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**Typhoons and Temperature Impact Crime Rates:
Evidence from the Philippines**

Master's Thesis

International and Development Economics

*Key Words: Natural Disasters, Temperature, Crime, Environmental Economics,
Climate Change*

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ABSTRACT: This study assesses the impact of typhoons and temperature on interpersonal, property, and non-index crime rates using a novel data set from the Philippines. Distributed lag OLS regression analysis shows that in the concurrent year of increased precipitation, theft rates decrease, but in the year following high average wind-speeds, theft rates increase again. The only significant result of impacts crimes against persons is the rate of physical injury which decreases in years of higher precipitation. These results are defended by interview and focus group information. This study also shows that higher average temperatures cause significantly higher rates of murder, index crimes, and non-index crimes in the concurrent year and increased murder in the lagged year as well. These results uphold conclusions from previous research, and make substantial contributions to the existing knowledge on this subject. The conclusions drawn here have significant implications as our climate continues to change.¹

¹ The author would like to thank Mary Recelis, Luz Malibaran, and the Philippine National Police for their help in gaining access to the necessary data for this study. Also, a sincere thank you to Solomon Hsiang for the use of his typhoon dataset. Lastly, thank you to the University of San Francisco Department of Economics and to Jesse Anttila-Hughes for the outstanding guidance and advice that I gained throughout this process.

I. INTRODUCTION

The current debate of how people respond to environmental shocks is a passionately deliberated topic in current literature. Over the last decade, dozens of researchers have tried to understand how humans react after a natural shock strikes. Because this is a relatively new field of research, there are still many questions to be answered. One topic in which there is still very little known is how the sociological and economical decision making process changes after a shock. The purpose of this research is to add to the current knowledge base in this field by focusing on two questions. The primary concentration of this study is to establish if wind speed of typhoons and precipitation have an effect on index, non-index, and total crimes. A secondary inquiry looks at how temperature impacts the same crime variables.

These two research questions are particularly salient given the projections of the world's climate increasing between 1.5 and 4.5°C within the next century (IPCC, 1995). In 2012, the Philippines were ranked as the third most at risk country in the world to be affected by climate change (UN World Risk Report, 2012). Each year, between 15 and 18 typhoons surround the country and 5 to 9 make landfall. Their third place rank was given to them based on their likelihood of being impacted in both an increased frequency of storms and an increase in the intensity of storms that hit the country each year meaning that the effects of typhoons are projected to get much worse in the coming years. Inhabitants of the Philippines are already feeling the effects of stronger storms, claiming that the typhoons in the last few years have felt stronger and people have witnessed more destruction than in prior years.

There are two opposing hypotheses regarding the impact that a disaster, specifically a typhoon, will have on crime rates. The first hypothesis predicts that there will be an increase in crime rates following a natural disaster. The three main theories which promote this hypothesis are Becker's (1968) Economic Theory of Crime, Cohen and Felson's (1979) Routine Activities Theory, and Merton's (1938) Strain Theory. While each theory suggests crime rates will move in a positive direction, there is no agreed upon measure for the magnitude of increase. The trend of increasing crime rates is quite variable depending on the duration of the reconstruction period (Leitner et al, 2010). In the Philippines, there is significantly less government aid available for disaster victims than in developed countries, such as the US. Additionally, people have little

savings to put toward reconstruction, and in many cases the typhoons destroy the only means of income generation available to the household, which will make the reconstruction period much longer. The magnitude of destruction forces people to live in shelters, with friends and family, or on the streets and subsist by whatever means necessary. Crime rates, therefore, have the potential to climb because the desperate living conditions may lead some to commit crimes in an effort to survive.

The opposing claim, of course, is that crime rates will decrease after a typhoon strikes. The main argument for this is that there will be an increase in solidarity and pro-social behavior after the storm. Rodriguez, Trainor, and Quarantelli (2006) found that in the three weeks after Hurricane Katrina hit, there were incredible amounts of pro-social behavior including both physical and emotional support. This type of behavior is often expected following a tragedy and was outlined in Fritz's (1961) Theory of Therapeutic Community. Fritz claimed that disasters break down social norms and the most pressing need is to get through the disaster and rebuild the community. He also acknowledged that disasters create a situation where suffering is visible which tends to increase empathy, cooperation and solidarity.

The secondary component of this study assesses the impact that temperature has on crime rates. Current literature finds either a positive impact or no impact on crime due to temperature fluctuations. There is an abundance of literature showing a relationship between temperature and various types of conflict, aggression, and uprisings, however, until recently, few have been able to define a causal impact using panel data. Much of the current literature is based in psychology and sociology, however, economic studies have begun to appear more frequently in the last decade. The foundational theory relating temperature and crime is the frustration-aggression hypothesis created by Dollard et al in 1939 and was later expanded on by Leonard Berkowitz (1989, 1990, 1993). The other common explanation for the correlation traces back to the Routine Activity Theory (Cohen and Felson, 1979) which says that warmer weather often leads people to spend more time outside, consequently having more interactions with other people and, at the same time, leaving property unattended. Both of these create situations where interpersonal and property crime rates have the opportunity to increase.

In this study, a distributed lagged ordinary least squares model was used to evaluate how wind speed, precipitation, and temperature each affect crime rates. The conclusions that have been reached here seem to support many of the existing theories in this body of literature. The basic findings show that in the concurrent year of high levels of precipitation, theft, total crimes against property, and non-index crimes, all significantly decrease. In the year following high winds, however, theft rate and total crimes against property rate tend to increase again. Additionally, temperature seems to have a significant positive impact on non-index rates in the concurrent year and murder in the concurrent and lagged year. These significant results could have important policy implications regarding the most effective steps that can be taken to help prevent crimes from spiking in the aftermath of these shocks.

In the following section, I will review the current literature on theories and empirical work surrounding the relation between both natural disasters and crime, and temperature and crime. After covering the data used to conduct this study in section 3, section 4 will discuss the identification strategy, regression equation and variables. Section 5 will discuss the results and section 6 will analyze various policy implications that this information could have and section 7 will make some concluding remarks.

II. LITERATURE REVIEW

a. Natural Disaster and Crime Theoretical Literature

Beginning in 1938 with Merton's anomie theory, sociology was one of the first disciplines to come up with a theory on the causes of crime. Since then, crime has been a heavily studied subject in sociology, economics, psychology and many other fields. The study of natural disasters came later in the century with the original purpose to figure out emergency preparedness plans in the event of a nuclear attack. Natural disasters were the closest that government officials could come to replicate the effects of war, thus the study of natural disasters was born in 1957 with Flemming's "The Impact of Disasters on Readiness for War." Since the founding of each of these subjects in academia, scholars have created several theories which help explain why a natural disaster would have an impact on crime rates.

This review will delve into the theories linking natural disasters to crime. In this literature, there are two main theoretical predictions regarding what will happen to crime rates after a

natural disaster; either crime rates will increase, or they will decrease. These theories are vastly different from each other and to this point, there has been no consensus on whether one is “more right” than another. Further empirical works will be necessary to determine which of the following theories has more traction in the real world.

The first cluster consists of three theories which speculate that in the aftermath of a storm, there will be an increase in crime rates. The first, and arguably one of the most influential theories on crime, predicts an increase in crime rates of varying degrees depending on the response of authorities and the magnitude of devastation. In 1968, Gary Becker published his economic theory on crime which stated that there is a two factor function determining whether or not someone will commit a crime. The first part of the equation is that the criminal will engage in the crime if the expected benefits outweigh the potential costs. The second factor is society’s decision on how much surveillance to enforce as well as how harsh the punishments should be (Becker, 1974).

The second theory which suggests an increase in crime rates is Cohen and Felson’s (1979) Routine Activities Theory. This theory states that there must be a minimum of three criteria met in order for a crime to occur. These factors are 1) suitable targets to victimize 2) motivated offenders to carry out the crime and 3) a lack of guardians to prevent the crime from occurring. This would predict an increase in crime because following a disaster, many people are displaced from their homes and living in informal communal areas which increases the number of times that these three conditions coincide.

The third of the main theories is Robert Merton’s (1938) strain or anomie theory. This framework says that crimes are committed because there is frustration over the differences between the perceived goals in a society and the means for an individual to attain those goals (Merton, 1938). While it can be used as a theory for understanding why crime occurs following a storm, it is more frequently used as an assessment of underlying factors, such as socio-economic status, which may influence the chance of crimes being committed.

Each of these theorists consider many different aspects of human behavior and rationality when constructing their unique framework, however one element that each one is missing is the idea of cooperation and caring for friends and neighbors. The singular theory that suggests a

decrease in the rate of crime following a natural disaster was Charles Fritz's 1961 Theory of Therapeutic Community. This theory presumes that crime rates will decrease because people will come together and exhibit more pro-social behavior than would otherwise be seen following a disaster. Rather than taking advantage of their neighbors in their vulnerable state, people will empathize and do what they can to help each other.

b. Natural Disaster and Crime Empirical Literature

Because the relationship between natural disasters and crime is a relatively new focus and there aren't many researchers in this field, the sheer number of studies is quite small. Furthermore, the research that does exist takes place almost exclusively in the United States or other developed countries and has a very limited timeline. The majority of studies look at singular events and the outcomes that occur in the 1 to 10 months after the shock. This section gives an overview of what has been done so far and where there are gaps in the current literature.

One study which finds an increase in crime rates is Roy's (2010) "The Impact of Natural Disasters on Violent Crime." This paper focused on the effects in India after Hurricane Oressa hit in 2004. To accomplish this research, Roy looked at three factors within each state. She gathered information on the trend of crime rates following the storm, pre-storm media coverage, and the amount of emergency government aid that each state was allocated. Roy found that, while property crime increased in all states, the magnitude depended on the levels of media coverage; where higher media coverage was found to be correlated with lower crime rates. This supports Becker's theory because Roy also found that areas with more media coverage received higher amounts of government aid. One reason given for this is that officials try to avoid negative press during their time in office, so they give more aid to states with higher media coverage which helped to mitigate some of the effects that often come with disasters of this magnitude. Large amounts of relief have been shown to decrease the reconstruction period (Leitner et al, 2010) as well as reduce the effects of unemployment (Xiao, 2011) which, in turn, lessens the need and opportunity for crime.

A further study to support these theories is Zahran, Shelley, Peek and Brody's (2009) study looking at the long term effects of hurricanes in Florida. The authors of this paper observed instances of all types of natural disasters and crime across each of the counties in Florida. This

study looked at disasters' impact on violent, property and index crimes, as well as domestic violence. This was a longitudinal study using data from 1991 through 2005. The end results, interestingly, strengthen Strain Theory, Routine Activities Theory and the Theory of Therapeutic Community. First, the authors found a significant increase in domestic violence after an event at a rate of about 13 additional cases per disaster. This backs Strain Theory because it is hypothesized that there is increased stress while trying to cope with loss and get back to pre-storm life (Zahran et al, 2009). There is also likely an inefficient allocation of law enforcement which decreases the victim's protection. In the framework of the Routine Activity Theory, the abuser would be the motivated offender and the abused is the victim. Because of the significant stress in the domestic sphere (Zahran et al, 2009) and the lack of formal authorities (Roy, 2010), domestic violence is much more likely to occur.

Despite finding these increases in domestic violence, they found that all other forms of crime declined in the wake of natural disasters. The study concluded that, on average, each event reduced total index crimes by 57 incidents. Of this, violent crimes decreased by about 11 crimes per event, thus property crimes are reduced by about 46 crimes per occurrence. These findings are empirical support for Fritz's 1961 theory which predicts more pro-social behavior immediately following a storm. Despite being a long term study, the authors did not disaggregate their variables into long and short term time frames. Because of this, there is no way to know if there was an overwhelming decrease at first followed by a steady increase, if the crime rates dropped and then held steady at a lower level, or if there was another pattern to the data. One study that can potentially help with this found similar results and looked only at the short term effects.

In 2011, Leitner et al. conducted a study in the cities where evacuees were taken during and after Hurricane Katrina. Their original hypothesis was that crime would increase because the increased collision of the three conditions stated in the Routine Activities Theory. This study was done in much the same way as Bass (2008) and both found that crime rates either held constant or decreased in the areas that were highly affected with evacuees. Leitner et al (2011) found that violent crime significantly changed in 16 of the 64 parishes and 14 of those were decreases. In

the 11 parishes which had significant changes in property crime, all of them were reductions. Again, both of these uphold Fritz's theory.

Further studies on pro-social behaviors have been composed both quantitatively and qualitatively. Rodriguez, Trainor and Quarantelli (2006) studied behavior three weeks after Hurricane Katrina struck and found that people coped with the tragedy by engaging in non-traditional pro-social behaviors. Rodriguez et al looked at five different institutions including hotels, hospitals, neighborhood groups, rescue teams and joint field offices and determined that each of these played a vital role in promoting solidarity throughout the affected areas. In fact, the authors note that "emergent activities in the impacted region showed a different and opposite pattern to those suggested by the imagery employed by the media outlets" (84). One example of these emergent activities occurs immediately following a storm when people must come together to save the lives of neighbors to whom they likely had no previous ties before the storm (Messias, Barrington and Lacy, 2011). The emergence of pro-social behaviors such as this builds on the ideas of Fritz (1961) and has significant implications for the action that should be taken after a storm.

Despite the immense diversity between theories that predict an increase versus those that predict a decrease in crime rates, both sides are upheld in the literature. There is an array of approaches to find whether or not crime is impacted following a natural disaster and the results are fascinating. These findings are dependent on magnitude of the event, the amount of aid given to the victims, location of the storm and what type of crime is being studied. This data, nevertheless, is very limited by the number of studies and types of studies that have been done. Looking at the impact of natural disasters on crime rates is undoubtedly an understudied topic. Those that do exist are primarily in the United States, with few exceptions taking place in developing countries. Research almost exclusively looks at a time frame of under 10 months and only one study was a true longitudinal analysis. This lack of research leaves an overwhelming gap in the current literature, which is where this study furthers our knowledge on the subject. Not only did the following study take place in a developing country, but it will look at both short and long term impacts of crimes against persons and property. The conclusions will also help make recommendations to officials in the Philippines as to potential policies that could have drastic

impacts on the pattern of crimes following typhoons. The more we can learn about people's behavior after a natural disaster, the more prepared governments can be to allocate their limited resources where they will have the highest and most positive impact possible.

c. *Temperature and Crime Theoretical Literature*

There are two main disciplines which have created theories on the relationship between temperature and crime; psychology and sociology. Nearly a century before any theories were formalized, however, the correlation between heat and crime had been studied. The earliest research in this field observed and hypothesized that the spike in violence is due to the level of discomfort of individuals when it is hot outside. This was the ultimate conclusion in the seasonal study by Adolphe Quetelet in 1842, when he published the first known observations associating temperature and violence. Since then, it has been repeatedly documented that our immediate environment shapes our moods and behaviors (Bell, Garnand, and Heath, 1984; Griffitt, 1970; Griffitt & Veitch, 1971) and many social scientists use this common knowledge to presume that a person who is in an environment with increased temperatures to the point of discomfort will engage in higher levels of violence towards those around them.

The earliest works done in the field of psychology postulated theories based on biological responses to heat. The first of these theories on the relationship between temperature and crime was published in 1939 by Dollard et al. His theory, called the frustration-aggression hypothesis presumes that in heat, the body reacts with frustration which then becomes aggression. If there is no outlet for this aggression, it will get displaced onto other individuals. Leonard Berkowitz expanded on this in 1989, 1990, and 1993. His research found that uncomfortable temperatures produce negative affects which will kindle thoughts and memories which are correlated with the fight or flight response. This could trigger an abnormal amount of violence if the urge to fight is not controlled.

Many social scientists take a different approach and attribute the link between temperature and crime to the Routine Activity Theory. This theory can be applied to both an increase in interpersonal crime as well as property crime. Interpersonal crime, according to this theory, would be impacted because more people tend to go outside when it is warm. This creates an environment where the three criteria of the theory: motivated offender, suitable target and

lack of guardians or law enforcement, will collide more often. Similarly, property crime will be more prone to increase because as more people go outside, more properties are left unattended which again increases the number of “victims.”

d. Temperature and Crime Empirical Literature

The relationship between heat and crime has been studied using a variety of environments and methods. One of the foundational studies associating high temperatures with aggression was done in 1986 by Kenrick and MacFarlane. They gathered observations in Arizona and found that those who had air-conditioning in their car were less aggressive drivers and honked less than those without air conditioning. A further application of this relationship looked at the reaction of baseball pitchers in warmer weather (Larrick et al, 2011). The authors found that in hot weather, pitchers tend to hit batters with a ball more often if their players had been hit by the opposing team’s pitcher. Another study found that prisoners had significantly more rule infraction citations during the summer months than during any other time of the year, over a four year period (Haertzen et al, 1993). While these are all fairly unconventional applications of the temperature aggression hypothesis, there have also been several interesting studies done in a more conventional settings.

One such study found that both assaults and property crimes in Wales and England increase when the temperature is higher (Simon, 1992). He claims that assaults will increase because more people spent time outside, thus increasing the potential victim pool and the number of possible offenders. Property crime, on the other hand, increases because there are more properties left unattended so the opportunity of getting caught is minimal. In addition to finding that hot weather increases aggression, Anderson et al (1996) found that extreme cold temperatures have a similar effect in causing aggressive thoughts. Field studies also showed that there was a very clear association between heat and aggressive thoughts and behaviors, including horn-honking behavior, spousal abuse, violent crimes, and delivering electric shocks (Anderson, 1989).

There has been a surge of studies in the last several years which have shown how heat impacts a variety of aggressive behaviors in both individual and group situations. Effects have been revealed through the use of large panel data sets showing that heat significantly increases

the tendencies of human aggression in a variety of settings. These situations include civil conflict (Hsiang and Meng, 2014), riots and civil uprisings (Hsiang and Burke, 2013), and interpersonal violence (Cane et al, 2014; Hsiang et al, 2013). The type of studies done in this realm have very clearly shown that heat not only impacts an individual, but has large scale impacts on society. Each of these papers stress the importance of research in this field as our climate continues to get warmer.

III. DATA

To estimate the impacts of typhoons on crime rates, secondary data was used for both weather shocks and crime measures. As a supplemental element, qualitative data was collected in the forms of both interviews and focus groups.

a. Crime Data

The crime statistics exploited for this study were obtained directly from the Philippine National Police (PNP) in the department of the Directorate for Investigation and Detective Management (DIDM), located at the national headquarters in Manila, Philippines. The data was compiled from each of the 17 Regional Police Offices from 1990 until 2008. Throughout these 19 years, the standards of crime reporting remained consistent but the administrative borders of the regions went through several divisions. To account for these changes, some of the regional crime data had to be combined so as to keep consistency over the areas where crimes were reported. After this consolidation, there were a total of 13 regions for which fluctuations in crime rates could be estimated.

The types of crimes in each of these regions was broken down into index and non-index crimes. Index crimes were further differentiated into 6 categories: murder, homicide, physical injury, rape, robbery and theft. Each of these statistics was based solely on crimes reported to the police. Because of the severe distrust of officials, in many neighborhoods (locally called *Barangays*), in many cases crimes were reported to the community leaders, rather than directly to police. Barangay leaders often relayed the crime reports to the police, but not always. According to conversations with local citizens both on and off the record, this type of informal reporting appeared to be common practice across the country. This would suggest that there should not be great concern with using biased data. However, if there is an impact on the

estimations due to insufficient reporting, it would create a downward bias on the results reflecting a smaller impact than would otherwise be seen.

Table 1 summarizes each of the officially reported crimes which are used in the estimations that follow. The crime rates are given as a rate per 100,000 people in the region. For example, the first row shows homicides. The minimum number of homicides across the 13 regions in a specific year was nearly 2 homicides per 100,000 people in that given region. As this table shows, there is significant variation among each of the crimes.

Descriptive Statistics				Table 1	
Variable	Obs	Mean	Std. Dev.	Min	Max
Homicide Rate	247	7.283	4.157	1.949	21.463
Murder Rate	247	9.740	4.995	2.970	37.454
Physical Injury Rate	247	21.570	12.612	5.145	77.979
Rape Rate	247	3.636	1.145	0.828	7.3063
Total Crimes Against Persons Rate	247	42.230	19.385	14.275	113.171
Robbery Rate	247	10.693	9.602	2.366	57.675
Theft Rate	247	15.909	16.966	1.866	102.440
Total Crimes Against Property Rate	247	26.602	25.903	5.158	160.115
Index Crime Rate	247	68.833	41.679	22.875	255.700
Non-Index Crime Rate	247	47.870	24.701	11.879	170.255
Total Crime Rate	247	116.704	60.985	37.288	376.163

*Crime rates are per 100,000 pop.

b. Wind-speed Data

Yearly typhoon wind speed observations were taken from Solomon Hsiang's (2010) data set. This is a comprehensive collection of every typhoon that has occurred from years 1950 through 2008. During that span, he documents 837 storms which passed through the Philippines. Hsiang recreated the wind field for each storm and measured the wind speed every 6 hours that

the typhoon was over land in the Philippines. To get the full reconstruction, the author used a program called the Limited Information Cyclone Reconstruction and Integration for Climate and Economics, LICRICE. The wind field for each region is approximated by taking the maximum wind speed across each pixel, which is $1/34^{\circ} \times 1/34^{\circ}$, within each province or region. This average is then taken across all storms in a given year for each pixel and made into a single average yearly observation of wind speed in each region which is measured in meters per second. Although this data is complete at both the Provincial and the Regional levels, the PNP was only able to provide data at the regional level so those are the figures implemented in these estimations.

Table 2 below shows the descriptive statistics for yearly wind speed, temperature and rainfall. The most crucial source of variation for the identification strategy to hold is the variance in trajectory and strength of the wind in each region. As table 2 shows, the minimum wind speed in a region was zero meters per second. This highlights the variation of typhoon wind speed, pointing out that some regions were not hit by storms in certain years. Throughout the 19 years of data analysis, this occurred a total of three times in two regions.

c. *Rainfall and Temperature Data*

Precipitation and temperature data were also used to test for any significance of these variables on crime rates. This information was obtained from Hsiang and Anttila-Hughes' (2013) complete data set. Temperature records were originally acquired from the National Center for Environmental Prediction (NCEP) using the Climate Data Assimilation System I (CDAS1). This reports the average high temperature in Celsius for every year in each region.

Rainfall data was gathered using Merged Analysis of Precipitation (CMAP) at the Climate Prediction Center (CPC). The precipitation measure accounts for the total average precipitation in a given region each year, measured in centimeters.

While there is less variation in temperature than either wind speed or precipitation, it is still an important addition to this research. As discussed above, previous studies have found significant impacts on crime due to changes in temperature. As such, including this in the regressions will give an estimation on whether small changes in temperature have an effect on crime rates in the Philippines.

Descriptive Statistics					Table 2
Variable	Obs	Mean	Std. Dev.	Min	Max
Wind Speed	247	16.892	9.816	0	41.379
Precipitation	247	73.052	13.802	42.376	105.331
Temperature	247	27.430	0.737	25.228	28.823

d. Qualitative Data

In addition to quantitative data, interviews and focus groups gave further insights into the perceptions of the changes in crime rates due to the weather shocks. Over the course of eight weeks, I conducted 2 focus groups and 27 in-depth interviews. The first focus group consisted of 7 women who were community “block” leaders in a village just outside of metro-Manila. The second focus group had 2 women and 1 man from a small rural village in the mountains of the Ifugao region. The interviews were primarily held in metro-Manila since that is where nearly all of the organizations have their headquarters. Those that were asked to take part in the interviews were people who had first-hand experience with the effects of typhoons and, in most cases, also had experience with disaster relief, agriculture, or criminal behavior.

The two focus groups lasted for approximately one hour each and the interviews lasted in the range of 20 minutes to one hour. During that time, the participants were asked what ‘crime’ meant to them and what they think cause people to commit crimes. The participants were then asked to tell stories about their experiences with typhoons. This included questions regarding their biggest concerns before, during, and after a typhoon and what the most harmful element of the storm is. If the issue of crime or safety had not come up during their story-telling, I asked questions regarding their feeling of personal safety and the security of their possessions before and after a typhoon strikes. While this data was not directly added into the quantitative estimations, the discussions helped frame the arguments in the following sections. The insights of local populations and professionals in these areas of interest were invaluable sources in helping to identify potential channels through which the results take place.

IV. IDENTIFICATION

The basic premise of this study relies on the variation of wind speed, precipitation, and temperature shocks in each region across time. The Philippines is an ideal location for studying these weather shocks, with typhoons being particularly relevant. While there are many countries that would be sufficient to study the effects of temperature on crime, there are a select few which are struck by disasters as frequently as the Philippines, which allows for the effective use of panel data. The Philippines are located in one of the most active storm belts on the planet which makes it possible to gain useful insights into the short and long term impacts of typhoons on crime rates.

Typhoons are fully exogenous forces that strike the Philippines every year. Each is different in size and intensity, with the storms ranging from a strong wind to a severe storm. There is also significant variation in where they strike as well as the number that hit each region in a given year. Although there are general patterns, there is no set path that the typhoons follow, and every year, each region is affected differently. In addition to the variation of these storms, there is also a definitive space which the typhoon occupies at any given time. This allows for highly precise wind-speed data.

Typhoons often bring both high wind speeds and a large amount of precipitation to any region it strikes. To more accurately determine what is causing the changes in rates and when the changes occur, we break down the variables into wind-speed and precipitation. Although logically it would seem that wind speed and precipitation are highly correlated, there is actually just a 23% correlation between the two since there is rainfall throughout the year in each region. Because of this, both variables can be added in to the regression without creating problems of collinearity.

The identification for temperature is based on much smaller variation than typhoons. The Philippines is a tropical country with consistently warm temperatures. The data does not show any large temperature shocks over the time period of interest, however because of the relatively stable temperature patterns, any small changes in average yearly temperature could show large scale impacts on crime rates. Since the climate tends to be fairly warm year around, theories based off of routine activity theory would likely no longer be relevant. For example, the

suggestion that crime increases because people tend to go outdoors when it is warmer, would not be a viable solution anymore as the temperature increases are not large enough to drive that behavior. It could, however, be a significant enough change in temperature to influence biological responses or other reactions to the elevated temperature.

Because of this random variation of typhoons and temperature, I was able to use a distributed lag OLS model to empirically estimate the impact that different weather variables have on crime rates. In addition to concurrent yearly weather patterns, there is a one year lag added in to the equation for each of the variables. Previous research has found that there are significant economic impacts in the years after a typhoon hits a region which could impact criminal decision making during that time period (Anttila-Hughes and Hsiang, 2013). This lag will account for changes that occur in the one year following a typhoon to see if crime rates follow a similar pattern. The repeated exposure to these events allow for the use of panel data. Both the variation of the events and the use of panel data strengthen the identification strategy used in this study.

The results were estimated using an ordinary least square distributed lag model. The general equation that was used is:

$$Y_{rt} = \beta_0 + \beta_1 W_{rt,t-1} + \beta_2 P_{rt,t-1} + \beta_3 T_{rt,t-1} + \mu_t + \tau_t + \varepsilon$$

Where Y_{tc} is the crime rate, W is the wind speed, T is temperature, P is precipitation, t is time, r is the region, τ is region fixed effects, μ is year fixed effects and ε is the error that is not explained by these variables. To account for heteroskedasticity in the data, this model includes robust standard errors.

There could be concern that some regions may have cultural values or other unobservable characteristics that may inherently lead them to have differing criminal reactions to typhoon exposure or temperature variation. To address this possibility, regional fixed effects are added in to absorb any cross-sectional differences. Year fixed effects are also added in to control for any pattern within the region over time that may influence the crime rates.

As with any research, there is some unease with the potential validity of a few aspects of the study. One such issue may result from the number of observations. There are only 247 total observations, but with the one year lag, that decreases to 234. There is a chance that this is too

small to find the true impacts. In spite of this, the qualitative data matches very well with most of the quantitative results. This would lead us to believe that the general direction of the impacts is accurate, although the magnitude may be less precise than it would otherwise be with more data. This concern could be rectified with more years of data or doing a similar study using provincial rather than regional data. A second potential issue is that the police are widely perceived to be a corrupt agency. This could affect the crimes reported but if this is the case, there is likely the same pattern across all of the regions which would not greatly impact the overall effect. The fixed effects should also account for much of the variation due to political or police corruption. Third, there is some concern that after a typhoon strikes, a police station or roads leading to a police station could be washed out causing the inability for citizens to report crimes. While this may seem like a substantial problem in data reporting, I believe that each region would be equally likely to face this problem. Infrastructure throughout the country is in poor condition. Even in cities and towns where roads are paved, there is constant concern of flooding, sinkholes and landslides leading to roads being unusable. As such, there would be little to no bias in the data since all regions would be similarly affected by the problem. Despite these weaknesses, the quantitative results found seem to corroborate those found in other literature as well as sync with the qualitative results.

V. RESULTS AND DISCUSSION

This section presents the quantitative results gathered from running the regressions described above. The qualitative data will also be interjected as evidence which either supports or counters the empirical findings.

a. Crimes Against Persons

The first set of OLS estimations look at the impact that wind-speed, precipitation, and temperature have on crime rates against persons. This group of crimes include murder, homicide, physical injury and rape as well as the aggregate effect on total crimes against persons. Table 3 shows the impact of the three weather variables in the concurrent year and their 1 year lagged effects across each type of crime. Beginning with the impact of wind-speed, this table shows that there is no significant effect in any crime rates against persons during the concurrent or 1 year

lag due to increased wind-speed. However, this is not true of the other two weather variables in this table.

Crimes Against Persons					Table 3
Variables	Physical Injury Rate	Homicide Rate	Murder Rate	Rape Rate	Total Crimes Against Persons Rate
Wind Speed	0.013 (-0.083)	-0.026 (-0.024)	0.003 (-0.033)	-0.003 (-0.012)	-0.013 (-0.124)
Lagged Wind Speed	0.102 (-0.081)	-0.009 (-0.023)	0.030 (-0.027)	0.005 (-0.011)	0.128 (-0.112)
Precipitation	-0.160** (-0.075)	-0.003 (-0.029)	-0.046 (-0.035)	-0.007 (-0.013)	-0.217* (-0.112)
Lagged Precipitation	-0.003 (-0.073)	-0.021 (-0.026)	-0.040 (-0.033)	0.002 (-0.011)	-0.063 (-0.107)
Temperature	1.062 (-4.556)	1.54 (-1.315)	3.821* (-2.139)	0.605 (-0.653)	7.028 (-6.456)
Lagged Temperature	-3.845 (-4.372)	1.523 (-1.071)	3.193** (-1.565)	0.48 (-0.557)	1.35 (-6.141)
Constant	106.1 -121.6	-77.25* -41.6	-183.6*** -65.11	-24.73 -17.27	-179.5 -182
Observations	234	234	234	234	234
R-squared	0.769	0.845	0.802	0.56	0.817

Note: Observations made at the region level. Standard Errors (robust) are in brackets. ***p<0.01, **p<0.05, *p<0.1. Includes year and region level fixed effects.

Table 3 reports that, for each centimeter of additional precipitation across a region, the rate of physical injury decreases by .16 assaults per 100,000 people. The total crimes against persons is also impacted by the amount of precipitation. For each additional centimeter over the average amount of rainfall, total crimes against persons decreases by .217 incidents per 100,000 people. This finding is consistent with the literature on pro-social behavior. Increased precipitation could indicate higher levels of flooding, landslides and washed out roads. According to Fritz (1961) and much of the research on disasters, there is an increase in pro-social tendencies

which would decrease inter-personal conflicts and assaults. Lagged precipitation appears to have no effect on crimes against persons.

Precipitation is not the only variable that has an effect on this category of crimes. According to these estimations, an increase in average yearly temperature of just 1 degree leads to almost 4 additional murders per 100,000 in the concurrent year and just over 3 additional murders in the year following higher than average temperature. The contemporaneous estimate is consistent with a multitude of studies in the literature. Since the foundational study done by Kenrick (1986), dozens studies have found links of temperature on violence, war, civil disobedience, riots and many more (Anderson, 1987, 1996; Hsiang, 2013; Cane et al., 2014; Hsiang and Meng, 2014; Hsiang and Burke, 2013; Hsiang, Burke and Miguel, 2013). The magnitude and significance of this result pair well with current literature stating that increased temperature will increase crime and conflict.

During the focus groups and interviews, people stated that they did not feel any more threatened for their personal safety following a storm. While this is consistent with the findings for typhoons, there was also no mention of increased aggression during times of unusual levels of heat. As previously stated, this could be due to the relatively stable hot climate that those in the Philippines face year around, which makes it difficult to differentiate one hot day to the next if the variation in temperature is not large enough. Unfortunately, there is no previous work stating the threshold at which biological changes take place, so this is not a testable hypothesis.

b. Crimes Against Property

Wind-speed, precipitation and temperature are all found to have significant impacts on crimes against property which is consistent with previous work done in the field of economics. Table 4 presents the impacts of the three weather variables on theft and robbery rates, and on total crimes against property. In the concurrent year, precipitation is the only weather shock to significantly impact theft rates. An increase of 1 centimeter of rainfall is estimated to yield a decrease in thefts of .365 per 100,000. An alternative way of framing this result is that a decrease in temperature could cause an increase in theft. As a largely agrarian country, the Philippines is heavily reliant on rainfall to water their crops. If there is a bad year of rain, the effects could be highly damaging to the income of a household. There is wide variation of average rainfalls across

the country, but presumably within any region, an unusually dry year will cause crops to have a less than sustainable yield, creating a need for people to steal in an effort to support their household. Consequently, there would likely be lasting effects into the year after as well, since low crop yield would negatively impact the ability of a family to save for the following year. This hypothesis is supported in the results for the lagged year. In the 1 year lag, according to the inverted estimations, a decrease of 1 cm of precipitation increases the theft rate by .203 per 100,000.

Crimes Against Property		Table 4	
VARIABLES	Theft Rate	Robbery Rate	Total Crimes Against Property Rate
Wind Speed	0.088 (-0.092)	0.040 (-0.047)	0.129 (-0.133)
Lagged Wind Speed	0.262*** (-0.095)	0.091 (-0.059)	0.353** (-0.143)
Precipitation	-0.365*** (-0.093)	-0.061 (-0.056)	-0.427*** (-0.144)
Lagged Precipitation	-0.203** (-0.088)	-0.015 (-0.053)	-0.219 (-0.136)
Temperature	4.89 (-5.084)	1.075 (-2.78)	5.964 (-7.626)
Lagged Temperature	-8.650* (-5.04)	-3.549 (-3.009)	-12.2 (-7.567)
Constant	152.4 -145.4	79.79 -86.01	232.2 -220.3
Observations	234	234	234
R-squared	0.831	0.854	0.848

Note: Observations made at the region level. Standard Errors (robust) are in brackets. ***p<0.01, **p<0.05, *p<0.1. Includes year and region level fixed effects.

Reversing the interpretation again, there are several other hypotheses which, while less likely, one could plausibly use to explain the decrease in theft rates due to an increase in precipitation. One hypothesis is that there is destruction of infrastructure within and between

villages due to washed out roads, landslides or general flooding damage. While gathering the qualitative data, many of the participants mentioned that during and after a heavy rainfall, the water often destroys parts of the frail infrastructure which renders citizens incapable to move between villages. Many of the participants made a point to say that they were never concerned that people from their own village would commit any crimes against fellow community members, rather, they were worried about people coming in from neighboring villages to steal from them. If there is no feasible way for a person to move from village to village, then the ability to steal from nearby villages declines.

A more altruistic theory regarding the decrease in crime rates during a year of higher precipitation is an increase in pro-social behavior. Many participants in our interviews stressed that in times of need, community members always came together to help each other. This could be anything from giving a family a place to stay or helping clear a mudslide off of the road or even rebuilding houses and community buildings together. After a disaster strikes, in this case a flood, many researchers have found that social barriers fall and people come together to survive and get through the hard times as a community, rather than turning on each other (Fritz, 1961). This is likely at least a partial explanation for the decrease in thefts throughout the regions of the Philippines during contemporaneous and lagged years of increased rainfall.

Table 4 also indicates that lagged wind speed has a significant effect on theft rates. There is an estimated increase in the theft rate of .262 thefts per 100,000 for each additional meter per second of wind-speed. The likely mechanism driving this is that if a storm strikes a region with high enough winds, crops and other livelihoods are likely to be destroyed. If this happens, a household may have enough savings to get through the year, but is unlikely to have enough to get them through the following year, thus increasing crime in the 1 year lag. This finding supports research by Anttila-Hughes and Hsiang (2013) which found that during this same period of time following a typhoon, there is a significant decrease in family income and expenditures. A decrease in expenditures would suggest that a family has likely run out of any savings it had to begin with and is significantly worse off. This could put a household in a potentially fatal situation if another form of employment was not obtainable. For those living at, or even slightly above subsistence, a shock of this sort could push individuals to engage in the only type of “employment” they found

readily available; criminal activity. Stealing from other households, while likely not desired by most, could be seen as a temporary way to sustain a family until another solution is found.

To further support this argument, there were no significant impacts in robbery for either the concurrent or lagged year for any of the shock variables. Intuitively, this makes sense. A person who would normally not engage in this deviant behavior may be forced to commit crimes for survival. In that case, a person would be more likely to engage in the act of stealing rather than the more violent crime of robbery. The thought that a person would shift from a law abiding citizen to a violent robber is far less plausible than slightly shifting their behavior to engage in a lesser crime of petty theft or a similar act. It is more logical to assume, then, that the increase in thefts due to wind-speed is an act of survival rather than malice.

This increase in theft seem to follow the general sentiments of the people I spoke with in the interviews and focus groups. During the discussions, nearly all of the participants mentioned, that they felt their possessions were less secure after a typhoon struck. Since they felt there was no direct threat to their personal safety, the highest concern was that of their belongings. Most people have so few possessions, that to lose something as simple as a pot could take months of work to replace. The concern of theft after a storm does appear to be a legitimate fear according to these results.

The overarching trend in total property crimes is a decrease in the concurrent year of typhoons by .427 crimes per 100,000 people and then increase in the year after by .353 crimes per 100,000. If the true impact in the concurrent year is that a decrease in precipitation causes an increase in theft, then this coefficient is difficult to interpret. If an increase in precipitation does indeed cause a decrease in theft then it is likely either due to an increase in pro-social behavior or the destruction of infrastructure. Both of these results follow the findings in current literature and the hypotheses for the mechanism behind this result is similar to those described previously. In the concurrent or lagged year of decreased rainfall and in the lagged year of increased wind speed, crime rates could increase due to insufficient savings and lack of income, creating a desperate situation for household member's survival. Together, the latter situation would likely lead to an increase in theft rates.

c. Index, Non-Index, and Total Crime

Typhoons appear to have a significant impact on index crimes as well. From table 5, the estimates show that there is a decrease of .643 crimes per 100,000 people for each additional centimeter of rainfall. In the following year, index crime rates increase by .482 crimes per 100,000 people for every meter per second increase in wind-speed over the average. Index crimes are simply a combination of crimes against persons and property. Since this is the same pattern as crimes against property, and there are stronger results in property crimes than crimes against persons, the former is clearly driving these results, which again could be difficult to interpret depending on the true direction of the theft rates.

Total Crime Rates		Table 5	
VARIABLES	Index Crime Rate	Non-Index Crime Rate	Total Crime Rate
Wind Speed	0.115 (-0.236)	-0.105 (-0.168)	0.010 (-0.344)
Lagged Wind Speed	0.482** (-0.23)	0.206 (-0.235)	0.687* (-0.382)
Precipitation	-0.643*** (-0.236)	-0.650*** (-0.169)	-1.293*** (-0.34)
Lagged Precipitation	-0.282 (-0.222)	-0.048 (-0.155)	-0.33 (-0.312)
Temperature	12.99 (-12.61)	14.93* (-7.74)	27.92* (-16.7)
Lagged Temperature	-10.85 (-12.64)	-18.01 (-12.14)	-28.86 (-20.56)
Constant	52.69 -369.7	179.3 -344.8	232 -586.2
Observations	234	234	234
R-squared	0.83	0.742	0.83

Note: Observations made at the region level. Standard Errors (robust) are in brackets. ***p<0.01, **p<0.05, *p<0.1. Includes year and region level fixed effects.

Interestingly, precipitation impacts non-index crimes in nearly an identical manner as it does index crimes. Non-index crimes consist of all crimes such as drug possession, driving under

the influence, negligent manslaughter, vandalism and any other crime where there is no physical confrontation, which do not fit into any of the previous crime categories. The table shows a decrease in non-index crimes of .65 crimes for each additional centimeter of precipitation in the concurrent year. Additionally, there is an estimated increase in non-index crimes of nearly 15 incidents per 100,000 people in the concurrent year due to an increase in temperature of 1 degree. The current literature could give some insight as to the rationalization of this result.

In the concurrent year, higher temperatures can increase aggravation and potentially push people to act more deviantly. This defiance may drive people to use drugs and drink which leads to crimes such as drug possession and driving under the influence of alcohol. Increased levels of irritation due to heat could also push people beyond their comfort level and drive them to commit other crimes in which they would normally not engage. In addition to crimes due to higher temperature, the negative effect of .65 crimes per 100,000 people could again be due to pro-social behavior or decreased infrastructure between communities. Without drivable roads, the opportunities to get drugs from village to village, drive while intoxicated or commit other crimes in this classification would be severely diminished. On the other hand, if it is pro-social behavior that is driving this trend, people may be too busy with rebuilding their own communities to engage in deviant activities.

While it is useful to break down these effects into impacts on different types of crime, it is pertinent for policy making to look at the aggregate effects on all crimes due to inclement weather exposure. Table 5 shows that the total crime rate declines by nearly 1.3 crimes per 100,000 for each additional centimeter of rain in the concurrent year of a typhoon striking. In the following year, there is a .687 crime increase for every additional meter per second wind-speed from the previous year. These effects again follow the results found for property crime and index crimes. The effect of temperature on total crimes is almost 28 crimes per 100,000 people. This large impact is consistent with other literature finding that increased temperature will increase criminal behavior.

VI. POLICY IMPLICATIONS

The results in this study have some potentially large scale impact on future policy recommendations for the Philippines. The Philippines were ranked as the number three country

most at risk to be impacted by climate change (UNU WRI, 2012). Because this rank was given to them based off of the increase in expected number of typhoons as well as the intensity of each storm, the results from this paper clearly show that there are some necessary changes needed to account for the continuation of climate change. Since there were significant results found for wind speed, precipitation and temperature, there are three main threats which can be considered when analyzing possible plans. I believe that two basic policies, and one recommendation, have the potential to drastically decrease the rate of crime following an environmental shock.

The first policy is to create either formal or informal insurance for households in the agricultural industry. Small scale and subsistence farmers appear to be disproportionately affected by strong winds due to typhoons, and during years of low rainfall. Many developing countries have informal insurance through communities, family or friends. This strategy would be difficult in this environment since a typhoon or drought affecting one farm is likely to equally impact the neighboring farm. Another option to carry this out could be a formal state organized insurance plan for individuals or communities. Implementing a safety net such as this could help farmers survive their losses during these rough years without the necessity to steal to survive. Forming and establishing a plan for insurance would likely take years to implement. In the meantime, another strategy could prove a helpful tool to reducing the number of crimes in a given neighborhood.

A second possibility would be to establish a community based system that would operate much like the US based "Neighborhood Watch" program. This would have many benefits if done correctly. First, as previously mentioned, it could be used as a strategy in the interim while insurance coverage is formulated. Second, with an extra set of eyes watching out for the community, it could serve to curb crimes of all types, both violent and property violations. Third, with the severe distrust of police officers and government officials, having a person from the neighborhood "on duty" could help assist the Barangay leader to take care of matters relating to crime. One further benefit is that people may be deterred from committing a crime simply from knowing that there is someone observing the neighborhood. This program would not take up

significant resources from the state and it would not be difficult to implement. As such, these neighborhood organizations can be put to use almost immediately.

A further recommendation is stress the need to more efficiently allocate foreign and domestic aid in the wake of a typhoon by stressing the continuing need of aid into the following year. Since criminal effects after a typhoon are felt in the year following a storm as well as the year of a shock, ongoing financial assistance could help those who have enduring needs. There are clearly needs such as food, clean water, and shelter, which need to be taken care of immediately following a typhoon. Millions, if not billions of dollars of aid are sent in these situations, but these sources tend to dissipate quickly, especially once media coverage leaves the scene. Encouragement for funding to continue through the next year, or a different distribution scheme could help to alleviate some of the lasting desperation that many households face. This solution, while potentially effective in reducing crime, would likely be difficult to implement since a significant portion of financial assistance rests on the kindness of outside organizations.

With the information and estimations gathered in this study, one can credibly propose that the effects of crimes due to temperature and typhoons will increase in magnitude as our climate changes. It is of particular importance that governments and citizens alike begin to make changes in policies and programs in an effort to adapt to the changing environment. To create an environment where people are safe should be of utmost concern after a disaster strikes, and the implementation of each of these programs would likely help facilitate that goal.

VII. CONCLUSION

This research exploited a novel data set to find whether typhoons and temperature impact crime rates in the Philippines. The results show that there are significant impacts on crime rates due to wind-speed, precipitation and temperature in both the concurrent and lagged years. These conclusions follow the findings and logic of previously conducted research and are also able to contribute several new results to the current literature.

While the body of research linking crime to natural shocks is quickly expanding, there are still many gaps to be filled. The research that exists often looks at a single event or a time span of less than two years and usually takes place in a developed country. Therefore, the contributions of this study are threefold. First, this is one of very few studies that is able to look

at the impact that shocks have on crime rates which are broken down by region and type of crime. Furthermore, it is the only study that has looked at this relationship specifically focusing on wind speed as the catalyst. Secondly, the research takes place in the Philippines which is a developing country. Out of all the research I have found thus far, most has all taken place in the U.S. or other developed country. Third, it is rare to have two datasets of this nature which span such a long overlapping period of time. Nearly all studies, with a few exceptions, have looked at singular events. This research was able to use panel data to observe the effects over an 18 year time span which strengthens the identification strategy outlined above.

Looking at the big picture of these results, there is a very strong trend that crime rates decrease in the concurrent year of a typhoon and then increase again in the following year. These results are highly significant and have potential for some serious implications for both citizens and the government of the Philippines with regards to the specific policies that can be implemented to help curb the criminal aftermath of these shocks during the immediate recovery period and into the year after. To test the external validity of these findings, further research must be conducted in a similar fashion. Developing countries, in particular, are prone to the shocks of natural disasters and it is important to recognize all of the consequences that occur in the time after disaster strikes. If these results are taken seriously by policy makers, there is potential to improve the safety of millions of people after the next environmental shock devastates their country.

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