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Are you better off than you were before the disaster: Examining how natural disasters impact growth rates

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Are you better off than you were before the disaster: Examining how natural
disasters impact growth rates

by

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A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the
degree of

MASTER OF ARTS

Major: Political Science

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Abstract

Research on the impact of natural disasters, while young, is starting to take shape as a field of study in political science. Already, a range of studies and methods have been produced, examining the varying effects of different types of disasters on economic growth. This thesis investigates the relationship between disaster frequency and economic growth rates for 127 countries over a thirty year period (1975-2005). This thesis examines if countries with a higher frequency of natural disasters experience a negative change in growth rates. The panel data fixed effects model used in this paper shows that a higher frequency of natural disasters has a statistically significant positive effect on economic growth rates.

Chapter 1: Introduction

If a country experiences a higher frequency of natural disaster, what sort of impact does that have on growth rates over time? This thesis examines that question by looking at growth rates and natural disaster occurrences for 127 countries over a thirty year time period. I theorize that having frequent disturbances (caused by natural disasters) on the economic processes in these countries will lead to a negative impact on growth rates. To study this impact, I utilize an empirical test to examine the relationship between growth rates, represented by purchasing power parity and disaster frequency. I also use a country's geographical location and polity score as control variables.

The field of study on the economic impact of natural disasters is a relatively young one in economics. I decided to use a large N (for this field), aggregate study due to the fact much of the research done has so far been more nuanced and focused on particular aspects of the economy or focusing on one type of natural disaster (i.e. hurricanes). Before venturing down a focused path, I want to try and determine if one can fit some sort of generalizable theory on the impact of natural disasters in as many countries as I could get data on. The few studies that have attacked this topic from an aggregate viewpoint have still only used anywhere from 20 to 80 countries for their samples.

Within the field of disaster studies, researchers often look at specific types of natural disasters, such as either a hurricane or earthquake. This is done because there is evidence to show that certain times of natural disasters have varying effects on a population; the difference between a geological and climatic event has been noted in studies presented in the literature review. For this paper, I look at natural disasters as a whole. I wanted to start from the very top of the literature for my first empirical attempt at addressing this field. From

here, I can then further narrow down my research into sub-groups of natural disasters if I decide to continue examining this field. My main goal for this paper is seeing if there is a negative impact on economic growth following a natural disaster. Starting out with a broad base also allows me to focus on creating a generalizable theory in that a disaster, regardless if it is climatic or geological, should have an impact on economic growth.

Chapter 2: Literature Review

Given the complexities inherent of the studies done in this field, the most effective way to craft a literature review is to take a three step approach. Since the literature itself can be quite confusing at times, it is best to break up the studies into two groups: short-term effects studies (generally three years or less) and long-term effects studies (five years or more).¹ Before that, this review will go into the roots of the field and some of the important early works that have been the catalyst for today's studies.

Seminal Works and Ideas

Dacy and Kunreuther's 1969 book *the Economics of Natural Disasters* is considered the seminal work in the field and one of the first studies to examine the economic effects of a natural disaster in relation to Federal policy.² The paper focused on the aftermath of the 1964 earthquake in Alaska that had devastating effects in the state. Their findings showed that the earthquakes were actually beneficial to the economic state of Alaska following the events, a controversial claim at the time.³

They also, for the first time, acknowledged the differences between the short-term and long-term problems that future researchers are still grappling with. They treat the short-term phase with microeconomic theory while long-term recovery is seen through a macroeconomic lens. They reason this by the uncertainty and necessity that guides events

¹ Cavallo and Noy produced an extensive literature for which the structure of this review leaned on for guidance.

² This paper was published not only after the Alaskan Earthquakes but also after the introduction of the National Flood Insurance Act of the United States in 1968.

³ Dacy stated years later in an interview that he received hate mail and even death threats for years after that study was released. People were upset that their conclusions stated the disaster had "positive" outcomes.

immediately following a disaster; where focus is put more on survival and sustaining than rebuilding.

Amartya Sen's *Poverty and Famines: An Essay on Entitlement and Deprivation* is an important work for this literature review to discuss. Published in 1981, Sen's work examines the economic situations surrounding famine events and he comes to a conclusion about natural disasters that has helped define the field of study and the theory behind this paper: disasters are an economic event. Sen concludes that economic factors are the driving force of the "actual" disaster and that the natural event is not any more at fault than the economic conditions that catapult a situation into a disaster.⁴ Researchers typically agree that economic circumstances are "an equal if not greater" indicator of how devastating an event will be aside from the actual physicality of the natural disaster (Cavallo, 14).

Sen's work leads into a fact that is in the background of much of the literature: poor and developing countries are the hardest hit by natural disasters.⁵ While a troubling fact in itself, this presents other problems regarding empirical studies. This disproportion will be reflected in the data collection and will certainly have an impact on statistical results. Developing nations bring a host of issues along with the problems caused with disasters, if they are overly represented in the data, this will create an issue with bias.

⁴ Sen attributed the actual "disaster" of the Bengal famine to a hoarding of food rather than a natural occurrence causing poor food yields.

⁵ Data has shown that the majority of disasters and deaths from disasters occur in Asia. Due to the large population in that part of the world, this is not surprising. This result may be driving some of the statistical results seen and is important to take note of.

Short-Term Studies

Albala-Bertrand's 1993 work *Political Economy of large natural disasters*, is important due to it being a pioneer in conducting a cross-national study on disaster impacts rather than focusing on case studies or qualitative methods.⁶ He examines 28 disaster events in 26 countries, during 1960-1979 to study their short-term effects on macroeconomic outputs. He finds that disasters have a .04% positive effect on economic growth rates during this time. Albala-Bertrand is noted as one of the first to try and empirically answer questions about disaster impacts on an aggregate level. His methods in recent years have been described by scholars as a bit "simplistic", but given the time and resources his study is still of great value to scholars in the field by showing that an empirical analysis was not only feasible, but fertile for the field.

Are External Shocks Responsible for the Instability of Output in Low-Income Countries? by Claudio Raddatz examines short-term implications of natural disasters by examining external shocks in developing countries. His work is notable in this paper as it was the first to utilize a panel-VAR model, a model that other researchers in the field would use a variant of in other studies. Raddatz is also noteworthy in that his paper begins to distinguish the effects of geological and climatic events for short run implications. He finds that climatic events have a negative 2% impact on GDP per capita while geological events were not statistically significant (Raddatz, 16-9). This finding attests to the greater economic costs of losing human capital during a disaster event. Eric Strobl also finds that climatic events (hurricanes) have a negative impact on economic growth rates at 0.8% of per capita income (Strobl, 23-4).

⁶ His work is the basis for the methodological approach this thesis takes.

Ilan Noy's 2009 work on floods in Vietnam bring to the literature the notion of "creative destruction", first discussed by Joseph Schumpeter in the 1950s.⁷ Noy sees evidence of this in Vietnam with disaster events allowing for new and better infrastructure to be built, thus allowing more efficiency in the economic cycle. This concept is noted in a variety of studies and is a thought for why disasters may in fact have positive benefits.⁸ Noy's study states that this is the case in only capital destructive events; events that are more lethal are seen to have a negative impact (Noy, 16-8).

Noy published another article in 2009 that added onto Raddatz's findings of adverse short-term effects of disasters, but more importantly concluded that viable institutions are able to mitigate some of the damage. He finds that higher literacy rates, better institutions, openness to trade, increased spending at the national level and high levels of credit allow a country to weather the effects of a natural disaster, also deterring further negative long-term results. (Noy, 228-30) Noy also does point to a caveat with this finding; you simply cannot look at all the different angles and have control variables for everything without the study spiraling on to tangents.

Noy's and Raddatz's findings harken back to Amartya Sen's notion that outside forces are often equally important as the event itself in determining the economic windfall. A building with a solid foundation and support structure can more readily survive a disaster than a straw hut. Corruption and incompetency with post-disaster aid has plagued many countries affected by natural disasters and may have in fact been responsible for more long term damage than the disaster itself.

⁷ Schumpeter based the notion of creative destruction off of work by Karl Marx linking to the "accumulation and annihilation of wealth under capitalism"

⁸ Skidmore and Toya have often used "creative destruction" in a variety of their papers to account for some of the positive effects they see from disaster occurrence.

Rodriguez-Oreggia et al. (2009) focuses on a case study of municipalities in Mexico; examining to see the economic implications on that level in dealing with disaster events and how they fare compared to other levels of government. What makes their study interesting is the use of the Human Development Index as a dependent variable. This variable takes into account: life expectancy, standard of living and literacy rates as indicators for development.⁹ Their study finds that disasters push back the HDI by 2 years and also increase “severe” poverty by 0.036%.

Hochrainer (2009) and Loayza et al. (2009) examine the impacts of natural disasters by relying heavily on counterfactuals to see what growth would have been like without the occurrence of disaster. This is done by examining pre-disaster trends and extrapolating on the direction of those trends. Hochrainer compares the counterfactuals with observed GDP data and concludes that natural disasters do have a negative impact on growth rates on average. Loayza expands on Hochrainer’s model and, not surprisingly in this field, finds different results for the same disasters. This can be attributed to the mathematical formulas and statistical models that were utilized for the separate studies. Also, to what “extreme” the counterfactuals were taken in these studies is up for debate and may have had an impact on the findings.¹⁰

There are other eminent smaller scale case studies on the short term effects of natural disasters. One in particular is Mechler (2009) who looks at how consumption rates are impacted after a natural disaster. He found no significant results that explained the changes

⁹ I must note that the use of HDI is seen as controversial in some sectors due to the index’s measurements of certain variables and heavy reliance on education as a variable.

¹⁰ While counterfactuals are a part of Political Science research, I have read and through conversations been informed that while counterfactuals are accepted, scholars tend to draw a line on how “extreme” they can be taken. Eliminating one event is seen as acceptable where conducting a research where you remove a host of observations to do a complete “what if” scenario is seen to be taking the process too far.

in consumption rates observed. Overall, short-term studies have shown that, on average, disasters have a negative impact on growth and development.

Long-Term Studies

Studies on the long-term growth effects of disasters are fewer in number than the short-term studies. This review will cover the three main studies in this sub-section of the disaster literature. This possibly reflects the difficulties in isolating the impacts of natural disasters years removed from the event or a problem of “fading memory”. Skidmore and Toya (2002), Noy & Nualsri (2007), and Cuaresma et al. (2008)) are the main studies this section will focus on.

Skidmore and Toya examine the frequency of natural disasters from 1960-1990, with their sample of 86 countries being normalized by land size. They expand the study by breaking down disasters into climatic and geological events, examining the effects each has on economic growth. They find climatic events have a positive long-term impact of 0.42% on GDP while geological events had a statistically significant negative impact of -0.32% on GDP. Skidmore and Toya believe this outcome has something to do with climatic disasters speeding up the “creative destruction” process. They also attribute geological disasters to be responsible for more deaths which in turn decreases human capital.

Noy and Nualsri (2007) use a “killed” variable and a “damages” variable to examine the differing effects of disasters on human capital vs. damage to physical capital. They find that deaths have a statistically significant impact on long-term growth rates while the damages variable was not statistically significant. Later works by Jaramillio (2009) and

Raddatz (2009) support Noy and Nualsri's findings and find that geological events tend to not have a statistically significant impact on long-term growth rates. Raddatz found that one climatic event every three years reduces GDP by over 2% in a decade (Raddatz, 2-3). Raddatz further found that droughts and extreme temperatures were the most damaging natural events for GDP; at an average of 1% and 5% respectively.¹¹

Raddatz's long term study is important because he describes a few of the contemporary problems with the literature as it stands. He explains that while case studies have their place in the literature; they do little to help form a generalizable theory on the economic impact of natural disasters. He also comments on the size of the samples being used in studies is rather small, which is never beneficial when striving to find a generalizable theory. Omitted-variable bias and small sample sizes are two of Raddatz's concerns with the current state of the literature. He also states that while the models used in the insurance industry do tell us a bit about the nature of disasters, those models only cover insurable losses in developed countries; omitting a large portion of potential data.

Conclusions

The disaster field a nascent one, a fact that brings opportunities for innovative new ideas, but that also, at the current state, leaves us a confusing and contradicting field. When studies examine the same disaster in the same location and find strikingly different results, one begins to realize the difficulties in quantifying such a complicated event as a natural disaster. Disasters are fascinating economic phenomena, one that scholars are just starting to learn more about. While Skidmore and Toya attributed increased growth to "creative

¹¹ These findings were based on a sample of only 12 countries.

destruction”, Noy’s findings were starkly different in regards for long-term growth. Noy himself has attributed “creative destruction” to increased productivity in Vietnam after flooding events (Noy, 15-17). Authors do tend to agree that greater death rates have more of an adverse impact on economic growth than damages to infrastructure. The literature review reinforces that the surrounding economic situation can have just as an important role to play as the physicality of the event itself.

Soon, the reader will notice that this study does not abide by the short-term or long term time parameters that I have discussed in the literature review. Instead this study looks at a range of time that falls somewhere in the middle. One of the main takeaways from the literature review would hopefully be the added complexity that time adds to an already difficult subject to study quantitatively and how that measurement can impact results. For this study, I wanted to utilize a measurement of time that worked in line with the theory presented and a range of time that was manageable for the empirical tests I use.

Chapter 3: Theory

In the case of this study, the theory presented strives to be as simple and straight forward as possible; guiding the reader from point A to point B. The hypothesis presented is the following:

H₀: Higher frequencies of disasters have no effect on growth rates over five years.

H_a: Higher frequencies of disasters have a negative effect on growth rates over five years.

In this chapter I will lay out the background on the difficulties in shaping a cohesive framework for disaster theory and the argument in defense of my hypothesis; why I expect to see negative growth when there is a greater frequency of natural disasters.

Developing an overarching theory for how disasters impact economic development can be troublesome at the best of times. This comes from the fact that researchers on the subject have postulated different ideas on what exactly a disaster is related to economic activity. Are disasters exogenous shocks, whose severity and frequency (or infrequency) set them apart completely or are disasters simply part of the normal frustrations found in a business cycle? Yasuhide Okuyama proposes that question in his update to the seminal work by Dacy and Kunreuther.¹² My theory comes down to four main aspects on why a higher frequency of disaster is detrimental for growth rates:

1. Human capital and physical capital are damaged from constant disaster events. Human capital is hindered either through death or migration while the productive capabilities of businesses are interrupted by the onset of disasters.

¹² Yashudie Okuyama published a review and updated version of Dacy and Kunreuther's seminal work on disaster economic research in 2003. "Economics of Natural Disasters: A Critical Review"

2. Rebuilding efforts are drawing resources from other ventures, which very well may be resources for future investments. A factory may be rebuilt with updated materials, but the construction of new factories is put on hold due to lack of funds.
3. Uncertainty created by risk created by the constant threat of a looming disaster. While there is controversy regarding the use of uncertainty, its presence in the minds of those affected by the event and investors is too strong not to take into consideration.
4. Aid money often brings misery rather than salvation.

Frequency is at the heart of this study and the theory presented. If disasters are happening at more frequent rate, any of the positive effects seen (increased capital from aid flows and reconstruction efforts, for example) is lessened. Having consistently bad outcomes are no better than having one large bad event happen (unless you are talking about an extinction level event, which then renders this whole conversation mute). You can make an argument that if you know an asteroid will hit your parking spot every Tuesday, you simply will avoid parking there. There's no danger since there is a consistent and knowable threat. The real danger, you would argue, is in the large one off event. Disasters, even with advancements in forecasting, are still unpredictable forces of nature whose destructive power is not fully known until after the event is over. In his 1966 work on the Black Plague, Jack Hirshleifer showed how the frequencies of plague contributed to nearly a century of economic depression following the initial event of the Black Plague in Europe during the 14th century. Recurrences have been seen in the past to disrupt production outputs. (Hirschleifer, 14-7)

Supporters of the positive implications of the disaster events often point to the notion of creative destruction (Skidmore & Toya, 2002; Noy, 2009). The idea that a disaster allows for a clean slate for new and better industries to take root is not an invalid approach to

looking at disasters. There is reason to believe that such destruction is a good thing as seen in Noy's case study of Vietnam. Old roads and housing can be demolished for free by nature in order for them to be replaced with modern upgrades. This particularly was a boon in some provinces in Vietnam, allowing for goods to reach destinations with greater haste. However, there is a caveat to this idea.

Creative destruction can only happen a few times before it simply becomes destruction. Reallocations of resources that may have gone to investments are now being spent on rebuilding efforts and replacing what was destroyed. Yes, a factory may get new technology, but this may mean that two new factories will not be built due to lack of funds. It is also not good enough to say that funds budgeted for a disaster will be able to cover the expenses, even more so when disasters happen more than once. In a "one off" event, such destruction may be good for an impacted region, but when these events are happening with greater frequency, the scope and magnitude start to matter less. What matters is that the everyday life and business in that area is being frequently disrupted. Small and poor countries in particular cannot bear this constant disruption if they hope to climb out of development into the exalted position of "developed" nation. It is hard to develop and grow when one is constantly being held back.

While larger and more developed nations may be able to diversify their industries more and lessen the blow from a disaster than a smaller nation, this does not completely mitigate the damage done to economic growth rates. A disaster in one part of a large country can just as easily be felt in another part, or in multiple parts of the country. If the region hit is the nation's primary breadbasket, this will have a reverberating effect on food prices and availability across the country. If that nation's breadbasket is getting hit with greater

frequency, this will have long term effects on prices and may spur the need for more imports from outside producers.

Since productivity can be at the mercy of the normal business cycle (periods of boom and recession have an effect on the rate), it seems logical that shocks from frequent disasters would have an impact on production. Rebuilding efforts may be a boon for the construction industry, but even they will eventually be overwhelmed with greater frequency of shocks from disasters. Disrupted supply chains from a disaster event may make building materials harder to acquire and may necessitate costly importation of materials. Those raw materials needed for rebuilding may have been in fact impacted by the disaster itself, further complicating the matter.

While the hit to production is damaging in itself, the hit to human capital can be just as crippling to economic activity. Deaths from a disaster can hinder economic activities for a time after the event, requiring the training or importation of new persons skilled in that field. This is not sequestered to just one industry; a disaster can easily eliminate or scatter professionals in a variety of fields, further damaging the overall economy. It takes longer to educate a professional and for that professional to acquire the years of skill and practical experience to be useful in adding to productivity than it does to rebuild a processing plant.

The impact on human capital is felt starting at the family level. Families impacted by disasters are concerned with the essentials; food, water and safety, no longer about purchasing luxury commodities or putting money back into the system; uncertainty lends itself to a “wait and see” mentality or to vacating the impacted region entirely. Resource uncertainty is compounded by job uncertainty following a disaster. If the plant or job location the provider of the family works at is destroyed, that family’s income is directly

abated. Their ability to spend capital is severely mitigated by information uncertainty on where future earnings will come from and often a lack of places to spend money, due to destruction or looting.

Adding to this, disasters are explicable tied with population displacement. Evacuations may last anywhere from a few days to months to possibly even a year. A displaced population does little to help stimulate economic growth following a disaster. Even after the disaster and subsequent clean-up work, there may not be anything left for the displaced persons to reclaim. While aid money will help some, there is usually not enough to go around and that money may only allow persons to reach a level slightly below their pre-disaster economic situation. World Bank studies have linked displacement to increased levels of poverty and decreased opportunities for employment adding to the problem.

If a country is prone to frequent disasters, which I would argue leads to greater economic uncertainty, outside investment could dry up. A cost-benefit analysis would show that while ventures in that country may be profitable, uncertainty from natural disasters may very well hinder the application of those ventures. A counter-argument to that claim would be companies often work in dangerous areas or, that by happenstance; the world's more valuable resources (oil and gems) are the primary industries in some of the most volatile locations on the earth. I would counter that defending against hostile persons is a more manageable venture than defending against the onset of a geological or climatic event.

Increased aid money and outside investment do follow highly publicized natural disasters, but to limiting effects. Corruption can do even more damage to the populace after a disaster when left unchecked; we need no better example of this than in the aftermath of events in Haiti. Aid money is called "relief" for a reason, it is not necessarily to spur growth,

but rather to allow affected persons the chance to survive long enough to rebuild. While disasters may bring capital to a country, that alone does not correspond with increased growth.

Amartya Sen's arguments on famines that the surrounding economic implications in essence make a disaster a "disaster" more than the physicality of the event itself. Sen argued in his work on famines that, "starvation is the characteristic of some people not *having* enough food to eat. It is not the characteristic of there *being* not enough food to eat."¹³ Human actions (or inactions) are often what turn an event into a disaster. A small disaster incompetently handled may very well have just as damning effects as a large scale event. That notion also leads to why I do not believe the size of an event matters as much as the frequency or the subsequent response.

Theory alone does not even begin to answer how disasters impact growth rates; this boils down to being an empirical question. There is no easy answer as to how disasters impact growth rates due to the unpredictability of the event and the reaction. A certain type of disaster, handled effectively, may indeed produce positive outcomes. That same disaster, handled poorly, could be catastrophic for the region, regardless of the physical magnitude. I aim to answer if frequency of disaster has a statistically significant impact on growth rates. The other aspects of a disaster, I must leave to future studies.

The reader will soon note that aid, while discussed in the theory, is not included as a variable in the empirical test. While I do suspect aid playing a role, time constraints prohibited its inclusion in the models. When I revisit this study, I will include aid as a variable, but for now, my main focus was testing the variables I could readily get data on and

¹³ Italics in original version.

testing those as precisely as possible. Adding more variables into the mix would have made for a better overall analysis, but again a concern about time limitations steered my decision toward making the models more simplistic. I decided to focus on what I thought was most important, the relationship between frequency and growth, for this thesis.

Chapter 4: Data and Methodology

To test the hypothesis presented, this paper utilized, as the primary test, a panel data fixed effect model along with other, subsequent, robustness tests to ensure reliability and consistency in the results. Four variables are used in this study: purchasing power parity converted GDP as the dependent variable with Disasters as the independent variable. Polity score and a country's distance from the equator were used as control variables. This paper adds to the literature by using a new methodological approach in a fixed-effect model with a forward lag of five years.

Data

The widely used and accepted source for data relating to disaster research is the Emergency Events Database (EM-DAT), which is maintained by the Center for Research on the Epidemiology of Disasters (CRED). The database contains a variety of information on disasters that occurred from 1900 to present. This information includes: monetary damages, disaster frequency, death rates, and displacement figures. It is important to note that monetary damages reported by CRED are only reported as direct damages; this consists of damage to infrastructure, housing and agriculture. For benchmark specifications, I have data for 127 countries with an average of 22 annual observations per country.

CRED requires one of four specific requirements to be met in order for a disaster to be entered into the database: (1) ten or more reported deaths; (2) 100 people or more affected; (3) state of emergency declared; or (4) a call for international assistance issued by the affected state (CRED). Disasters then can be broken down into different categories, such

as man-made, natural, small or large. This paper examines only natural disasters occurring from 1975 to 2005 in 128 countries. As noted in the literature review, natural disasters are often broken down into climatic or geological sub-groups when conducting empirical work on the economic effects of such occurrences. Where geological disasters are seen as positively impacting growth in certain studies, climatic disasters are seen negatively impacting growth rates due to their more adverse impact on human capital rather than destruction of infrastructure (Cavallo, 11-4). For the purposes of this paper, I am looking at natural disasters on the whole, rather than looking at the differences between climatic and geological events.

From 1975 to 2005, there were 6,660 disasters recorded by CRED occurring in 127 countries in the world. A snapshot of this data shows a severely right skewed histogram, indicating the need for a transformation in order for this data to be used in a statistical model. The initial transformation, a logarithm, was unsuccessful in adapting the data to a suitable format for this study. The disaster variable was still substantially right skewed. The underlying reason why this is a problem relates to the distribution of the errors. With the variable being skewed, the errors will not be distributed normally leading to a technical problem in which the other variables will be impacted by the skew, therefore impacting the outputs.

Having data that does not follow a normal curve (or is symmetrical) brings with itself a set of conceptual problems. Primarily, where the center or the average value in the distribution. For symmetric distributions, the problem disappears because the mode, mean, and median are identical. For skewed distributions, however, these three markers are decidedly different. Simply put, a normal distribution lends itself to statistical analysis with

greater ease and reliability than a severely skewed distribution. The histogram and scatterplot for the original and logarithmic disaster variable can be found in Table 1 in the appendix.

The decision was made to instead use a binary format (1 = presence of disaster in that year/country, 0 = no disaster present). Allowing for a binary transformation will allow the errors to be distributed normally and eliminating many of the concerns stated in the previous paragraphs. This transformation changes the scale in which we will be examining the coefficients and in general the scale in which we will be able to postulate an effect. While disappointing, this change does not go against the baseline theory or hypothesis presented in this paper as it still allows for disaster frequency to be taken into account.

The dependent variable used in this study is PPP converted GDP per capita, at 2005 constant prices.¹⁴ These figures were collected from the Penn World Tables, a database maintained by the Center for International Comparisons at the University of Pennsylvania. The Penn World Tables “provides purchasing power parity and national income accounts converted to international prices for 189 countries/territories for some or all of the years 1950-2009.” (pwt7) This variable was chosen as a measurement of growth primarily due to the fact that it is PPP converted. Purchasing power parity, or PPP, measures how much it would cost to purchase the same “basket of goods” in one country compared to another.

PPP was developed out of the notion of “the law of one price”; a statement that, in the long term, identical goods and services should have one price. This measurement allows exchange rates and inflation to be taken into account, giving a more level and applicable

¹⁴ The GDP variable was taken from The Penn World Tables, it will be cited in the text using pwt7, representing the 7th and current version of the table.

measurement of growth to use across countries and across time. I found this to be the best possible measurement for use in panel data time series analysis.

Transformations and a forward lag were applied to the GDP variable in order to ensure the variable would be mathematically useable for analysis and to ensure that the relationship between disasters and GDP were being accurately observed. By using a forward lag of five years we are able to time the disaster event first and then the resulting economic response. Reverse causation is always a serious concern when running a test like time-series data observed at the annual level and it was important that measures were taken to ensure this sort of fallacy was avoided.

Polity scores (coded as polity) were taken from the Polity IV database and a country's distance from the equator (coded as lat) was computed by using the centroid from the population center, rather than the geographical center of a country.¹⁵ Using this measure of distance is more beneficial for an economic analysis given that many countries (Australia and Algeria for example) have their physical centroid located in the middle of uninhabited space, far removed from economic activity.

Polity Score and distance from the equator were used as control variables. Disaster literature shows that, in essence, better institutions (stable democratic regimes) reduce disaster impact and are beneficial to economic growth. Political accountability is seen as a critical component in post-disaster economic recovery efforts; a fact seen with great negative consequences in the aftermath of Hurricane Katrina. This accountability furthermore, plays a role in highlighting poor disaster prevention; politicians will sound the horn for post-aid

¹⁵ These figures are attributed to a database constructed by Robert E. Hall and Charles Jones: Why Do Some Countries Produce So Much More Output Per Worker Than Others?

money, but were nowhere to be found when funds were needed to help bolster preventative measures.

Methodology

The impact of natural disasters on GDP across countries is estimated using an OLS panel data fixed effect model. A forward lag of five years on GDP was also used to ensure the relationship between disasters and GDP is accurately analyzed for the purpose of this study. The variables of polity and lat were used as control variables for the model. The unit of analysis used was country/year, with $n = 127$ and 2,846 observations.

The fixed effect model was decided upon over other time series models for a few different reasons. A fixed effects makes the assumption that the individual specific effect is correlated to the independent variable, unlike in a random effects model which assumes there is no correlation. The fixed effect model allowed me to observe the series of changes in growth rates from one period to the next. This is different than predicting the change in GDP, which in an autoregressive model would be highly correlated, given the predictive power of the previous year's GDP on the current year's GDP. Observing the change in GDP output by percentage also increases the likelihood that the dependent variable was stationary, an important condition in using a first difference approach. While other papers in the literature are more geared towards fitting a model for the world, focusing on interdependencies, this paper is focused on testing a hypothesis. Using this model and a forward lag, we are predicting the change in GDP; thus seeing if x causes y .

Chapter 5: Analysis and Findings

This chapter covers the findings and analysis from the regression models used to test the hypothesis. Readers will soon note that while in the text, findings are rounded for easy reading, within the tables the numbers are left as they were computed by the statistical package. The results from my fixed effect model showed that disasters had a positive and statistically significant impact on growth rates by .3% and a p value of 0.001. Polity was also statistically significant along with latitude falling out due to the fixed effect. The constant coefficient showed that with, a Polity score of zero and zero disasters, growth would have been at .4%. At the 95% confidence interval for the impact of disasters on growth rates, the true value lies between .1% and .6% growth increase. The Rsquare (within) accounts for 2% of the variance, which given the data, is not surprising. Due to an oversight in the model, the constant is noted as 1.004835. This is because I did not subtract 1 from the model while using the statistical package. The constant, which means that without any natural disasters and a polity score of zero, a country's growth would be around .5% over five years for that observation.

Table 1^a
Fixed Effects Model (Primary Test)

	Coef.	Std. Err	P-Value	95% Conf. Interval	
Disasters	0.00349	0.0010544	<0.0005*	0.0014198	0.0055549
Polity	0.00058	0.0001108	<0.0005*	0.0003623	0.0007967
Lat	(dropped)				
_cons	1.004835**	0.0007148	<0.0005*	1.003434	1.0062237

^a Number of observations = 2827

** This was due to not subtracting 1 from the model; growth, with a polity score of zero and no disasters, would be around .5%.

To ensure the errors were not the result of faulty coding on my part and to reinforce my findings, I ran different robustness tests on the data to see if the results would be consistent¹⁶. I first ran a random effects model which again showed disasters being statistically significant at .3% along with Polity and Latitude having <0.0005 p values. In addition to the random effects model, I applied other changes to insure consistency. The GDP variable was transformed in such a way that caused the distribution to suffer from high kurtosis, a “peakedness” in the distribution. By inputting the values at the 1% and 99%, this helped to ensure that the outliers were taken into account in the model rather than just the strong presence of the 1% growth at the middle of the distribution. This model found disasters to be statistically significant again, with the coefficient at .3%. Polity and latitude also maintained consistent results.

Table 2^b
Random Effects Model

	Coef.	Std. Err	P-Value	95% Conf. Interval	
Disasters	0.002973	0.0007327	<0.0005*	0.0015373	0.0044095
Polity	0.000396	0.0000711	<0.0005*	0.0002875	0.0005357
Lat	0.000248	0.0000589	<0.0005*	0.0001324	0.0003632
_cons	0.999702	0.0018805	<0.0005*	0.9960164	1.003388

^b Number of observations = 2827

¹⁶ Tables 2 & 3

Table 3^c
Kurtosis Test

	Coef.	Std. Err	P-Value	95% Conf. Interval	
Disasters	0.003075	0.0007464	<0.0005*	0.0016139	0.0045411
Polity	0.000445	0.000078	<0.0005*	0.0002875	0.0005935
Lat	(dropped)				
_cons	1.005078**	0.5085	<0.0005*	1.004081	1.006075

^c Number of observations = 2771

The results found from these models allow me to reject the null hypothesis presented in this paper. The results also showed that disasters did have a positive impact on growth rates over the five years from the disaster event.¹⁷ The results not only rejected the null hypothesis, but were in fact the exact opposite of the alternative hypothesis. Prior to running the tests, I was unsure if I would even come away with statistical significant results; given that, I am very pleased in the results. While I have no problems with the findings, the methods used will require some tweaking if this study is to be done again. Also, a reexamination of the theory may also help determine if I should have seen these results coming to begin with, contrary to my initial suspicion that more frequent disruption of economic activity by disasters would hinder, not spur growth. Examining the magnitude of each observation would be the first change I would implement in the study.

The models used can be, at best, described as slim and simplistic. While polity, latitude and the GDP variable do account for many important controls, more would be needed to strengthen this study. Controlling for country-size in particular would be one aspect I would change for a future run at this same study. I do think that the fixed-effects

¹⁷ These findings are consistent with Albala-Bertrand's 1993 quantitative study.

model does help in this regard and also that PPP-converted GDP is a great variable to use given how PPP accounts for inflation and exchange rates, but there is always more a researcher can do. Given time and ability constraints, the measures and the model used were the best available given the circumstances. As stated previously, measuring magnitude and incorporating that into a new theory I believe would help explain the findings.

Time measurement, as a factor, may have contributed to the findings seen above. I did not, with better precision, take into account the amount of time that elapsed between each disaster. Perhaps countries that were hit more often by disasters were not hit close enough together in time to hinder economic processes. Impacted areas had enough time to rebuild and update between disasters so that the onset of a new disaster did not compound problems left behind from the previous event. In dealing with frequency, proximity of events is an important aspect to take into consideration, something this study failed to accommodate.

Chapter 6: Conclusion

I am pleased to have found statistically significant results, even though they were not what I initially expected to see. The findings have also spurred a curiosity to continue studying this topic, but with different methods utilized than the ones found in this paper. There is little doubt that more precise measurements need to be used along with different forward lags to analyze the three year, five year and ten year outlooks after a disaster event. I also believe better management of the time variable is the key to a better study. As mentioned before, determining why the impact was positive, not negative, would be a key part of a future study.

In the future, I hope to first replicate this study with more control variables and a more precise measurement of time elapsed before I look at region specific events. I do believe there is a great deal to learn looking at aggregate studies than focusing on case studies surrounding disaster specific events. There is also merit in separating disasters into sub-groups, such as climatic and geological events, to see if there are differing effects on growth rates, though one should always start at the beginning before starting down divergent paths.

I do now understand, given the difficulties of an aggregate study, why researchers tend to focus on case studies or specific aspects of the economy to see how disasters impact those areas. From a policy standpoint, such studies do make sense in that each country/region will react differently to a disaster event, which will impact recovery efforts. That is not to say case studies do not bring their own inherent problems as we have seen in the literature.

While I have noted the drawbacks of the study, I need to emphasize that I do find many positives to take away. With the literature review as a prime example, there are many

different factors that impact how a disaster affects economic activity (for better or worse). Given my theory and what I had researched, I was drawn to the conclusion that the impacts would be negative rather than positive. I was incorrect. While being wrong is never fun, I was pleased in the fact there was a statistically significant impact on growth, regardless of the direction. I was able to look at data for 127 countries over a thirty year period and find statistical significant results that frequent natural disasters have a positive impact on growth rates. That is truly exciting as it allows further study in a number of divergent paths, paths that would have showed less promise, if I had not found statistically significant results.

The results fall in line with the early aggregate works done by Albala-Bertrand and Skidmore and Toya (Albala-Bertrand in fact also found a .3% positive impact on growth). What makes my study different is the expanded N, which I felt was one of the most important parts of this study. This study aimed to examine as many countries as possible and with research and a bit of luck, I was able to do that with the 127 countries noted in the study. I hope the empirics of this study add to the previous aggregate studies and continue to build upon the ideas and statistical methods being developed in this field.

What do these findings tell us from a policy standpoint? Since disasters were seen to have a statistically significant positive effect on growth rates, are disasters something a country should hope for? The simple answer, no. To truly develop a policy framework around these results, the study would need to measure more variables to really get at the crux of why having more disasters is beneficial to growth. This study again was more interested in the question of is there an impact, period. Now that I have seen there is an impact, the

next step would be to narrow down the interactions that help create that impact other than the disaster.

During the course of my graduate studies, I have developed a habit to be hesitant in immediately extrapolating a policy implication from an empirical study. Given this study, I am even more hesitant due to the nature of the models and the nature of disasters themselves. Just because there is a noted positive impact on growth, does not mean disasters are beneficial. Property is still destroyed and people are killed. There are surely more appealing ways to spur economic growth than a natural disaster. While others will surely disagree (the inherent nature of academics) I do not see any policy implication to take away from this study nor, if pressed to do so, would I even begin to try and extrapolate something from the results. The models simply do not tell us enough about the interactions between variables and what exactly is helping to spur growth, due to omitted variables such as aid.

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