THE IMPACT OF CLIMATE CHANGE UPON SOCIAL WELFARE

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**Introduction**

Although fossil fuels have been in use by humans for thousands of years, it hasn’t been until the last 150 years or so with the worldwide advent of fossil fuel powered machines that the use of the fuels has become a problem. The continued ever-increasing usage of petroleum, coal and natural gas is slowly leading towards more intensified climate change, which is a change in global or regional climate patterns, and global warming, which is the rise in the average temperature of the Earth’s climate system that has occurred over the past 150 years, along with their related effects (these two issues will be collectively referred to as climate change throughout the remainder of this paper, for the sake of simplicity). While this change in the Earth’s ecosystem is not affecting humanity substantially yet, the next generation of humans will have a much more intense problem to deal with thanks to using fossil fuels now, as the negative externalities expunged through the use of such fuels will continue to mount and multiply, leading to an overwhelmingly negative impact upon social welfare for the entire planet.

With gradual change of the Earth’s climates over the past century, many things have been changing and will continue to with increasing intensity in the future. Warmer temperatures mean that more intense storms will become common, with Hurricane Katrina being a good example of what exactly can happen when a “perfect storm” of factors combine together to bring forth a massive disaster. Katrina ended up being the costliest natural disaster to ever grace this planet (NOAA, 2011), and with the climate change only increasing in speed, it will surely be surpassed in the future.

As previously stated, while the effects of climate change are not felt currently, in the future they will be infinitely more annoying and obvious. Because of this, most people, including the vast majority of governments around the globe, are not attributing much of a priority on fighting back against greenhouse gases (the gases being released into the atmosphere through the burning of fossil fuels, e.g. CO2). The social costs of climate change simply are not high enough for many governments to care enough to do anything right now. This is exemplified by the United States’ refusal to sign the 1997 Kyoto Protocol, an international treaty that extends the 1992 UN Framework Convention on Climate Change, which commits states which have ratified it to reduce greenhouse gas emissions. As David Pearce noted in his article on the social cost of carbon and its implications on government policies, the USA did not ratify the treaty due to three separate factors “… (a) a perception that the domestic costs of compliance are [too] high, (b) recent work suggesting the benefits of control are very low for the USA, and (c) the realization that future agreements will require significant side payments to developing countries to bring them ‘on board’ with the Protocols (Pearce, 2003).”

Now while climate change may not be affecting the USA and other modern nations today, and will likely not affect them all too much in the future as their economies are/would be resilient to climate changes for the most part, 3rd world and other not fully developed countries have economies which are much more climate-sensitive (Pearce, 2003). Therefore, with climates around the world beginning to change drastically, the future prospects of such countries are daunting (not to discount the plight of developed nations of course, but again they would be affected less-so). This will lead to drastic changes not just in the economies of these countries due to numerous things such as natural disasters, which have more of an impact on 3rd world countries than developed ones (e.g. the 1970 Bhola cyclone which killed over 300,000 people in India/Pakistan), but also major changes around the rest of the world. For example, ice all around the globe is melting (notably at the Earth’s poles and at major glaciers around the world), sea levels are rising quickly, and most important, the changing temperature has brought more rain and hotter, more intense weather, which is leading to crops which thrived in areas simply not being able to survive there anymore. With this happening, countries that still rely on such crops as a main pillar of their society are being harmed substantially, and this is a result of countries like the USA consuming so much of the world’s fossil fuels, and consequently outputting the most greenhouse gases. So, the poorest of the poor will be the ones hit the hardest, and this can set back entire countries several years, leading to a major crisis affecting not just the countries hit hard, but also the rest of the world due to the extreme interconnectedness of economies, and even more so in the future when these externalities are truly felt the most.

Climate change is an issue that many people today still do not believe is mainly caused by man, despite broad scientific consensus on the matter (NASA, 2016). This knowledge alone should be an indicator of why there should be more research done on the subject to quell the doubt still on some people’s minds. With that said, this paper is meant to explore not why climate change is happening, as we already know that, but how exactly will it impact social welfare and why it is important to research both what its continued impacts will be, and what we can do to slow its progress.

Climate change is a global issue and as such there have been some people, along with some notable economists, who have devoted their time and effort to such a significant issue. Despite climate change being a problem that could lead to a major global catastrophe, there has not been nearly enough research, both relating to economics and the physical sciences, done on the topic. The point of this section is to look at some of the important pieces of research done on the effects of climate change and, more importantly, what we can do to combat the issue.

**Climate Change’s Effects**

Nicholas Stern’s monumental report (Stern 2008) on climate change is one of the largest and most widely known and discussed report on climate change ever compiled and was sponsored by the UK Government itself. Stern’s report was wide-ranging and went in depth about several of the effects which come from climate change, including both the various, wide-ranging effects that climate change is having on the world currently (including the melting of ice caps in the north and south poles, causing ocean levels to rise, among other effects), and some possible solutions that could be enacted to help stall and fight back against the issue. Before we delve into some of the specifics that Stern talks about in his report, it is important to hear why he believes the topic is so important. He states that all people around the world produce greenhouse gas (GHG) emissions, and everyone of us is already suffering from them. If GHG emissions continue to rise, there could be potentially catastrophic impacts in the future, and so these greenhouse gas emissions should not be viewed as typical, local externalities, but rather should be looked at on a global scale.

Stern says in his report that if we do not act in the immediate future, the overall costs and risks of climate change will be roughly equivalent to losing, at the very least, 5% of global GDP each and every year, in perpetuity (Stern 2008, p.22), and this is with relatively minimal estimates of increased temperature. This would first hit underdeveloped countries, causing irreparable damage to them and starting a dangerous avalanche of economic and governmental collapses across the globe. The undoing of the world economic system thanks to climate change would first start with extreme weather cases such as floods, droughts, storms and so on increasing in frequency over time, as evidenced by research from physical scientists (Stern 2008, p.2). Not only would economies suffer as a result of the randomness and higher frequency of extreme weather events, but human life would as well as countless lives will be destroyed.

In another report on climate change, Richard Tol takes a slightly different aim at the issue as he writes about how he believes that despite the incredible risk of a major catastrophe happening as a result of climate change, there is a notable lack of quality research done on the topic (Tol 2009). For example, Tol notes that in spite of the research already performed on the effects climate change will have on various areas such as “agriculture and forestry, water resource, coastal zones, energy consumption, air quality, and human health,” the full assessment, even within each category, is far from complete (Tol 2009, p.43). Some of the examples he gives for missing effects of climate change is that the effects of sea level rise on coastal zones omit costs of saltwater intrusion in groundwater, increasing water temperature would likely lead to the increase in the cost of cooling power plants and that larger storms may lead to higher, and therefore more expensive building standards, among others (Tol 2009, p.43). These points cannot be ignored and therefore there is certainly much more research needed on the issue to fully quantify what the economic effects of continued climate change will be.

Graciela Chichilnisky and Geoffrey Heal’s paper on global environmental risks defines what exactly the type of risks and their associated effects that climate change could bring about are. They state that “we are dealing with risks that are poorly understood, endogenous, collective and irreversible,” which in other words means that we need to work together against this threat as soon as possible (Chichilnisky et. al 1993, p.3). Chichilnisky and Heal believe that despite the large costs that working to fight against climate change now would incur, it is worth it as the risk is simply to high to ignore, and so we must mitigate that risk in any way possible (Chichilnisky et. al 1993 p.20).

Robert Pindyck’s paper echoes what Tol’s research concluded: that we simply do not have enough research on the topic to fully quantify what the effects of climate change will be, and because of this, people do not fully understand the magnitude of the issue at hand (Pindyck 2013, p.12). For instance, Pindyck believes that many different models simply ignore the fact that a large-scale catastrophic outcome outside of severe weather, such as a major, negative, global economic effect that leads to huge declines in human welfare (Pindyck 2013, p.11). This leads to the issue that policies that will help to alleviate the problems caused by climate change will simply not be enacted, thereby leaving us in our current state with no effective policies and the Earth’s state slowly degrading as a result.

**Possible Solutions**

Stern’s report on climate change also outlines some of things that would have to come to fruition if the world would like to see any sort of progress done against climate change. He outlines the following four points as key elements in the fight against climate change: emissions trading, technology cooperation, action to reduce deforestation and adaptation, with each of these points including a call for increased cooperation between nations and that climate change be fully integrated into the policies for development of nations going forward (Stern 2008).

Richard Tol’s paper also outlines some possible solutions to fighting back against climate change in addition to listing some of the more nuanced effects that could come about as a result of the issue. He notes that the high-income countries have varying costs associated with carbon emissions ($78/ton of Carbon for the EU, but $15/tC for the US), which leads to conflicting views on the topic (Tol 2009, p.46). Tol states that he believes that there is a very strong case for action against climate change in the short-term, likely starting with a low cost of carbon for all countries (again, stressing international cooperation, as Stern suggested), with an increase in the cost over time to “ease the transition and to give analysts the ongoing ability to evaluate costs, benefits and policy mechanisms” (Tol 2009, p.46).

In another statement on what should be done to combat climate change, Robert Pindyck in concluding his paper on the effects of climate change goes on to say how he believes that it would make sense to take the Interagency Working Group’s estimate on the social cost of carbon ($21 or an updated $33) “as a rough and politically acceptable starting point and impose a carbon tax (or equivalent policy) of that amount” (Pindyck 2013, p.12). This would help to quantify the cost of carbon, or climate change, and put in people’s minds that it truly is a large issue that needs to be taken care of.

Daniel Etsy’s work on the solutions for climate change brings up some interesting points with regards to the strategy that nations should be subscribing to if they would like to solve the problem. Etsy believes that in order for the world to succeed in ridding itself of the climate change problem, we must first realize that just by stating how much of an economic problem climate change will be in the future will not be enough to turn heads towards the issue (Etsy 2008, p.6). He believes that the way towards chipping away at the issue is to create and implement an institutional approach that “starts with the well-established learning about public goods and the logic of collective action can provide,” in addition to appropriate policy implementations and ethics principles (Etsy 2008, p.6). With this, he believes that there is hope for humans to start working towards first stopping climate change in its tracks, and then working to reverse the process.

Finally, a paper by Graciela Chichilnisky and Geoffrey Heal brings up an important point if any of these solutions are to make any significant progress and that is that economists on their own cannot solve the issue: it will take close work between both them and physical scientists if we would like to see progress on the issue (Chichilnisky and Heal 1993, p. 20). Once work between countries, scientists and economists can be done without any hindrances, true progress will begin to be made on the topic of climate change.

**Research Proposal**

The purpose of this section of the paper is to propose and implement a quantitative analysis on the impact which climate change has upon social welfare. Before we delve into the specifics of the model, it is important to first take a look at any research and studies which have been performed on the topic.

While there are still people today that may not believe in how climate change is a real and dangerous threat to society, there are not many scientists or intellectuals who subscribe to this same notion. There are essentially no recent peer-reviewed documents attempting to disprove that climate change is real. On the contrary however, there are numerous documents noting that climate change is a threat to social welfare that needs to be further researched in order for society to try to properly fight against it. We will first look at two important components of social welfare, happiness and economic well-being, and how they are affected by climate change.

In a paper looking at the impact of climate on life satisfaction, David Maddison and Katrin Rehdanz analyze the impact of climate upon the average life satisfaction of several countries in an attempt to show how climate change can lead to disastrous outcomes (Maddison et. al. 2005). The authors go on to show through a least-squares approach how even when controlling for external factor, climate has one of the most significant effects on country-wide self-reported levels of happiness. By confirming through statistical analysis that this effect holds true, the authors then surmise that human-induced climate change could dramatically change the levels of happiness that exist between countries (Maddison et. al 2005). Some countries would inevitably move towards a more preferred climate than the one they are currently in, and others would obviously move away from them.

This effect of climate change, along with rising sea levels, would likely be one of the major reasons that mass migrations begin to happen in the future, completely changing the demographics of the globe. These people who have to move are environmental migrants/climate refugees forced to leave their home due to long-term/sudden changes to their environment, and this is certainly something that will be happening in the future due to climate change.

The happiness of people is just one of the factors that is a part of social welfare, and it is most certainly not the only thing that is being affected by climate change. In a piece of research attempting to put a price of greenhouse gas emissions, Samuel Fankhauser, provides one of the first papers that looks at the global potential costs of climate change and puts a price on damage estimates (Fankhauser 1994). It is interesting to note that even when Fankhauser controlled for climate catastrophes and other extreme outcomes, an exceedingly disastrous outcome is still more likely to occur than a tolerable one.

He found that an average cost per ton of carbon emission of $20 for the 1990s was appropriate, with the value rising to 28 $/tC by 2030, but that including at least one extreme climate case made the number rise to 33 $/tC (Fankhauser 1994, p. 180). Assuming there are no changes made to combat the advance of climate change, these numbers would theoretically continue to rise into the future as carbon emission continues to increase over time. This higher cost per ton of carbon means that the cost overall of climate change will rise above current levels, meaning that it will take even more funding to halt its advance and possibly reverse it. By acting now, the issue can be dealt with without having to shell out even more money. Fankhauser notes that while these estimates paint an effective picture of how damaging climate change is and will be, they are likely best used in project appraisal with respect to climate change (Fankhauser 1994)

William D. Nordhaus and Joseph Boyer’s book on the economic models that have been created to assess what climate change will do references some of the earliest climate change models along with the most successful ones as well (Boyer and Nordhaus 2000). One of the variables seen in many of the early models and most successful ones as well throughout the book is the use of carbon intensity, or the amount of carbon in the atmosphere to global, or regional, GDP. This metric shows how effective countries are using their carbon-emitting machines and demonstrates whether or not the benefits are outweighing the costs by doing such.

In Chris Hope and Erica Plambeck’s Policy Analysis of the Greenhouse Effect (PAGE) model, the authors set out to model the effects of greenhouse gases upon the globe through the use of a heavily modified integrated assessment climate change model from 1991 (Hope and Plambeck 1996). What they created was one of the most successful and adaptable climate change models that has been assembled thus far. It uses a number of varied inputs to value the impacts of climate change and the costs of policies to fight back against it (Hope 2011) and it’s first iteration, PAGE95, introduced equations to the model several things that led to an estimate of a carbon tax of $21 per ton of carbon being needed. Some of the equations used in that paper were: the emissions of CO2 and CH4, regional and global temperature effects, regional and global economic growth, and adaptation to climate change. The model has been used in several massive publications, such as Nicholas Stern’s “The Economics of Climate Change,” and has been updated several times by Chris Hope, with the most recent update coming in 2009 where linear gases was added to the number of gases included raising the total to 4 (N2O was added in 2002), along with sea level rise being explicitly incorporated now.

On the flip side of the issue, and because of there being no documents arguing against climate change having an effect on social welfare, the only opposition to people advocating for a fight against climate change are people doing the same thing. However, while the opposition does believe that climate change is a problem, they do not believe it is as pressing of an issue as their peers think it is.

In Richard Tol’s paper on the economic effects of climate change he notes that some studies have countries and regions around the world would actually benefit from climate change (Tol 2009). These countries would shift into having more favorable climates that would increase happiness (as shown in Rehdanz and Maddison’s paper) and lead to more beneficial climates for economies (especially those of developing nations). Tol also notes that the economic effects of the amount of CO2 in the atmosphere doubling would be “relatively small” compared to what most people think it will be (Tol 2009).

However, despite these apparent advantages gained from climate change, Tol also notes that the supposed benefits resulting from a changing climate would not last long in these areas as climate changec ontinues. Along with this, it must be noted that although some countries/regions would be positively affected by climate change (for a time), there would likely be more countries that are more hurt by the change rather than helped, which would mostly be the current developing and underdeveloped countries (Tol 2009)

In summary, there are numerous effects which climate change has upon social welfare, but the two most important and wide-reaching effects, those upon happiness and economic well-being, are some of the factors of social welfare that are hit the hardest, despite apparent gains in both areas at first. The remainder of this paper will attempt to add onto the the body of knowledge regarding the effects that climate change has upon social welfare and will do so through econometric analysis.

**Data**

The dependent variable, global GDP growth, is an important and logical marker that shows how well the world economy, and world in general, is faring at any given time. As global GDP levels have only started to be compiled within the last 15 years or so, the data being used for this analysis is from a study by J. Bradford DeLong of UC Berkeley, who estimated the world’s GDP from 1,000,000 years ago to the present, with more detailed information for the years 1900-2000, by compiling the studies done previously on the subject (DeLong 1998). It is clear that this data is lackluster as there are only a handful of studies DeLong was able to use as there simply aren’t many that estimate world GDP, but this was the best estimate for world GDP growth that could be gathered.

Ocean level increase by year should have an effect, as by increasing the ocean level communities and people’s livelihoods could possibly be destroyed as the area they are in may be engulfed in water as a result, thereby decreasing happiness and GDP growth. The data on sea level rise was gathered from the Environmental Protection Agency (EPA 2016). The variable representing the increase in global carbon emissions by year is a critical component of the model as carbon emissions are one of the main cause of climate change in the first place so theoretically the increase in carbon emissions should have a negative effect on social welfare by increasing the rate of climate change. The data on global carbon emissions was gathered from the National Oceanic and Atmospheric Administration (NOAA 2017).

Both of the variables representing methane (CH4) and nitrous oxide (N2O) should also have a negative effect on the dependent variable as they are also instrumental in climate change, and both sets of data were gathered from the Environmental Protection Agency (EPA 2016). Average temperature change by year is also an important factor as increasing carbon emissions affects the global temperature, and hotter temperatures are not kind to people and places that are traditionally in colder climates, so there should be a negative effective on global GDP growth. The data for global average temperatures was gathered from NASA (NASA 2016). Finally, the carbon intensity level is an important bellwether for how efficiently countries around the world are using polluting energy sources such as gas, oil and coal, so it is important to include as it shows whether the pollution we emit is worth the cost. This set of data was provided by the World Bank (World Bank 2017).

**Model**

The aforementioned pieces of research looked at climate change broadly or looked mainly at the economic effects of climate change on specific regions of the world. As opposed to these works, this model and analysis will be looking at not only the economic effects that climate change has on the world, but also the implications on the other parts of social welfare as well. Based on the synthesis of the research of others provided above, along with my own research into the topic, the following section will outline the model which will attempt to quantify the effect which climate change has upon social welfare. The following is the basic model which will be used:

Where *GWP* is the global GDP growth at the end of a given year, with *t* being the year, *SEALEVEL* is the increase in global sea levels by year, *CO2* is the growth rate of atmospheric CO2 levels by year, *CH4* is the growth rate of atmospheric CH4 levels by year, *N2O* is the growth rate of atmospheric N2O levels by year, *AVGTEMP* is the change in global mean surface temperatures in degrees celsius by year relative to 1951-1980 average temperatures, *CO2INT* is the worldwide carbon intensity by year and is an error term. The years from which the data will be extracted from are 1960 to 2000.

**Empirical Findings**

Table 1 in column A shows results of the aforementioned regression equation (1) after being run through STATA using the ordinary least squares (OLS) method with a double-log form. Looking at the regression overall, there are clearly some areas in which the analysis is lacking. Even though the R-squared hits a decent level of .8187, taking the adjusted R-squared results in a lower number, albeit only slightly lower at .7867, showing that there is still a large amount of data not explained by the given variables. The estimated coefficients of the independent variables vary greatly when looking at their effects on the dependent variable. For instance, sea level increases (SeaLevelchange or SEALEVEL), the growth rate of CO2 in the atmosphere (CO2) and the growth rate of CH4 in the atmosphere (CH4) all had negative impacts upon Global GDP Growth (GWPGrowthRate), which was expected of them.   
 On the contrary, the growth rate of N2O in the atmosphere (N2O) and average temperature (AVGTEMP) both actually have positive impacts upon Global GDP Growth, which was an unexpected outcome. Looking at the last variable representing CO2 intensity (CO2INT), the impact of increasing CO2 intensity on Global GDP Growth was expected as the variable itself is computed using global GDP, so the positive value was not a surprise.  
 To make sure that the regression was not affected by heteroskedasticity or multicollinearity, both the Breusch-Pagan and White tests were performed on the regression results, in addition to a VIF test and a correlation of the variables. Looking at the tables containing the Breusch-Pagan and White tests (table 2 and 3, respectively), we can see that the chi2 on the Breusch-Pagan is relatively low, indicating no heteroskedasticity. Although, upon further inspection with the White test, there is a higher chance that it exists, though it is no guarantee. Looking at the tests for multicollinearity (table 4, the VIF test, and table 5, the correlation of the variables), we can see that the mean VIF is a 5.47, indicating that the regression might suffer from slight multicollinearity. Looking more into the results, we can see that sea level and CO2 intensity are quite high with 11.07 and 12.53, respectively, which indicates there are multicollinearity issues there, although both variables are instrumental to the analysis.  
 The P-values for all of the values are important to look at in this analysis, and looking at the regression results we can see that only sea level change and the constant are significant at the 5% level, meaning that all other variables are not statistically significant from 0, but it is important to note that both CO2 intensity and CH4 atmospheric levels are close to being significant. However, despite these variables being significant, one must remember that both CO2 intensity and sea level change showed some of the highest levels of multicollinearity, indicating these P-values are skewed.

Table 1 in column B, along with Table 7 also demonstrates what happens when the regression is run using robust standard errors to control for heteroskedasticity. We can see that in comparison to the original regression run without robust standard errors, there are now 2 variables significant at the 5% level: sea level change and CH4 levels in the atmosphere. In addition to this, the P-values for all of the other variables drop slightly as well as a result of the robust standard errors being used.

**Conclusion**

The task of this piece of research was to determine what the effect of climate change upon global social welfare was and through regression analysis we have determined that for the most part climate change has not affected social welfare over the past 40 years. Most of the variables had the expected coefficients hypothesized, though some have shown that there are multicollinearity issues with them. In addition, most the variables used in the equation were not statistically significant at the 5% level, though 3 (sea level change, CH4 and CO2 intensity) were at the 10% level, showing that there was not much of an effect upon global social welfare after all. This shows that although there is much research to show that climate change will be a much bigger issue in the future, over the past few decades it has not had much of an impact.

**Bibliography**

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Chichilnisky, Graciela and Geoffrey Heal. 1993. "Global Environmental Risks." Journal of Economic Perspectives. 7(4): 65-86.

* SUMMARY
  + Chichilnisky and Heal’s report focuses on what are the most efficient ways to allocate the risk of climate change. They provided an analysis of a market framework in which climate change can be insured against. They also note that there are essentially two different ways to think about solving climate change: mitigation or insurance, and how both are difficult to work with in their own ways (especially in current times, where climate change has not had a big impact just yet). The authors make an important note that for any sort of progress to happen on the topic, we need economists and physical scientists to share their thoughts and work with each other more often, as this issue most certainly needs both to come to a solution.
* HOW IT WILL HELP
  + This paper stresses the fact that we (economists) need to work together with others, notably physical scientists, to show how big of an issue climate change is and how exactly we can solve it, in addition to noting the various effects that climate change is having on the world now and what it will have on the world in the future. Helps the paper in that it talks about how there is a market for insurance regarding climate change and goes into detail about how it can be quantified and broken down into individual effects.

DeLong, J. Bradford. 1998. “Estimating World GDP, One Million B.C. - Present.” [www.j-bradford-delong.net](http://www.j-bradford-delong.net). (accessed April 14th, 2017).

Environmental Protection Agency. 2016. “Climate Change Indicators in the United States.” <https://www.epa.gov/climate-indicators>. (accessed April 14th, 2017).

Etsy, Daniel C. 2008. “Rethinking Global Environmental Governance to Deal with Climate Change: The Multiple Logics of Global Collective Action.” The American Economic Review. 98(2): 116-121.

* SUMMARY
  + Etsy’s article outlines what exactly needs to be done to start working towards a global, collective solution for climate change. He establishes some main points at the end of his paper, including the fact that just by stating how much of an economic problem climate change will be in the future will not be enough to have countries band together on working on the issue. There must be an “institutional approach that starts with the well-established learning about public goods and the logic of collective action can provide, in combination with appropriate legal, policy, and ethical principles, a foundation that moves the world forward."
* HOW IT WILL HELP
  + Describes how current legislation and world view of the issue of climate change is not in a good place and that there needs to be a new, methodical approach to the issue.

Fankhauser, Samuel. 1994. "The Social Costs of Greenhouse Gas Emissions: An Expected Value Approach." The Energy Journal. 15(2). doi:10.5547/issn0195-6574-ej-vol15-no2-9.

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Hope, Chris., and Plambeck, Erica L.. 1996 “PAGE95: An Updated Valuation of the Impacts of Global Warming.” Energy Policy. 24(9): 783-93.

NASA. 2017. "Climate Change: Vital Signs Of The Planet". [www.climate.nasa.gov](http://www.climate.nasa.gov) (accessed April 14th, 2017)

National Oceanic and Atmospheric Administration. 2017. “CO2 Atmospheric Data.” ftp://[aftp.cmdl.noaa.gov/products/trends/co2/co2\_mm\_mlo.txt](http://aftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt) (accessed April 14th, 2017)

National Oceanic and Atmospheric Administration. 2007. ”THE DEADLIEST, COSTLIEST, AND MOST INTENSE UNITED STATES TROPICAL CYCLONES FROM 1851 TO 2010 (AND OTHER FREQUENTLY REQUESTED HURRICANE FACTS).” NOAA Technical Memorandums.

Pearce, David. 2003. "The Social Cost Of Carbon And Its Policy Implications". Oxford Review of Economic Policy 19(3): 362-384.

Pindyck, Robert S. 2013. “Climate Change Policy: What Do the Models Tell Us?” Journal of Economic Literature. 51(3): 860-72.

* SUMMARY
  + Robert Pindyck’s paper is a counterpoint to models that assess possible damage from climate change. He goes on to say that these models cannot really be relied on and instead we must look to other things to determine what climate change will do. Believes that despite such models not really being that accurate or important, the issue is still very important and actions must be taken now to lessen the impact of climate change, and as such a carbon tax should be enacted right away so that politicians and public will come to realize that there is a social cost of carbon and that it must be internalized.
* HOW IT WILL HELP
  + This paper shows how the current research on climate change is not that effective and that we shouldn’t be relying on it, but despite this we must still act. Acts as a counterpoint to all of the research provided before on the effects of climate change without saying the topic is unimportant.

Rehdanz, Katrin, and David Maddison. 2005. "Climate and Happiness." Ecological Economics. 52(1): 111-125. doi:10.1016/j.ecolecon.2004.06.015.

Stern, Nicholas. 2008. "The Economics of Climate Change." American Economic Review. 98(2): 1-37.

* SUMMARY
  + An overview on climate change and the various effects it can and will have on the Earth over time by Nicholas Stern. The lecture (and its accompanying, much longer report) make numerous important points, with the most notable one being that the carbon emissions causing climate change are not ordinary, localized externalities, but rather ones that are creating havoc all over the planet, and thus, “risk on a global scale is at the core of the issue.” He notes that the economics of climate change is far from being fully developed and is very much in its infant-stage, and as such believes this to be one of the central issues in combating climate change. Other notable points include: 1. benefits of strong, early action on climate change vastly outweigh the costs 2. Scientific evidence points of increasing risk of serious, irreversible impacts 3. Climate change threatens the basic elements of life for people around the world 4. The poorest countries will suffer the most by far 5. Despite emissions continuing to grow with economic growth, stabilization of greenhouse gas concentration is possible 6. If strong collective action starts soon, there is still time to avoid the worst impacts.
* HOW IT WILL HELP
  + This outlines many of the various issues related to economics and social welfare of people all over the globe and also outlines what needs to be done to resolve the issue, and as such will be a major help for this paper.

Tol, Richard S.J. 2009. “The Economic Effects of Climate Change.” Journal of Economic Perspectives. 23(2): 29-51.

* SUMMARY
  + Richard Tol’s article on the economic effects of climate change comes to a head with a conclusion that states that despite the apparently massive size of the issue of climate change, there is not a large amount of quality research being conducted on the topic. He goes on to say that despite the inadequate amount of research on the topic, politicians are ready to spend “hundreds of billions of dollars” on greenhouse gas emission reduction, and economists can’t say right now if this is too much or too little. In addition, Tol states that based on carbon tax averages, the EU might be putting the cost of carbon emissions too high with their current tax ($78/ton of Carbon) when looking at other countries such as the US who places the current value at approximately $15/tC. Tol also notes that outside of the high-income countries of the world, regulation on carbon emission is essentially non-existant, even though “... these countries are the most vulnerable to climate change, and some of them like China and India are major emitters of carbon.” He strongly recommends in his final point that policy action in the near-term should be enacted, but it might be more effective to simply phase in a higher cost on carbon emissions over time.
* HOW IT WILL HELP
  + This paper helps to describe both more of the social costs associated with climate change, and what exactly we should do to combat the issue overall.

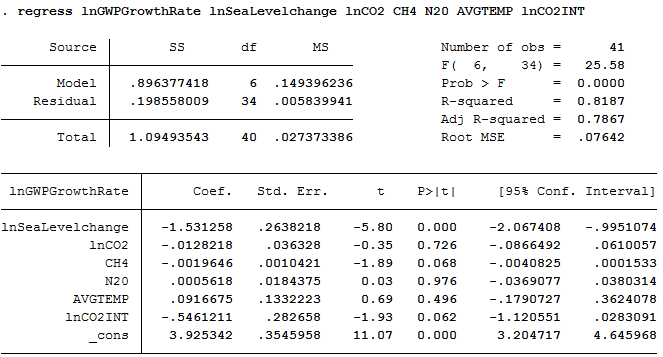
World Bank. 2017. “CO2 Emissions (kg per 2010 US$ of GDP).” <http://data.worldbank.org/indicator/EN.ATM.CO2E.KD.GD>. (accessed on April 14th, 2017)

**Tables**

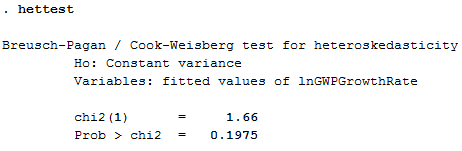
**Table 1: Regression Results**

|  |  |  |
| --- | --- | --- |
| **Dependent Variable: Global GDP Growth (standard deviations from the mean)** | | |
|  | **A (no robust SE’s)** | **B (robust SE’s** |
| **Constant** | **3.925 (0.355)** | **3.925 (0.281)** |
| **Sea Level Change (SEALEVEL)** | **-1.531 (0.264)** | **-1.531 (0.215)** |
| **CO2 Atmospheric Levels (CO2)** | **-0.0128 (0.036)** | **-0.013 (0.026)** |
| **CH4 Atmospheric Levels (CH4)** | **-0.002 (0.001)** | **-0.002 (0.001)** |
| **N2O Atmospheric Levels (N2O)** | **0.001 (0.018)** | **0.001 (0.016)** |
| **Global Mean Surface Temperatures (AVGTEMP)** | **0.092 (0.133)** | **0.092 (0.129)** |
| **Carbon Intensity Level (CO2INT)** | **-0.546 (0.283)** | **-0.546 (0.279)** |
| **R-squared (adjusted R-squared)** | **0.819 (0.787)** | **0.819** |
| **Number of Observations** | **41** | **41** |

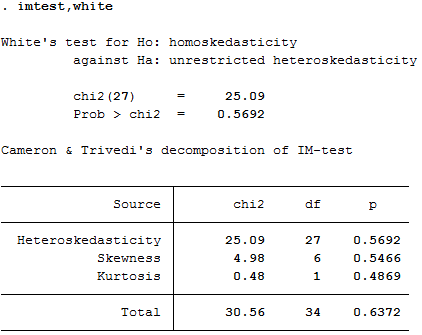
**Table 2: Regression Analysis**



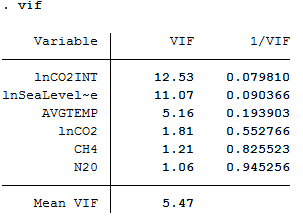
**Table 3: Breusch-Pagan Test of Heteroskedasticity**

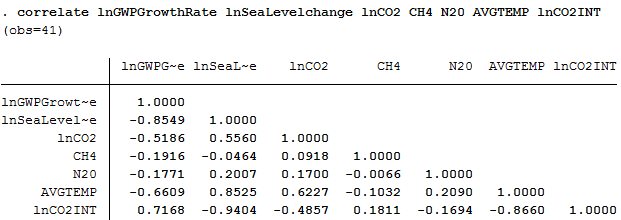


**Table 4: White Test of Heteroskedasticity**



**Table 5: VIF Test of Multicollinearity**



**Table 6: Correlation of Variables**

**Table 7: Regression with Robust SE’s**

