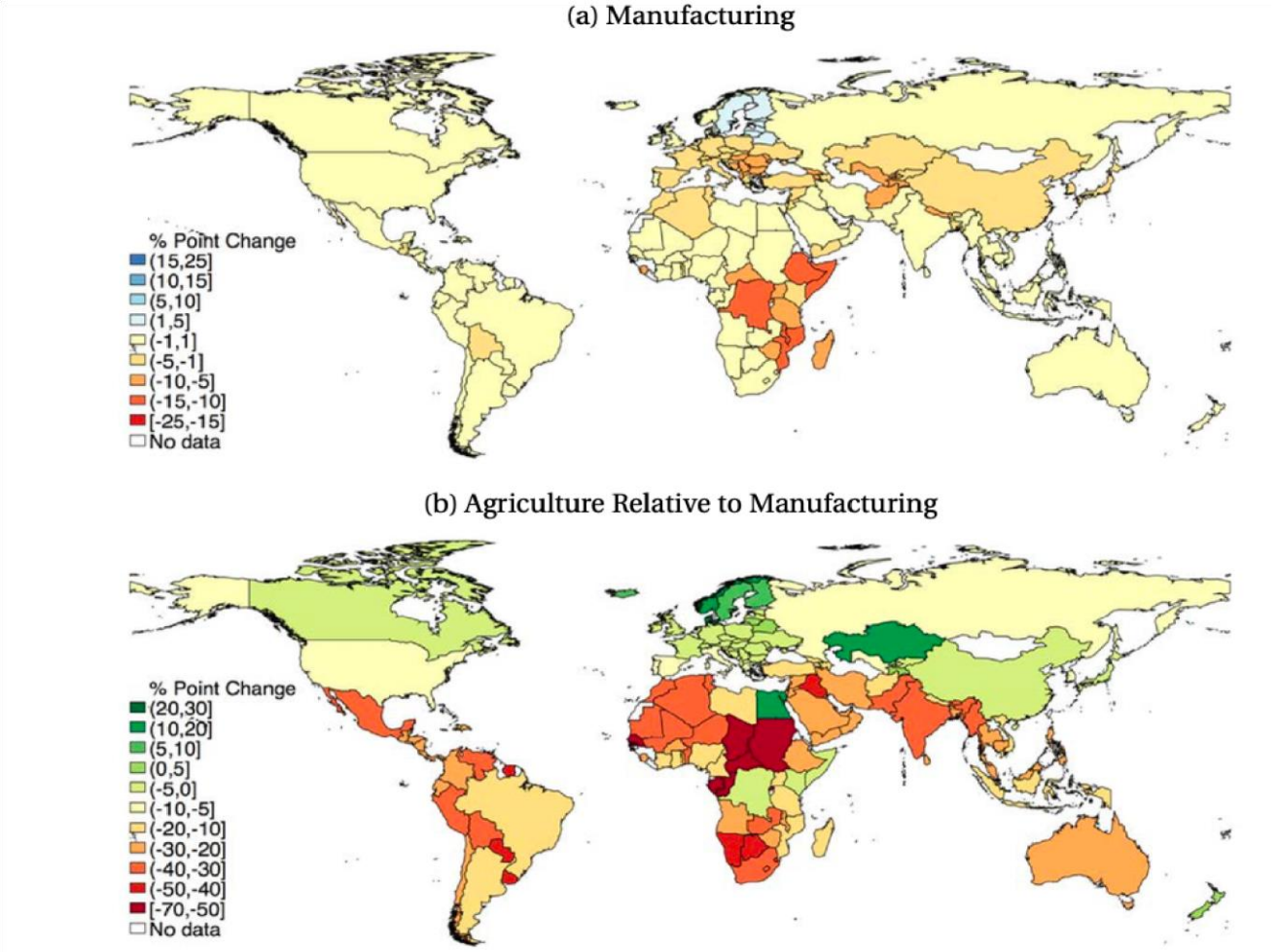
CHAPTER V

DISCUSSION

The model in this paper alongside the literature indicates that there is a negative relationship between temperature and labor productivity, whenever there is a deviation of temperature from the mean temperature, this means that labor productivity will be negatively impacted, consequently affecting the well-being of labor. For example, the health effects of extreme temperatures have been widely documented, including in Deschenes and Greenstone (2011). Several laboratory experiments, including Seppanen, Fisk, and Lei (2006) find evidence of reduced worker cognitive functioning. Graff Zivin and Neidell (2014) use time-use surveys to show that people work fewer minutes per day in the presence of extreme temperatures. Mentioning that labor productivity is affected by multiple variables other than the ones used in t used in this model such as technological progress, recessions, and climate adaption policies (Nath, 2020). Nevertheless, this was a limitation in this paper, due to the lack of data in the MENA region.

Furthermore, the effects of climate change fall far behind only affecting aggregate productivity in the manufacturing sector. According to the existing literature, it has a larger impact on agricultural sectors than non-agricultural ones.

Figure 1. Projected Impact of Climate Change on Productivity (Nath, 2020)



Consequently, it is likely to have significant impacts on global food production due to its impact on the aggregate productivity in the agricultural sector, particularly in developing countries that are more vulnerable to its effects such as the countries in the MENA (Nath, 2020).

Thus, international trade can help these countries cope with these impacts by providing access to food and other resources that may be scarce in their own domestic markets. It can also facilitate the transfer of technology and knowledge that can help countries adapt to climate change. For example, countries that are experiencing more

frequent and severe droughts may be able to import drought-resistant crops from other countries that have already developed these technologies.

However, there are also potential risks associated with increased international trade, particularly if it leads to greater environmental degradation or exacerbates existing inequalities between developed and developing countries (Gouel & Laborde, 2018).

Moreover, a carbon tax is likely to be the most efficient way to reduce greenhouse gas emissions which consequently reduces the cost of climate change. Such policy can create an economic incentive for individuals and firms to reduce their emissions, while also generating revenue that can be used to finance other climate-related initiatives. However, there are political and practical challenges to implementing such policies, particularly in countries with significant fossil fuel industries or a large number of low-income households that may be disproportionately affected by higher energy prices.

CHAPTER VI

CONCLUSION

Climate change is one of the most significant challenges facing humanity, and it has far-reaching effects on various aspects of life, including the global economy. The effects of climate change are already being felt worldwide, and it is projected to worsen in the coming years. This paper has explored the impact of climate change on aggregate productivity.

The research findings indicate that climate change has a negative effect on labor productivity, particularly in the manufacturing sector. The study revealed that deviation from mean temperature leads to a decline in productivity in the studied countries. Furthermore, the effect of climate change on labor productivity could lead to a decline in the well-being and welfare of employees.

The impact of climate change on food security is also a significant concern. Some countries will be better off than others, while others will be worse off, especially developing countries. International trade can help address food insecurity by providing access to food and other resources that may be scarce in their domestic markets. At the same time, it can also facilitate the transfer of technology and knowledge that can help countries adapt to climate change.

The study also suggests that reducing trade barriers is a necessary condition to curtail the costs of climate change. However, it is not sufficient to address the challenges posed by climate change fully. Future research can focus on the effect of

climate change on migration in the region and how it can affect sectoral allocation. The findings of such research can help policymakers design appropriate policies and interventions to mitigate the adverse effects of climate change.

REFERENCES

Graff Zivin, J., & Neidell, M. (2014). Temperature and the allocation of time: Implications for climate change. *Journal of Labor Economics*, *32*(1), 1-26.

Costinot, A., Donaldson, D., & Smith, C. (2016). Evolving comparative advantage and the impact of climate change in agricultural markets: Evidence from 1.7 million fields around the world. *Journal of Political Economy*, *124*(1), 205-248.

Bustos, P., Caprettini, B., & Ponticelli, J. (2016). Agricultural productivity and structural transformation: Evidence from Brazil. *American Economic Review*, *106*(6), 1320-1365.

Carleton, T., Jina, A., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., ... & Zhang, A. T. (2022). Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits. *The Quarterly Journal of Economics*, *137*(4), 20372105.

Comin, D., Lashkari, D., & Mestieri, M. (2021). Structural change with long-run income and price effects. *Econometrica*, *89*(1), 311-374.

Somanathan, E., Somanathan, R., Sudarshan, A., & Tewari, M. (2021). The impact of temperature on productivity and labor supply: Evidence from Indian manufacturing. *Journal of Political Economy*, *129*(6), 1797-1827.

Costinot, A., Donaldson, D., & Smith, C. (2016). Evolving comparative advantage and the impact of climate change in agricultural markets: Evidence from 1.7 million fields around the world. Journal of Political Economy, 124(1), 205-248.

Dekle, R., Eaton, J., & Kortum, S. (2007). Unbalanced trade. *American Economic Review*, *97*(2), 351-355.

Liu, Y., Zhang, Z., Chen, X., Huang, C., Han, F., & Li, N. (2021). Assessment of the Regional and Sectoral Economic Impacts of Heat-Related Changes in Labor Productivity Under Climate Change in China. *Earth's Future*, *9*(8), e2021EF002028.

Dasgupta, S., van Maanen, N., Gosling, S. N., Piontek, F., Otto, C., & Schleussner, C. F. (2021). Effects of climate change on combined labour productivity and supply: an empirical, multi-model study. *The Lancet Planetary Health*, *5*(7), e455-e465.

Kjellstrom, T., Kovats, R. S., Lloyd, S. J., Holt, T., & Tol, R. S. (2009). The direct impact of climate change on regional labor productivity. *Archives of Environmental & Occupational Health*, *64*(4), 217-227.

Tombe, T. (2015). The missing food problem: Trade, agriculture, and international productivity differences. *American Economic Journal: Macroeconomics*, *7*(3), 226-258.

Day, E., Fankhauser, S., Kingsmill, N., Costa, H., & Mavrogianni, A. (2019). Upholding labour productivity under climate change: an assessment of adaptation options. *Climate policy*, *19*(3), 367-385.

Uy, T., Yi, K. M., & Zhang, J. (2013). Structural change in an open economy. *Journal of Monetary Economics*, *60*(6), 667-682.

Von Below, D., & Persson, T. (2008). *Uncertainty, climate change and the global economy* (No. w14426). National Bureau of Economic Research.

Bansal, R., Ochoa, M., & Kiku, D. (2017). *Climate change and growth risks* (No. w23009). National Bureau of Economic Research.

Gouel, C., & Laborde, D. (2018). *The crucial role of international trade in adaptation to climate change* (No. w25221). National Bureau of Economic Research.

Kahn, M. E., Mohaddes, K., Ng, R. N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. Energy Economics, 104, 105624.

Linnenluecke, M. K., Griffiths, A., & Winn, M. I. (2013). Firm and industry adaptation to climate change: a review of climate adaptation studies in the business and management field. *Wiley Interdisciplinary Reviews: Climate Change*, *4*(5), 397-416.

Gasbarro, F., & Pinkse, J. (2016). Corporate adaptation behaviour to deal with climate change: the influence of firm-specific interpretations of physical climate impacts. *Corporate Social Responsibility and Environmental Management*, *23*(3), 179192.

Berkhout, F., Hertin, J., & Gann, D. M. (2006). Learning to adapt: organisational adaptation to climate change impacts. *Climatic change*, *78*(1), 135-156.

McNamara, K. E., Bronen, R., Fernando, N., & Klepp, S. (2018). The complex decisionmaking of climate-induced relocation: adaptation and loss and damage. Climate Policy, 18(1), 111-117.

Burnside, C., Eichenbaum, M., & Rebelo, S. (1993). Labor hoarding and the business cycle. *Journal of Political Economy*, *101*(2), 245-273.

Deschênes, O., & Greenstone, M. (2011). Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US. *American Economic Journal: Applied Economics*, *3*(4), 152-185.

Seppanen, O., Fisk, W. J., & Lei, Q. H. (2006). Effect of temperature on task performance in office environment.

Graff Zivin, J., & Neidell, M. (2014). Temperature and the allocation of time: Implications for climate change. *Journal of Labor Economics*, *32*(1), 1-26.

Hair, J. F. Jr., Anderson, R. E., Tatham, R. L. & Black, W. C. (1995). Multivariate Data Analysis (3rd ed). New York: Macmillan.

Gouel, C., & Laborde, D. (2018). *The crucial role of international trade in adaptation to climate change* (No. w25221). National Bureau of Economic Research.