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Economic Impacts of Climate Change: Evidence from OIC Member Countries

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Abstract

The paper attempts to explore the market impacts of climate change in the Organization of Islamic Cooperation (OIC) member countries. The market impact is examined through the production function using temperature in degree Celsius as a climate change variable. The paper finds that 1 percent increase in temperature is associated with1.2 percent fall in real GDP for OIC member countries. The findings confirm the general conclusions in the literature. In examining the data on the climate-related damages for the period 1992 -2011, Djibouti, Tajikistan, Guyana and Bangladesh are found to have lost on average around 2% of their GDPs to extreme weather events. The development banks should prioritize adaptation and mitigation measures for their member countries. In poor member countries, the projects should emphasize adaptation measures and emphasize mitigation measures in rich member countries. The rich countries are the big emitters, and they suffer relatively the least economic impacts of climate change, while the poor countries are the least emitters, and they suffer relatively the largest economic impact of the climate change.

1. Introduction

When temperature and precipitation change violently, there will be no doubt that some economic sectors will suffer from reduced output, or their output will be wiped out completely. Carbon dioxide emissions lead to concentration of greenhouse gases in the atmosphere resulting in global climate change. Coastal resources could be eroded, water stress and scarcity could increase, forestry could be lost to desertification, energy costs could increase, and tourism attractions could disappear resulting in lost tourism revenues. These five sectors will witness substantial changes as a result of climate changes. Though, they are estimated to account only for 5% of global economy, Mandelson (2009).At regional and country levels they could constitute major sectors in the economy. For developing countries that are commodity-based and resource-based economies and rely on the agriculture and tourism for employment, the damage caused by climate change could be far greater than 0.2% of GDP, an estimate for the world, Mendelson (2009). Climate change can increase rural-urban migration as agricultural farms are abandoned due to climate induced infertility of the lands and increasing costs of adaptation and mitigation. This migration will reduce the quality of living in the urban areas and increase poverty as the limited urban facilities will not be able to care for the excess population living in the slums. The next section explores the literature on the economic impacts of climate change. Section 3 discusses the data on emission, weather-related damages, and temperature in the OIC member countries. section 4 presents the estimation model and analyzes the results, and section 5 concludes and draws the implications.

2. Literature review

At global level, climate change damage is estimated to cost 0.2% of the world GDP, Mendelson (2009). This relationship can vary widely at regional and country levels, as some regions or countries are believed to face more damages from the climate changes than others do. Poor countries are more hardly hit by climate change than rich countries, and climate change will cause more damages to agriculture than other economic sectors, Dell, et al (2008). One-Celsius degree rise in temperature is expected to reduce growth by 1.1 percentage points in poor countries, Dell et al (2008).

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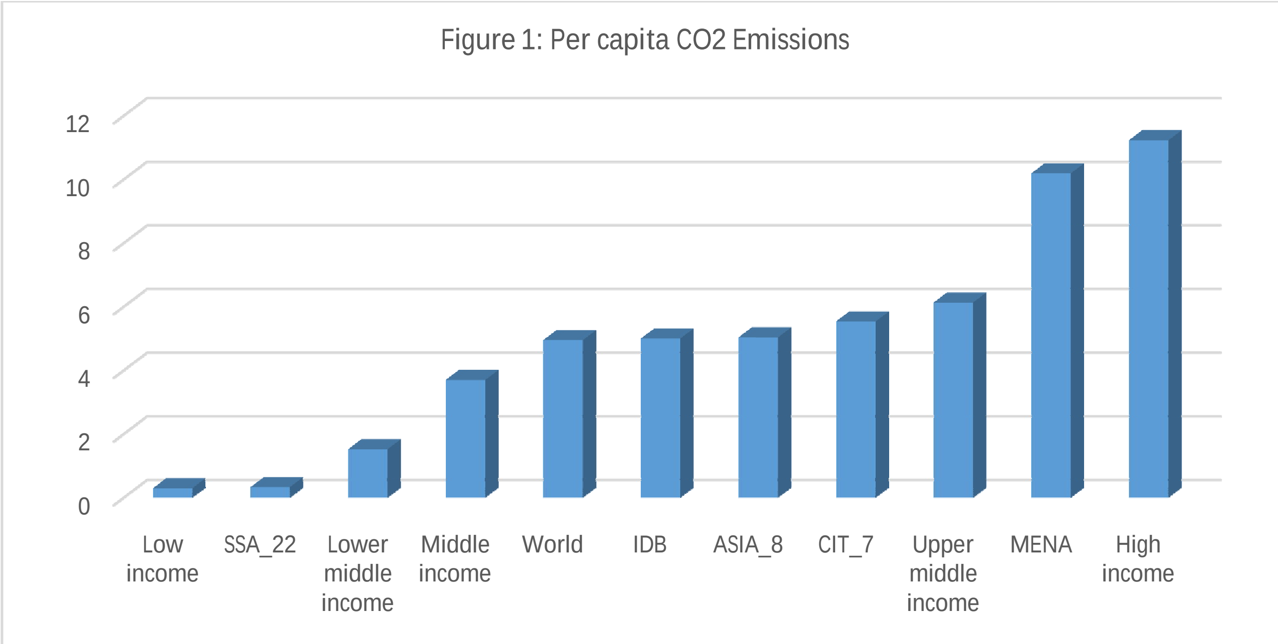
Their study finds that in Sub-Sharan Africa (SSA), where OIC has 22 members, one-Celsius degree rise in temperature reduces the economic growth rate by 1.897 percentage point. Alagidede et al (2014) confirmed this finding for Sub-Saharan Africa. They find an increase in temperature to reduce the economic performance in SSA, and precipitation has no significant effects on the economy. Climate change slows down the fight against poverty, as climate shocks worsen the conditions of the poor, who often do not have resources to adapt and recover from the climate change damages. Climate change sends poor farmers out of business, and without proper intervention, they will face permanent damage to their livelihood in terms of health and education of their children, trapping them and their children in a vicious circle of poverty. Agriculture and environmental resources are the main source of living for the poor, and these resources are the most affected by the climate change. Growth in agriculture can fall by 1.8% due to a cumulative 10-year rise in temperature, Dell et al (2008). Some findings have put the cost of climate damage at 3.6% of GDP, Ackerman and Stanton (2008). Using 2000 global cross sectional data, Dell and Olken (2009) find that income per capita falls by 8.5% for every one degree Celsius increase. Their findings indicate that 23% of variations in cross-sectional country income can be explained by temperature. The impact of climate change is also noted on international trade. Jones et al (2010) investigate the international trade data and they find that one degree Celsius rise can reduce a country's exports by between 2.0 to 5.7% in poor countries, and no effect is observed for the rich countries. The relationship between economic activity and climate carries a great deal of uncertainties and it is often non-linear and dynamic. This complicates its modelling and estimation. Roson (2003) observes that this relationship is not a one-time event, it rather evolves over time, and the nature and human system interact dynamically. Thus, Below and Persson (2008) doubt the usefulness of static models for estimating the relationship between climate change and economic activity. This does not rule out the immediate effects of climate change as found by Dell, et al (2008), Ackerman and Stanton (2008), Dell and Olken (2009, and Alagidede et al (2014). What is evident is that the relationship is non-linear and its magnitude becomes more dominant in the long run than in the short run. The non-linearity is evident regardless of whether the data is time series or cross-sectional, Schlenker and Roberts (2008). The findings of Tol (2002) show the relationship be both positive and negative depending on regions, sectors and periods examined. The negative effect is dominant in the long run and in the poor countries and less discernible in the rich countries. In the short run, the sensitivities of the economic sectors become very relevant. The uncertainties about the nature of the relationship has encouraged Stern (2013) to call for the overhaul of the current models and to look beyond the economic impacts and focus on the lives, livelihoods and the risks of large scale migration and conflicts that will happen as a result of climate change. However, as Decanio (2003) noted, climate change economic models with non-market environmental variables with representation of people, who are not born yet will result in multiple equilibrium solutions, and the results may not be more than the assumptions incorporated in the models. Therefore, both complex and simple models will help us understand some aspects of the relationship between economic activity and climate change. The current paper expects to add a value to the debate by providing further evidence on the nature of the relationship for OIC member countries and help identify the most affected regions by the climate change. The other value added will manifest in the use of both temperature and rainfall variables in a modified climate change function that enters multiplicatively the production function.

3. Data

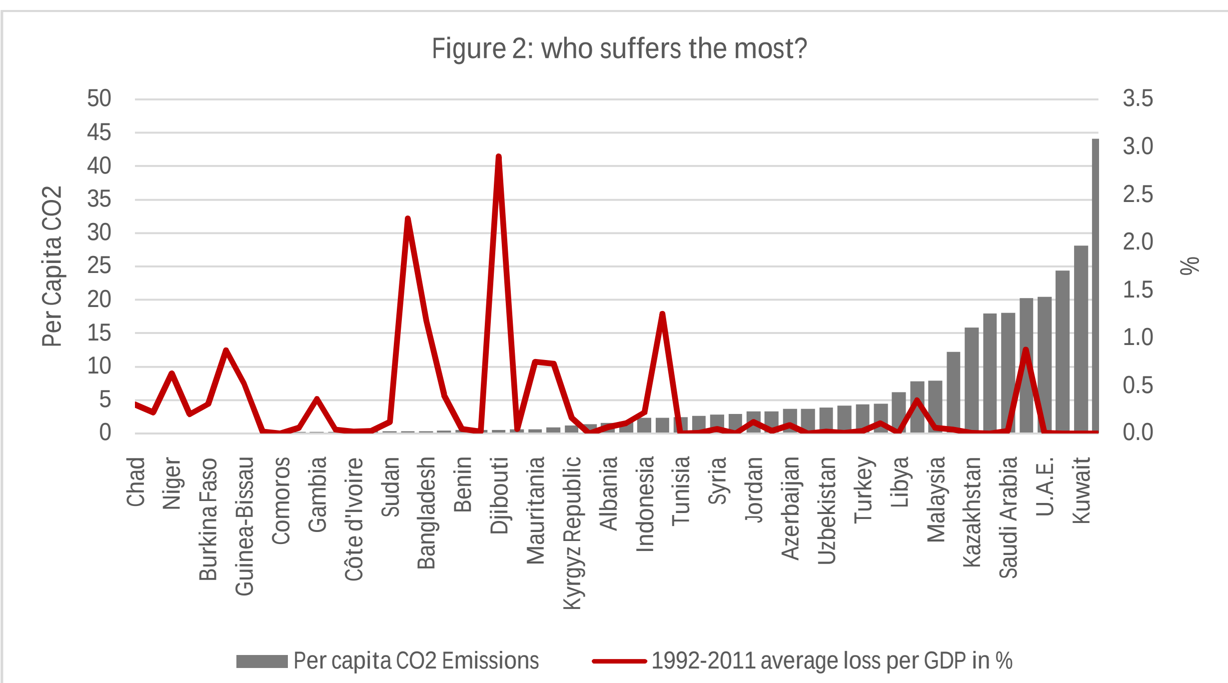
The paper sources its data on temperature from World Bank. The data on capital stock and employed labor come from the Penn World Tables.2011 observation of CO2 emission are employed in the visualization analysis. The costs of climate change (extreme weather events) are sourced from Harmeling and Eckstein (2013). We use figures 1, 2 and 3 to visualize some of the data. Figure 1presents the OIC groupings in relative to the world groupings in terms of per capita CO2 emissions. It illustrates that low income countries are the least emitters, and the high-income countries are the biggest emitters. Middle East and North Africa (MENA) members follow the high-income countries, and SSA members follow the low-income countries. That is, OIC has both major emitters and least emitters. The OIC average is above the world average, and this is driven by the MENA, CIT (countries in transition) and ASIA members. CO2 emissions constitute a major component of greenhouse gases, and other components such as nitrous oxide, methane and fluorinated gas, are converted into CO2-equivalents. To save the world from tragic climate effects, the greenhouse gases should be reduced to 450 parts per million CO2 equivalents, and the current level passes 400 PPM CO2 equivalents[†]. This calls for an urgent implementation of climate policies.

[†]https://www.originenergy.com.au/blog/big-picture/countdown-to-climate-change-talks-in-paris.html

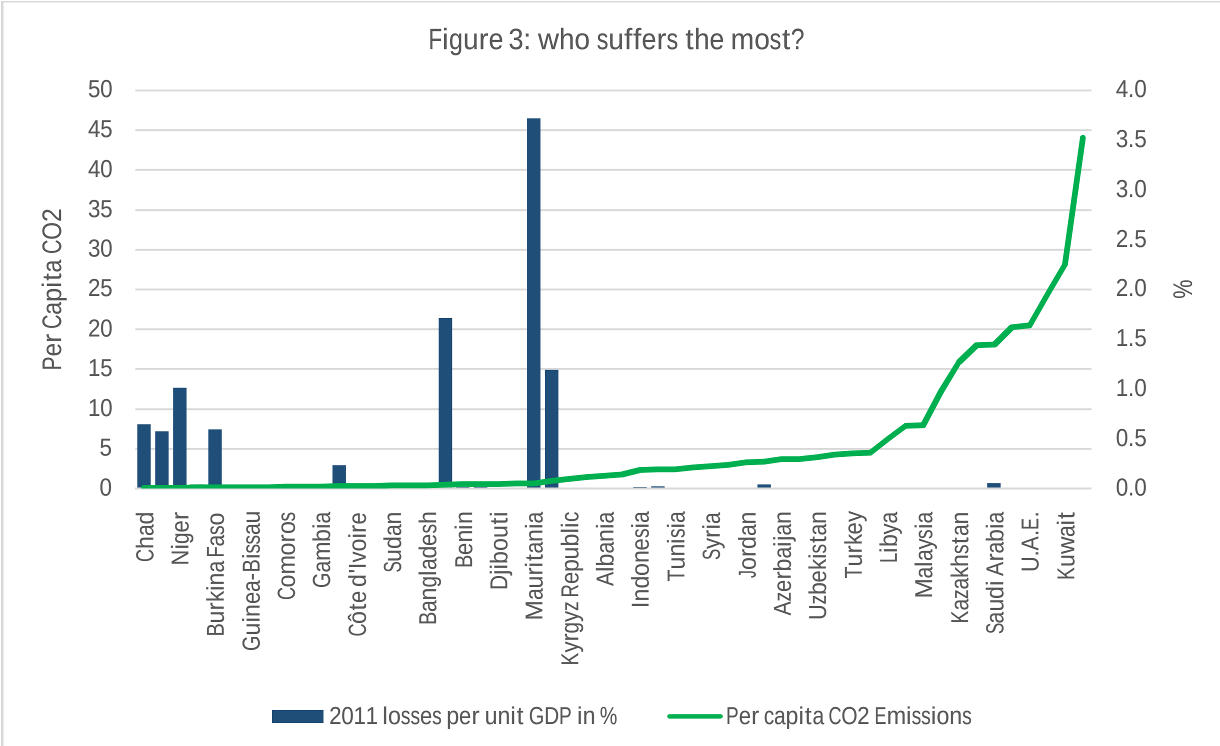


Source: World Bank

Figures 2 and 3 show that countries that emit less CO2 suffer the most in term of climate change related damages, and countries that emit the most suffer the least. Those who suffer the most are also generally the least developed countries that are grappling with the fight against poverty. Thus, climate change complicates their poverty reduction solutions. For the OIC members, this is a challenge to forge bilateral and multilateral cooperation among the members so that those who face the negative externalities of emissions can work together with the major emitters to mitigate climate change effects for both parties.



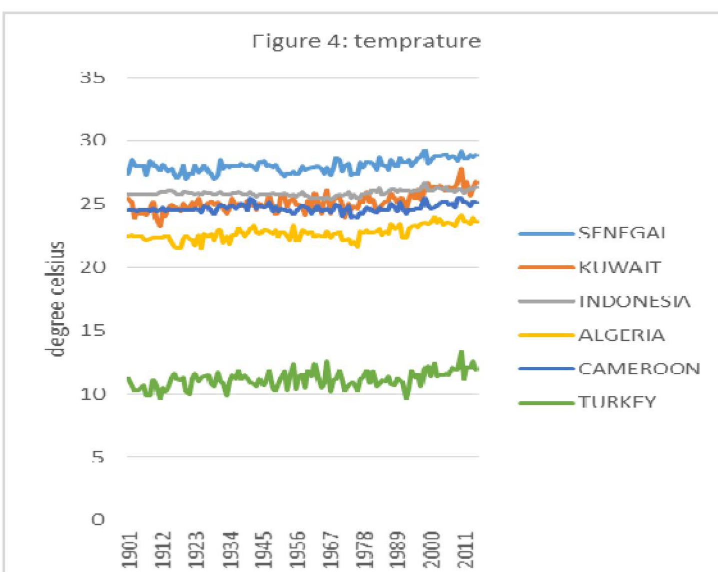
Source: World Bank, and Harmeling and Eckstein (2013), Germanwatch.



Source: World Bank, and Harmeling and Eckstein (2013), Germanwatch.

Is there an evidence of rising temperature in the member countries?

It is important to investigate this question, because it forms the basis for estimating economic impacts of climate change. The climate change can be observed through temperature changes, and particularly if those changes indicate steady rises. To attempt to answer this question, I collect annual average temperature data for 36 OIC member countries for the period of 1901 – 2015. I run principal component analysis to reduce the member countries into seven groups: West Africa, Central Africa, North Africa, Middle East, Europe, and South East Asia. The representative member countries for these six groups are Senegal, Cameroon, Algeria, Kuwait, Turkey, and Indonesia respectively. Figure 4 shows the trends of temperatures in degree Celsius. In this figure, there is an emerging steady upward trend in the data of each country starting from 1980's. The upward trends are distinctly visible for Senegal, Turkey, Kuwait, and Algeria.



Senegal saw its lowest temperatures in 1920 and 1929 at 26.92686 C° and 26.95891 C° respectively, and its highest temperatures in 1998 and 2010 at 29.20352 C° and 29.16289 C° respectively. From the lowest ever at 26.92686 C° in 1920, it has increased 7.289% to reach 28.8895 C° in 2015. Similar trend is observed in Kuwait, where the lowest ever temperature was recorded in 1911 at 23.2613 C°, and the highest ever temperature in 2010 at 27.75396 C°. For the last ten years, the annual average temperature in Kuwait has been rising steadily above 25 C°. Algeria saw its lowest ever temperature in 1925 at 21.49623 C°, and the highest ever in 2010 at 24.13558 C°. Turkey also saw a notable rise of temperature from the lowest ever in 1911 at 9.627659 C° to 13.31957 C° in 2010. From these observations, I can conclude that weather was colder in the earlier years than now in many countries. In the next section, I estimate how this rising temperature translates into the negative effects on the economic well-being of the countries.

4. Theoretical framework, Results and Analysis

For the least developed economies to grow, they have to industrialize first using the cheap available methods and energy, which are often costly to the environment and produce high CO2 emissions. For example, in South East Asia, forests with unique Bios stems are cleared to make ways for industrial plantations and infrastructures. The expansion and growth of the economy is associated with increasing CO2 emission and damage to the environment. These damages are necessary initially for the economic modernization as no country wants to remain a wildlife for the rest of the world. However, permanent and continued accumulation of the damages places a drag on the economic expansion and growth, and eventually reduces it and causes it to be negative. This indicates a non-linear relationship between the economic growth and the climate damage. Thus, human beings need to optimize the damage they cause during the economic modernization and growth. Using Ramsey-Cass-Koopmans economic growth model, Frankhauser et al (2005) allow their social planner to optimize a utility function that incorporates climate change variable with respect to capital and labor constraints, which too incorporate climate change variable. The model is set as

$$\max \int_0^{\infty} U(c, T) e^{(n-\rho)t} dt \qquad (1)$$

With respect to capital and population growth respectively

$$\dot{K} = F(K, L, T) - cL - \delta(T)K \qquad (2)$$

$$\dot{L} = n(T)L, \qquad (3)$$

In this optimization, the climate change variable, T(temperature), enters the model through four channels. The first channel is the utility function channel in equation (1). It assumes that people lose utility or happiness and pleasure due to loss of bio system and natural environments caused by climate change. The consumption process that produces utility for the people, it also produces carbon dioxide emissions, which causes damages to their utility. If the damage caused by temperature can be described by a reciprocal function to state that as temperature increases the function decreases, the relationship can be stated as.

$$f(T_t) = \left(\frac{1}{T_t}\right) \quad , T \succ 0 \qquad (4).$$

This loss or damage function is a simplified version of that of William Nordhaus (Pindyck, 2010). His direct damage function is stated as $f(\Delta T) = \frac{1}{(1 + \pi_1 \Delta T + \pi_2 \Delta T^2)}$

This damage function (4) is multiplied by the utility function as

$$U = f(T_{it}) U(C_{it}, X_{it}) \qquad (5)$$

To estimate this relation, using log form, we get

$$\ln U_{it} = \ln[U(C_{it}, T_{it})] = a_0 + a_1 \ln C_{it} + + a_2 \ln X_{it} + a_3 \ln f(T_{it}) + \varepsilon_{it} \qquad (6)$$

The happiness and pleasure of people increases with consumption of all other goods and service, C, and decreases with climate change damage. X stands for other control variables. The second channel, through which climate change could affect economic well-being, is production function channel. This is shown by the first part of the right hand side of equation (2),and it assumes that climate change is negative; it causes damage to the output to fall.

With the current technology and business as usual, the damage may be necessary initially for economic modernization and growth, but as the damage accumulates without climate change mitigation, the economic growth and expansion will slow down and eventually decline. Changing the technology with efficient ones that produce less emission or zero emission output can expand without increased emission. Here, we assume technology constant and exogenous. Thus, increased economic output means increased emission; and increased emission results in increased temperature, which consequently causes damages to the economy. This non-linear relation between the economic output and the climate change is specified by multiplying the economic output by the climate change function (5):

$$Y_{it} = f(T_{it})F(K_{it}, L_{it}) \qquad (7)$$

I use factor input data of Penn World Table for the capita stock and employment. I specify equation (7) in log form as

$$\ln Y_{it} = \ln[f(T_{it})F(A_i, K_{it}, L_{it})] = b_0 + b_1 \ln K_{it} + b_2 \ln L_{it} + \ln f(T_{it}) + v_{it} \qquad (8)$$

In this model, Temperature, T, enters non-linearly. The control variables are capital stock, k, and employment, L; while b_0 stands for the coefficient of the constant technology.

Table 1: level impacts of climate change on real GDP

Dependent variable: log real GDP				*Number of obs =*	*162*
				Number of groups =	*3*
R-sq: within = 0.8781				*Obs per group: min =*	*4*
between = 0.8858				*avg =*	*4*
overall = 0.8787				*max =*	*4*
corr(u_i, Xb) = 0.4291					
(Std. Err. adjusted for 36 clusters in country)					
variable	*Coef.*	*Std. Err.*	*t*	*P>t*	
ll	*.2774094*	*.0904491*	*3.07*	*0.004*	
lk	*.5327015*	*.0774658*	*6.88*	*0.000*	
lt	*-1.185774*	*.5816059*	*-2.04*	*0.049*	
cons	*.3096465*	*.7880865*	*0.39*	*0.697*	
sigma_u	*.26660972*				
sigma_e	*.09999087*				

The other two remaining channels relating climate change to the economy are the depreciation channel, the last part of the right hand side of equation (2), and the population growth, the right side of equation (3). Climate change is assumed to accelerate the depreciation of capital stocks forcing countries to tie up increasing investments in the replacement of the tear and wear of the capital rather than in the expansion and addition of new capital. Increased temperature is associated with wide spread of diseases resulting in increased mortality and health costs. Increased mortality and health costs are bound to affect the labor and human capital of a country and eventually the economic growth. These four relationships are an attempt to establish the economic impacts of climate change. In this paper, I estimate the relationship in equation (8) to provide some empirical evidence from the member countries of Organization of Islamic Cooperation. The estimation involves a panel data set consisting of 36 countries for 45 periods. V_{it} in equation (8) becomes a composite error term. This term consists of individual unobservable time-invariant effect and the traditional random error. The data set will follow a fixed-effect model if the individual effect is correlated with the explanatory variables; and it will follow a random-effect model if the individual effect is uncorrelated with the explanatory variables. After the Hausman test, I find the data set to follow a fixed effect model. I estimate this model with time-fixed effects, and the result summary is presented in table 1. The time-fixed effects were found negative and significant for each year in the period 1986 – 2002 and zero otherwise. This implies that the production function has shifted lower in the period 1986 – 2002 compared to the other years. This period has been termed by Siebert (2004) as the era of globalization; it witnessed sharp increases in the international trade, trade liberalizations and trade agreements.

The period also coincided with the World Bank and IMF's imposed economic restructuring programs (ERP) in several African countries. The ERP has forced African countries to liberalize their markets and remove government supports from several economic sectors. The combination of these two forces (globalization and ERP) could be a reason behind the downward shift of the production function during this period. As expected, the temperature is found to have negative economic impacts. 1 per cent rise in temperature is associated with 1.2% fall in the real GDP over time and between countries. This economic impact of climate change is slightly higher than 0.2% fall of GDP at global level, Mendelson (2009). It implies that the negative economic impact of climate change on average is higher in OIC member countries than the world average. This is not surprising given the dominant number of poor countries in the OIC memberships. Itis found that poor countries suffer more negative economic impacts of climate change than the rich nations, because the rich nations have financial resources to adapt and adjust to the climate changes, Dell et al(2008) and Alagidede et al (2014). Nevertheless, the findings in this paper are within the estimate of IPCC (2014) that shows that a 2-degree rise in temperature reduces real GDP by between 0.2% and 2%. It is far below the estimate of Dell and Olken (2009), who find one-degree rise in temperature to reduce income per capita by 8.5%.

5. Conclusions and Policy Implications

This paper attempts to explain the economic impact of climate change in OIC member countries. The impacts are divided into market impact and non-market impacts. The market impacts are defined as the damages to the real output (real GDP), and non-market impact is represented by the happiness and welfare of the people. The climate change variable is defined by annual average temperature in degree Celsius. We find that one percentage increase in temperature on average reduces real GDP by 1.2 percent for the OIC member countries. For climate-related damages, I find the worst affected member countries for the period 1992 – 2011, are Djibouti, Tajikistan, Guyana and Bangladesh. These countries have lost around 2% of their GDPs to extreme weather events. These countries are among the least emitters of CO_2, and the data show that poorer and least emitters often suffer the most in terms of climate related-damages. In the light of these findings, the paper has two recommendations to include in the climate policy of the development banks. The banks should prioritize adaptation and mitigation measures for their member countries. The banks should embody adaptation measures in all its projects for the poor member countries. All the projects in poor countries should be particularly temperature resilient to reduce costs of wear, tear and energy inefficiency. The projects for the rich member countries should include mitigation measures to reduce their contributions to the climate change. The banks have no control over the intended nationally determined contributions (INDCs) of member countries for greenhouse gas reductions, but they can follow the recommendations here to make their projects climate-specific as the economic status of the member countries is concerned.

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