Master thesis

The economic consequences of natural disasters

An empirical study to the effect of natural disasters on economic growth

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1. Introduction

This paper empirically investigates what the impact is of natural disasters on economic growth. The relevance of this topic emerges in the Copenhagen Consensus 2012. This expert panel of economists put natural disasters on the challenging list of the biggest problems in the world. Also the Intergovernmental Panel on Climate Change (IPCC) focus on extreme weather and climate events and the implications of these events for the society and a sustainable development in the world. There are regularly news items of natural disasters. Recently, the typhoon Haiyan ravaged the Philippines. In the summer of 2013, floods in Central Europe had cost eleven people their lives. In addition, shipping was shutting down because of the sharp rise in the water level (Huiskamp, 2013). Big natural disasters occurred in recent years. The tsunami in Haiti in 2010, which took the lives of roughly 222.570 people; In Japan there was an earthquake with 390.000 victims in 2011. Flooding in Bangladesh has brought enormous suffering. Undoubtedly, the magnitude and frequency of certain types of natural disasters depends upon the location of the country. Given the location, the question remains what the effect is on the macro economy. If there is an effect, how can you explain that this effect is different across the world? This paper tries to give an answer to these questions.

Empirically, my work is related to a number of other papers who attempt to uncover the link between natural disasters and economic growth. There is empirical evidence that natural disasters have a negative effect on overall GDP growth in the short run (Noy, 2009). Splitting up natural disasters to subtypes results in a significant effect of climatic natural disasters on GDP growth (Skidmore & Toya, 2002; Raddatz, 2007, 2009; Loayza et al, 2012). However, disasters like floods and droughts have a positive respectively negative significant effect on agricultural growth (Loayza et al, 2012).

Building on this literature, this paper contributes in several ways. First, I use a different approach in the measurement of natural disasters; I measure besides the size of population affected, killed and the economic damage, the number of disasters controlling for the country size. I measure all of them in one-year periods. Secondly, I combine some of the empirical approaches; I split GDP per capita growth up in agricultural, industrial and service growth. I also contribute by adding interaction terms of institutional variables as discussed in Noy (2009). I use interaction terms with GDP p.c., the Polity index and Aid inflows p.c. Thirdly, I use the number of disasters as an instrument for the consequences of disasters.

This paper answers the main question in several sub questions:

(1) Do natural disasters have a negative effect on short run economic growth?
(2) How does this effect differ when I split up GDP per capita growth?
(3) What is the effect of institutional and structural characteristics of countries in this relationship?

The first sub question will on the one hand test the effect of all types of natural disasters together on GDP per capita growth. On the other hand, I will test the effect of different types of natural disasters on GDP per capita growth. The second question will investigate this effect on agricultural, industrial and service value added per capita growth. The third question will estimate the effect of factors like democracy, income per capita and aid inflows in interaction with the natural disaster measurements. This makes it possible to examine why some countries experience higher losses when there occurred natural disasters. Because extreme events will have greater impacts on sectors with closer links to climate, such as water, agriculture and food security, forestry, health and tourism (IPCC report, p. 16), I use panel least squares with fixed effects to eliminate the impact of time independent factors.

The following major conclusions emerge. First, there is a consistent negative short run effect of natural disasters on GDP p.c. growth. The disaster measurement total population affected gives the best estimates. Observing the effect on different sectors, the agricultural sector is most sensitive to natural disasters. Second, amongst the types of disasters droughts appears to be the most significant one. However, storms have the greatest impact on economic growth. Thirdly, using the number of disasters as instrumental variable for the consequence measurements of natural disasters, gives less information that supports the hypothesis that natural disasters have a negative effect on economic growth. Finally, both GDP and aid inflow per capita mitigate the negative effects of natural disasters.

The paper proceeds as follows. In section 2, I start with a discussion of the existing literature. In section 3, I discuss the theoretical framework with the expected results. I also describe the ways in which disasters could affect economic growth. Section 4 contains the description of the data and the measurement of the variables. I proceed with the estimation framework in section 5. The empirical results are discussed in section 6, and section 7 concludes.

2. Existing literature

In their survey, Cavallo & Noy (2010) give an overview of the literature that examine the aggregate impact of natural disasters. They distinguish between short run (usually up to three years) and long run (anything beyond five years) indirect effects of disasters. The first study that focuses on the short run is of Albala-Bertrand (1993), who collected data for 26 countries with 28 disasters for the 20-year period 1960-1979. He found that there was no fall in GDP and in the GDP growth rate when there were natural disasters. Also inflation does not changed but agricultural output increased. The methodology used was a before-after statistical analysis where the immediate two pre-disasters years, t-2 and t-1, were taken as reference (Albala-Bertrand, p.62). A second important study is of Skidmore & Toya (2002) who examined the long run growth effects of natural disasters in 89 countries for the period 1960 to 1990. They found climatic disasters correlated with higher rates of human capital accumulation, an increase in total factor productivity and economic growth. However, they found no significant correlation between disasters and long term physical capital accumulation. Geological disasters like earthquakes had also no significant effect. Their reasoning is that, if disasters reduce the expected return of physical capital there will be less physical capital investment. On the other side, there will be a relative higher return to human capital, which increases investments in human capital (Skidmore & Toya, 2002). That stimulates the update of the existing capital stock with the adaptation of new technologies. They give this as an explanation why there is a significant increase in total factor productivity and why there are positive output growth rates. The paper of Skidmore & Toya provides some useful insights but there are also shortcomings. Not explained is why climatic disasters have a positive effect on GDP growth.

Two papers explicitly take account of natural disasters as an external shock. First, Noy and Nualski (2007) focus on the growth dynamics of countries that deal with natural disasters. Referring to the neo-classical Solow model and the contributions of the endogenous growth model they examine the impact of a natural disaster shock on the growth path of countries. Their sample contains 98 countries in the period 1975 – 2000, dividing in five, 5-year intervals. Estimation methods are panel fixed effects and generalized methods of moments (GMM). In their results they show that a negative shock to the stock of human capital decreases the growth rate of GDP. However, negative shocks to physical capital do not have a significant effect on the long run GDP growth rate. Secondly, Raddatz (2007) investigates natural disasters in external shocks in 40 low-income countries. For a small fraction of these shocks natural disasters explain the output volatility (measured as GDP per capita) in these countries. He finds a negative association of 2 percent between climatic disasters and the output volatility. Geological disasters have no significant effect on GDP per capita volatility.

A paper close to Raddatz (2007) is of Noy (2009), who describes institutional and structural factors that could determine the impact of natural disasters on GDP growth. His sample consists of 109 countries for the period 1970-2003. Interesting is that he uses interaction terms of the natural disaster measurement and the following variables: illiteracy, institutional strength, GDP per capita, government consumption, exports and tropics.[1] He finds that countries with a higher level of illiteracy will experience more negative effects of a natural disaster than countries with a lower level of illiteracy (Noy, 2009). In addition, institutional strength and higher GDP per capita are associated with significant lower costs of disasters (Noy, 2009). Furthermore, government consumption and a higher degree of openness to trade prevent countries from negative effects of natural disasters on the economy. However, location in the tropics does not significantly reduce GDP growth. The paper of Noy (2009) only uses economic damage as a measurement for natural disasters in their main analyzes. The reason therefore is that variables constructed with the number of people affected or killed are not significant in their estimations. He also looks to financial conditions such as the level of foreign exchange reserves that significantly prevent a spillover of natural disasters in the macro economy. However, he does not split up the disaster measurements in categories though it is likely that different types of disasters have different effects on GDP growth.

Using again a panel of low-income countries, the paper of Raddatz (2009) builds on his previous work, Raddatz (2007). He estimates vector autoregression models (VAR) and concludes that climatic disasters reduce real GDP per capita by at least 0.6 percent.

[1] Except the data for tropics the source of all those variables is from the World Bank.

Droughts have the most important impact on GDP per capita, with losses of 1 percent. Smaller and poorer countries are more vulnerable to climatic disasters. In addition, most of the costs realized in the year the disaster occurred. However, Raddatz (2009) uses GDP per capita as dependent variable instead of GDP per capita growth. Another approach is of Hochrainer (2009) who looks to the counterfactuals of the evolution of GDP. The approach is comparing the situation that the disaster would not have occurred versus the observed GDP. He compares both evolutions in a time-period up to five years after the disaster event. On average, disasters lead to negative consequences on GDP growth.

Recently, the paper of Loayza et al (2012) contributes to the existing literature by splitting up aggregate GDP growth in agricultural, industrial and service per capita growth. They find that different types of natural disasters affect the economy in different ways: droughts have a negative significant effect on agricultural growth; floods have a positive significant effect on agricultural growth. While moderate disasters can have a positive effect on certain sectors severe disasters usually, have negative effects on economic growth. Another conclusion is that natural disasters have more impact on developing economies than on developed economies. Loayza et al (2012) organize their data in five-year periods. The reason therefore is that in this way reconstruction efforts can work their way through the economy. An annual frequency analysis is beyond the scope of their paper but will be done in the empirics of this paper. As disaster measurement, they use the number of people affected. In their robustness tests they also use the number of people killed, the total economic damage is not used.

In summary, the described literature show different results about the effect of natural disasters on economic growth. For the short run, there is consensus that there is a negative relationship between natural disasters and GDP per capita growth. This effect is mainly driven by climatic disasters. This is interesting because the IPCC believe that through global warming there occur more of these types of disasters. For the long run, the results are largely inconclusive. Cavallo & Noy (2010) give as a possible reason the difficulty of constructing appropriate counterfactuals. Loayza et al (2012) take a different approach in using not only overall GDP per capita growth as the dependent variable.

3. Theoretical and conceptual framework

From the previous section, it is obvious that this study belongs to the economic growth literature. It examines what happens to economic growth when there are exogenous natural disaster shocks. Therefore, I will in this section first refer to the standard growth theories in economics and explore the theoretical predictions of these models. Secondly, I examine and make visible the possible ways through which natural disasters could affect economic growth.

3.1. The Solow and endogenous growth models

In explaining economic growth, the Solow growth model is the starting point for almost all analyses of growth. The model views technical progress and savings as exogenous, and thus not explained by the model. The principal conclusion is that the accumulation of physical capital cannot account for either the vast growth over time in output per person or the vast geographic differences in output per person (Romer, p. 8). Using a Cobb-Douglas production function with the inputs capital, labor and knowledge, you can explain theoretically the behavior of the output in the economy (usually in the form of output per unit of effective labor). [2] The outcome of the model is, under some assumptions, that the economy converges to a balanced growth path: A situation in which each variable of the model is growing at a constant rate.[3] But due to different causes the economy could move away from this steady state. Here the occurrence of a natural disaster comes in. This will have several implications for the growth path in the economy: First, the capital stock could decrease, which is likely the case with geologic types of disasters.[4] This results in an increase in the marginal returns of capital because capital becomes relatively scarce. That in turn increases capital accumulation and leads to output growth. However, when the amount of the effective labor force in the economy decreases relatively more than that capital decreases, growth decelerates.

Another possibility is that there are after a disaster event rebuilding investments in capital. These investments bring the capital stock back to the original level, with the advantage of

[2] Combining labor and knowledge gives the effectiveness of labor.
[3] The model's critical assumption is that the production function has constant returns to scale in capital and effective labor. That is, doubling the quantities of capital and effective labor doubles the amount produced.
[4] I assume that the natural disaster destroys physical capital more than effective labor.

an update of the existing capital stock by new technologies. This is in the literature called the Schumpeterian tradition of 'creative destruction'. In that case, there would be a positive growth impulse after a natural disaster. However, as discussed in Hallegatte et al (2007) those investments often take a long time to implement. Which is especially the case for developing economies where there are bad reconstruction capacities to manage the resources to the destroyed areas (Loayza et al, 2012). The rebuilding activities however give an explanation why studies focusing on the long term such as Skidmore and Toya (2002) generally find positive effects of natural disasters.

According to endogenous growth theories, human capital is the important factor of economic growth. In the Solow model, the only other determinant of output other than capital, named 'effective labor', is taken as exogenous. The endogenous growth model of Romer (1990) consists of two sectors: goods producing sector and a research and development (R&D) sector. In the R&D sector is investment in the stock of knowledge (Romer, p. 103). In this model, there are two endogenous variables: capital and knowledge. Including human capital in the theoretical model explains economic growth by human capital accumulation. Individuals invest in human and physical capital and the amount of human capital in the past has a positive effect on the accumulation of human capital in the future. What is the effect of natural disasters in this model?

Disasters could decrease the human capital stock by migration of skilled workers or reduction in school achievements of children. In the case of droughts and hunger, disasters affect child development negatively (Alderman et al, 2006). Endogenous growth models would predict a permanent decline in the growth rate when there is no human capital accumulation. Skidmore and Toya (2002) give the possibility that physical and human capital are substitutable. In that case, an increase in the risk of capital destruction leads to an increase in investments in human capital. This in turn leads to positive output growth rates. They mention also the possibility of an update of the existing capital stock after a natural disaster. This increases the expenditures in R&D and leads to a human capital accumulation which results in positive output growth.

3.2. Conceptual framework

The classical growth models use aggregate production functions. However, it is likely that there is a different effect of natural disasters on labor or capital intensive sectors. For example, droughts reduce the water availability that is an important input for the agricultural sector. Droughts and heat waves also lead to famines, which can decrease the labor force. Droughts can have less impact on capital. Earthquakes mainly destroy buildings and therefore they can have more impact on capital-intensive sectors. Floods can stimulate agricultural growth through the channel of collection of irrigation water; Storms can decrease agricultural growth by destruction of properties or harvests. Storms can also stimulate the reconstruction of buildings and hence leads to industrial growth. Besides all these different effects on sectors in the economy there are also other factors who can affect the impact and magnitude of natural disasters. You can see this in figure 1.[5]

First, when there is a natural disaster the impact depends upon the type of the disaster, the exposure to the disaster and the vulnerability of countries for a disaster. As said above, the *type of disaster* determines largely the impact on the economy. But there are also sudden and quick disasters. Earthquakes and hurricanes (storms) have an immediate impact. Droughts take a longer time-period to complete. Sudden disasters are associated with high numbers of damage per person affected while slow disasters as droughts have more impact on the population affected. This is supported by the data. See table 1, where the average cost of natural disasters are visible. Droughts and floods have less damage per person affected than earthquakes and storms.

Table 1 Average costs of natural disasters (1980 – 2012)

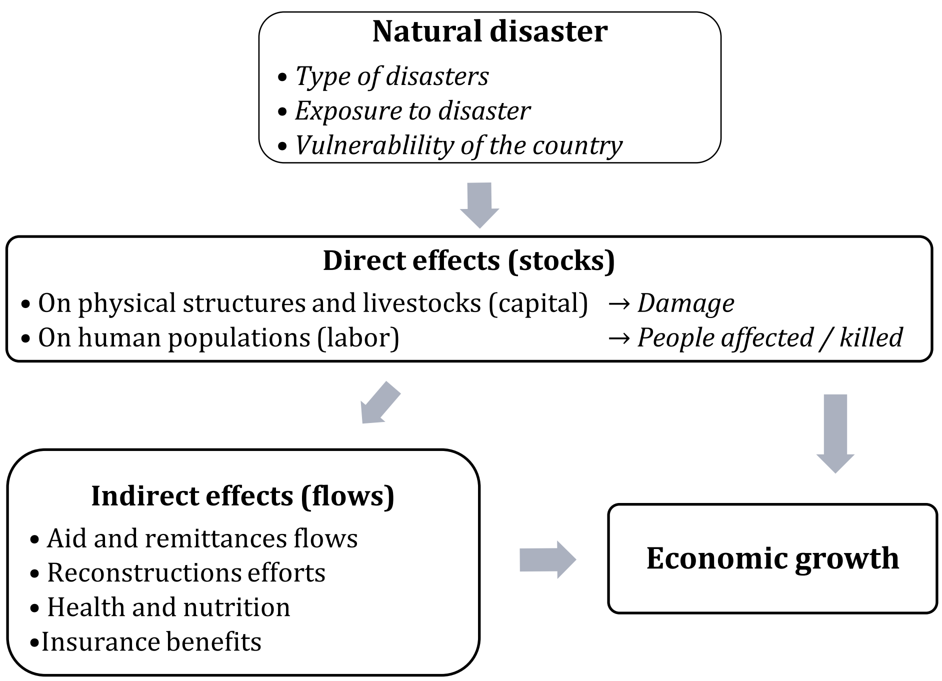
Disaster type	*Average number of people killed when economic damage reported*	*Average economic damage*	*Average number of people affected when economic damage reported*	*Average economic damage per person affected*
Droughts	25	$47.878.268.000	146336898	$327
Floods	143	$352.394.000	17475952	$306
Earthquakes	3043	$21.580.767.000	44933322	$481
Storms	342	$5.192.276.000	11309783	$459

[5] See page 13

In the next section, I will come back how I take account of the type of disaster in the construction of the variables.

Secondly, there is the *exposure* to a disaster. Under exposure the IPCC report sums up the presence of people; livelihoods, infrastructure or economic assets that can be affected. Think of an urbanized area that is exposed to more damage to capital than a rural area. Thirdly, there is the *vulnerability* as a set of factors that determine the impact of disasters. Vulnerability contains the environmental, social, economic and physical factors that give countries more risks for negative impacts of disasters. Think of the lack in government and community capacities to deal with disasters. Here also wealth and education play a role. Rapid and unplanned urbanization in hazardous areas, government failures and the scarcity of livelihood options for the poor are things the IPCC mentioned under vulnerability (IPCC report, p. 67). There is a link between exposure and vulnerability, in the sense that a high exposure makes countries also more vulnerable to disasters. But vulnerability is more; there are also institutional factors which can make countries less robust in dealing with disasters.

Figure 1 Conceptual framework



I make a distinction between the impact of disasters on *capital* and *labor*. Impact on capital will be associated with damage and destructions. The impact on labor can lead to affected people or deaths. Capital and labor impact can of course take place simultaneously. I consider in table 1 only the people affected and killed conditional on economic damage. I do this because it is likely that a natural disaster is associated with any damage.

Furthermore, I make a distinction between *direct effects* (stocks) and *indirect effects* (flows). The effects in the short run are direct effects but, as I mentioned already, there is the possibility of indirect effects. This is the possibility, also discussed by Albala-Bertrand, that high levels of direct effects can lead to, for example, aid and remittances flows. These flows can affect economic growth. However, not every disaster has these indirect effects. It is likely that it will be the case with big natural disasters with high impacts on capital and labor. Other indirect effects I refer to are high scale impacts on health and nutrition (for example as a result of severe droughts) and reconstructions. High damages to capital will lead to new construction of capital. There is the possibility of implementation of new technologies. Because this paper measures in one-year periods, I capture all the short-term (direct) effects. By including aid inflow per capita, I pay attention to possible indirect effects.

In summary, a natural disaster that decreases the capital stock and or labor force leads both in the Solow and in the endogenous growth model to a decrease in the output growth rate. If there are successful reconstructions in physical capital or an increase in the human capital stock (new technologies), there could be a positive effect on output growth. However, this effect is more likely to appear in the long term. There are different ways how natural disasters affect economic growth. The data used in this paper contains both direct and indirect estimates of capital and labor losses. In the following section this will be further explored.

4. Data

4.1. Natural disasters

Consistent with other empirical work the data on natural disasters is obtained from the Emergency Disasters Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED). This disaster database is one of the most complete and accurate in his field and widely used in comparable research. Information of disasters is compiled from various sources including UN agencies, nongovernmental organizations, insurance companies, research institutes and press agencies.[6] An event enters the database as a disaster when one of the following criteria is full-filled: ten or more people reported are killed, 100 or more people reported are affected, declaration of a state of emergency or a call for international assistance.

Table 2 Natural disaster types

Climatological:	Droughts (399 in total)	Wild/forest fires Extreme temperatures Heat wave Lack of rain
Geophysical:	Earthquakes (450 in total)	Earthquakes Tsunami's
Hydrological:	Floods (1606 in total)	Flash Flood General Flood General Flood/Mudslide Storm surge/Coastal flood
Meteorological:	Storms (1071 in total)	Tornadoes Extra tropical cyclones Tropical storms Snowstorms/Blizzards Sandstorms/Dust storms Thunderstorms/Lightening Severe storm/Hailstorm

I focus on four types of disasters divided in different subtypes (see table 2). Geological there are earthquakes. Meteorological respectively hydrological there are storms respectively floods. Climatologic disasters are droughts. The highest frequencies have the

[6] EM-DAT: The OFDA/CRED international Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.

meteorological and hydrological disasters. In table 5 and 6, the correlations between the different disaster types are reported (see appendix). The database contains also information on the event name, the location (usually given in provinces, districts or places), the region in the country and the continent. Furthermore, the data contains the day, month and year in which the disaster starts and ends.

4.2. Measurements of the disasters

There are three measurements of the consequences of disasters: the number of total people affected, people killed and the amount of economic damage. Killed are the persons confirmed as dead and persons missing and presumed as dead. Total people affected are people who are injured, homeless or otherwise affected. These are people requiring immediate assistance during a period of emergency; it also includes displaced or evacuated people. Homeless are the people needed immediate assistance for shelter. Injured are people suffering from physical injuries, trauma or an illness, requiring medical treatment as a direct result of a disaster. The amount of damage reported consists of direct and indirect damage in US dollar amount. It contains for example reconstruction and insurance payments. Other examples are damages to infrastructure, housing and crops. Besides these three measurements in the database, I also construct a measurement of the total number of natural disasters per country per year. I divide this measurement by the total land area (per 1000 km^2). Data of the land area is obtained from the World Bank. In table 4, the correlation between the different disaster measurements is reported (see appendix). As is visible the correlation between total population affected and economic damage is 0.410.

How a disaster affects economic growth in a year is likely to depend upon the magnitude of a disaster and the time the event took place in a year (Noy, 2009). Therefore, in correcting for the magnitude I divide the size of population affected or killed by the last year total population size. Economic damage is corrected by dividing through last year's GDP level. Furthermore, I assume that an event that occurs in January have more effect on that year GDP per capita growth than an event occurred in December (which is more likely to effect next year's GDP growth). I therefore use the following rate: (12- event month)/ 12, to correct for event time. This implies that the size of the affected population is multiplied by 6/12 if an event took place in June. In equation (1) the final measurement of population affected is visible (called total population affected). There, population $\text{affected}_{i,jt}$ is the number of people affected in country *i*, by disaster *j*, in year *t*. Total $\text{population}_{i,t-1}$ is the total last year population size. The left hand side of the equation represents the aggregate sum of all disasters (of type *j*) in year *t*. When I examine the relationship with all disaster types, I delete subscript *j* in the equation. To makes interpretation easier I multiply the measurement by 100 percent.[7]

$$(1)\ Total\ population\ affected = \left[\sum_{j=1}^{m}\left(\frac{total\ population\ affected_{\ ijt}}{total\ population_{i,t-1}} * \frac{12 - \ event\ month_{ijt}}{12}\right) * 100\%\right]$$

I use the same formula for the people killed:

$$(2)\quad People\ killed = \left[\sum_{j=1}^{m}\left(\frac{people\ killed_{\ ijt}}{total\ population_{i,t-1}} * \frac{12 - \ event\ month_{ijt}}{12}\right) * 100\%\right]$$

When I measure economic damage I divide by total $\text{GDP}_{i,\,t-1}$:

$$(3)\quad Economic\ damage = \left[\sum_{j=1}^{m}\left(\frac{damage_{\ ijt}}{total\ GDP_{i,t-1}} * \frac{12 - \ event\ month_{ijt}}{12}\right) * 100\%\right]$$

I correct the number of disasters with the land area:

$$(4)\quad The\ number\ of\ disasters = \left[\sum_{j=1}^{m}\left(\frac{Number\ of\ disasters_{\ ijt}}{land\ area\ in\ 1000\ squared\ km_{i,t}}\right)\right]$$

4.3. Data sources other variables

I use four dependent variables. First, I use the growth rate of real GDP per capita. The data on GDP per capita comes from the World Bank. Furthermore, I use measures of the growth rate of real per capita value added in the agricultural, industrial and service sector. These sector growth rates are obtained by dividing the value added of each sector by the total population size. All the dependent variables are measured in annual growth rates. One

[7] This makes the interpretation: a one-unit increase is a 1 percent increase in the ratio.

problem was the lack of data of the dependent variables. Especially in African countries, this was the case. Another point was the declaration of independency of some states during the period.

Consistent with other studies I include some control variables. These are trade openness (as percentage of GDP); government burden (general government final consumption expenditure as percentage of GDP); inflation (consumer price index, annual percentage change) and foreign direct investment (FDI, net inflows as percentage of GDP). I use for education the gross rate of enrollment in secondary school. This is the ratio of the number of students in secondary school to the number of people of the corresponding school age. I also include the annual percentage growth of gross capital formation. Furthermore, I include the log of GDP per capita. They are all obtained from the World Bank.

As discussed in the previous section the impact of disasters on human lives and the economic damages can depend on exposure (the size of the population in the affected area), the vulnerability of the area and the type of the natural disasters. I therefore include interaction terms of institutional and structural variables in the analysis. I do this in a way similar to Noy (2009).[8] As a measurement for institutions, I use a democracy variable from Polity 4. This variable has a range from -10 to 10, where the lowest value indicates an autocratic country and the highest value a full democracy. I assume that if a country is more democratic, it will be more open for political institutions. Furthermore, I include GDP per capita, assuming that richer countries have more money available for protection against natural disasters. The correlation between the Polity index and GDP p.c. is 0.517, therefore including both leads to multicollinearity problems. Therefore, I include them separately.

To measure the indirect effects of natural disasters I include a variable measuring the aid inflow per capita. I compose this variable by summing up the aid inflows of the United Nations Development Program (UNDP), United Nations Refugee Agency (UNHCR), World Food Program (WFP) and World Health Organization (WHO). From their websites, it

[8] How I will do this shall be explained in section 5.

becomes clear that all these organizations help countries in times of disasters.[9] Furthermore, observing the data confirms that when there are disasters in a country there are more aid inflows than the years without disaster events. I divide the total of the aid inflows by the total population size in the countries. The data of this variable comes from the World Bank.

4.4. Endogeneity issues

Because a natural disaster is an exogenous event, I have the advantage of no endogeneity. Whether or not a country experienced a disaster is exogenous and does not depend on the state of the economy. Natural disasters are not related to other factors determining output growth; this gives a good estimate of the causal effect of natural disasters on economic growth. Because I use a growth model I include for comparison the already mentioned control variables in the analysis. But in fact there is no omitted variable bias because there is no relationship between natural disasters and other factors determining economic growth. Thus, the covariance between natural disasters and those other factors is zero.

However, the consequences of natural disasters could possibly be endogenous. Economic damage may rise with income. Wealthier countries have more physical capital to damage. This is a problem of endogeneity, namely reverse causality. Also the number of people affected could decrease with a rise in income. Thus low income countries are likely to have more people affected due to the lack of spending money on safety. While wealthier countries are able to take more safety precautions. Here also reverse causality is the problem. The paper of Kahn (2005) had show that the death toll from natural disasters decreases with economic development. Finally, there could be an exaggeration of the data in developing countries of reasons of international assistance. The possible problem of reverse causality, is however not likely because economic growth has no causal effect on natural disasters. There is no empirical work that gives a significant estimate of GDP growth on natural disaster occurrence. The study of Kahn (2005) rejects the hypothesis that richer nations experience fewer disaster shocks.

[9] They pay attention to the typhoon Haiyan in the Philippines.

If there are problems of measurement error in natural disasters, I get an underestimation (a bias towards zero) of the effect of disasters on GDP growth. This is possible because the data of natural disasters is gathered from various data sources; also there could be an improving trend in recording disasters over time. This makes it more difficult to find the causal effect of disaster on growth. But, if I find anything I will also find it when appropriately addressing measurement error. The other possibility is measurement error in the dependent variable. But only if the measurement error in the output is related to natural disasters I get a bias. The likelihood of this is very small, so I do not care about this possibility.

I use an instrumental variable analysis (IV) to correct for the mentioned endogeneity issues (see section 6.3). IV can solve all the endogeneity issues if there is a good instrument. The instrument I use is the measurement of section 4.2 (equation 4) which was the number of disasters over the total land area per 1000 km^2. It is likely that the number of disasters affect economic growth only by affecting the consequences of disasters. Thus, the number of disasters is only related to economic growth through the consequences, affected, killed and economic damage. I just mention that the first stage results show the expected positive estimate (see also section 6.3). However, the F statistic is not bigger than 10.[10]

4.5. Descriptive statistics

There are 159 countries in the sample (see table 8, appendix). In table 3 (see appendix) the descriptive statistics are visible. GDP per capita growth has 4771 observations, for most of the country's GDP per capita growth was available. This changes when I use the other three dependent variables. The service sector has the lowest number of observations (3960). Of the control variables education and the gross capital formation has the lowest number of observations.

As is visible in table 3, there is difference between the means of the disaster types. Droughts and storms have the highest means of population affected. Storms have the highest means of economic damage, followed by earthquakes and floods. Storms also have the highest number of disasters. Population killed is for all the disaster types a variable

[10] That the F statistic bigger is than 10 is a rule of thumb.

with low values, the reason is that the number of persons killed is in general small.[11] From all disasters together, population affected has the highest mean (0.838), followed by economic damage (0.289).

Observing the maximums of the disasters measurements is interesting. Total population affected and economic damage have maximums of 117.597 and 152.214, both are from storms. This means that the ratio shown in paragraph 4.2 is higher than 100 percent, the size of the population affected or economic damage is more than the size of last year's population or last year's GDP level. In Albania was a drought that leads to 100.161 percent people affected in 1989. In the next year, 1990, there was a negative growth of -10.5 percent and there was a negative growth of -29.6 percent in 1991. In Samoa was over three years a negative growth: in 1990 -5.08 percent, in 1991, -3.02 percent and in 1992, -0.98 percent. Likely, this is related to the 152 percent economic damage caused by storms in 1990. These storms also leads to 101.4 percent people affected. Another example is the earthquake in Haiti in 2010, the event behind the maximum of 113 percent economic damage. There was a negative GDP p.c. growth of -6.64 percent. However, in 2011 there was a positive growth of 4.23 percent. I investigated that the amount that the aggregate aid organizations (UNDP, UNHCR, WFP and WHO) transfer to Haiti in 2010 was $13.3 million. The number of population affected was 34.4 percent and 2 percent of the population was killed.

To give an impression about the relationship between the average GDP per capita growth and the average of total population affected I make a scatter plot, visible in scatter-plot 1 (see appendix). This graph is an overview for the period 1980 – 2012 and thus not representative for the real estimations. However, as is visible there are countries with negative GDP p.c. growth and high levels of population affected such as NER, ZMB, ZWE, KIR and MDG.[12] An obvious outlier in this graph is China (CHN). In scatter-plot 2 (See appendix), I give the relationship between the average of the population affected and the agricultural per capita growth. Obvious difference with graph 1 is that there are more countries with a negative output per capita growth. Again, Albania is an outlier.

[11] Dividing by total population size makes the coefficient very small.
[12] For the complete list of country names of these abbreviations, see appendix table 8.

5. Methodology

This paper is interested in the estimation of α_1: the change of GDP p.c. growth as a result of a one unit change in the disaster variable. I specify the following estimation equation:

$$(4) \qquad \gamma_{i,t} = \alpha_i + \alpha_t + \alpha_1 Disaster_{i,j,t} + \alpha_2 \gamma_{i,t} + \beta' Q_{i,t} + \varepsilon_{i,t}$$

Where $\gamma_{i,t}$ is equal to the output p.c. growth rate, specified for GDP, agriculture, industry and service p.c. growth. The country specific intercept is α_i and the period specific intercept is α_t. The disaster coefficient is α_1 for disaster in country *i*, by disaster type *j*, in year *t*. α_2 is the coefficient for the initial output p.c. in logs. $Q_{i,t}$ is a vector of control variables; $\varepsilon_{i,t}$ is the error term which consists of country-specific, unobserved factors.

To estimate the effect of different types of disasters I use coefficients for the disaster types: droughts, floods, earthquakes and storms.

To estimate the institutional effects ($Z_{i,t}$), I use an interaction term captured by the coefficient δ. I also include the direct effect of Z_{it}.

$$(5) \qquad \gamma_{i,t} = \alpha_i + \alpha_t + \alpha_1 Disaster_{i,j,t} + \delta\left(Disaster_{i,j,t} * Z_{i,t}\right) + \theta Z_{i,t} + \alpha_2 \gamma_{i,t} + \beta' Q_{i,t} + \varepsilon_{i,t}$$

The regression method is Panel least squares. I include both cross section and period fixed effects. The White cross-section covariance method is used to correct for autocorrelation and heteroskedasticity.[13] Using fixed effects gives the advantage of controlling for unobserved time independent factors that could affect the impact of disasters on economic growth. Those factors, like geographical location, can influence the occurrence of disasters. Examples are the earthquakes in Japan due to plate tectonics and boundaries. Another example is droughts in Sub Saharan Africa due to closeness to the equator.

Additional to Panel least squares I estimate a Two Stage Least Squares (TSLS) regression. As explained in section 4.4 I use the number of disasters as an instrument for the consequences of disasters. The two stages are (also valid for the economic damage):

[13] I use this option in Eviews, which is equal to cross section clustered standard errors in Stata.

First stage: $Total\ affected_{i,j,t}\ =\ yCount_{i,j,t} + \alpha\gamma_{i,t} + \beta' Q_{i,t} +\ \varepsilon_{i,t}$

Second stage: $\gamma_{i,t} =\ \alpha_1(\tilde{y}Count_{i,j,t}) + \alpha\gamma_{i,t} + \beta' Q_{i,t} +\ \varepsilon_{i,t}$

Building on the estimation method and the theoretical framework the central hypothesis that will be test in this paper is:

$$H_1 :\ \alpha_1\ < 0,\ natural\ disasters\ have\ a\ negative\ effect\ on\ economic\ growth$$

6. Results

This section will first deal with the estimations of all types of disasters together on economic growth (GDP p.c. and the different sectors). Second, I will present the empirical findings regarding the different disaster types. Thirdly, I will change the estimation method to instrumental variables. Fourthly, I include the interaction terms in the analysis.

6.1. All types of disasters

Table 10 reports the estimations of the aggregate impact of disasters on GDP p.c. growth.[14] Two regressions show a significant relationship between disasters and economic growth: the percentage of the population affected, column (10.1), and the number of disasters, column (10.4). Note that all the disaster coefficients have a negative sign. The coefficient of population affected indicates a decrease of 5 percent in GDP p.c. growth when there is a one-unit increase in the ratio, which is a 1 percent increase. The interpretation of the number of disasters (column 10.4) is quite different: A rise of one-unit in the ratio indicates that there is one additional disaster in an area of 1000 km^2. This results in a decrease of 2.6 percent in the GDP p.c. growth rate. Not significant are people killed and economic damage. From table 9 (see appendix) you can see that without control variables these disaster measurements are significant and report negative coefficients.

6.1.1. Agricultural, industrial and service per capita growth

Besides the effect of natural disasters on total GDP p.c. growth, I also investigate the effect on agricultural, industrial and service p.c. growth. A part of the results is presented in table 11. Agricultural growth is most sensitive to natural disasters: A one-unit rise in the ratio of total population affected leads to a decrease of 18.4 percent in agricultural p.c. growth (see column 11.1). This is a bigger and more significant effect than the effect in column 10.1. People killed (column 11.2) and the number of disasters (column 11.4) have significant coefficients of -1.437, respectively, -6.051. Only economic damage has no significant effect on agricultural p.c. growth.

[14] See next page.

Observing the effect of natural disasters on industrial growth gives no significant information.[15] However, total population affected and people killed have a significant (but opposite) effect on service growth (see appendix, table 9: columns 9.5 and 9.6). I think that the coefficient of total population affected is more reliable than the positive (and less significant) effect of people killed because of the first more data is available.

Table 10 All disaster types and GDP p.c. growth

Dependent variable is GDP per capita growth				
Disasters	(10.1)	(10.2)	(10.3)	(10.4)
Total population affected Multiplied by 100	-0.050** (-2.412)			
People killed Multiplied by 100		-0.093 (-0.441)		
Economic damage Multiplied by 100			-0.177 (-1.499)	
Number of disasters Per 1000 square km land area				-0.026** (-1.993)
Controls				
Education: Secondary school enrolment rate	-0.024* (-1.698)	-0.024* (-1.656)	-0.024* (-1.683)	-0.024* (-1.668)
FDI: Net inflows/GDP	0.021** (2.276)	0.021** (2.301)	0.021** (2.309)	0.021** (2.285)
Inflation: % growth CPI	-0.003** (-2.513)	-0.003** (-2.527)	-0.003** (-2.530)	-0.003** (-2.525)
Government Burden: Government consumption/GDP	-0.155*** (-2.922)	-0.156*** (-2.986)	-0.156*** (-2.993)	-0.156*** (-2.991)
Trade Openness: (Exports + Imports)/GDP	0.024*** (2.703)	0.023*** (2.614)	0.024*** (2.636)	0.023*** (2.604)
Gross capital formation: % growth capital output	0.094*** (7.285)	0.093*** (7.250)	0.094*** (7.269)	0.093*** (7.239)
GDP per capita in logs: Initial output per capita	1.206*** (3.092)	1.211*** (3.063)	1.225*** (3.112)	1.211*** (3.071)
Observations	2215	2215	2215	2215
Number of countries	121	121	121	121
R^2	0.425	0.424	0.425	0.424

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
* Significant at 10% ** Significant at 5% *** Significant at 1%

[15] These estimations are not shown to save space.

Table 11 all disaster types and agricultural growth

Dependent variable is agricultural per capita growth				
Disasters	(11.1)	(11.2)	(11.3)	(11.4)
Total population affected Multiplied by 100	-0.184*** (-4.538)			
People killed Multiplied by 100		-1.437*** (-3.524)		
Economic damage Multiplied by 100			-0.737 (-1.458)	
Number of disasters Per 1000 square km land area				-6.051** (-2.007)
Controls				
Education: Secondary school enrolment rate	-0.013 (-0.338)	-0.009 (-0.248)	-0.011 (-0.293)	-0.009 (-0.238)
FDI: Net inflows/GDP	-0.045** (-2.184)	-0.044** (-2.203)	-0.044** (-2.244)	-0.049*** (-2.597)
Inflation: % growth CPI	-0.001 (-1.200)	-0.001 (-1.272)	-0.001 (-1.256)	-0.0012 (-1.267)
Government Burden: Government consumption/GDP	-0.047 (-0.468)	-0.052 (-0.535)	-0.049 (-0.512)	-0.051 (-0.528)
Trade Openness: (Exports + Imports)/GDP	0.003 (0.238)	0.0008 (0.0569)	0.0008 (0.053)	0.003 (0.192)
Gross capital formation: % growth capital output	0.052*** (3.564)	0.051*** (3.528)	0.053*** (3.736)	0.051 (3.549)
Initial output per capita (in logs)	0.120 (0.147)	0.151 (0.187)	0.204 (0.252)	0.057 (0.071)
Observations	2034	2034	2034	2034
Number of countries	114	114	114	114
R^2	0.087	0.081	0.084	0.083

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
* Significant at 10% ** Significant at 5% *** Significant at 1%

6.2. Different types of disasters

Aggregating the effect of disasters ignores the possible different impact of disaster types on economic growth. To explore this, I estimate the effect of droughts, floods, earthquakes and storms on total GDP p.c. growth and on the agricultural, industrial and service p.c. growth.

6.2.1. Droughts

Droughts have a statistically significant relationship with GDP p.c. growth. The causes of droughts can be food shortages/ famines or insufficient rainfall.[16] The coefficients are in all estimations negative. This confirms the hypothesis that droughts are bad for overall

[16] The information of the origins of droughts are specified in the database.

economic growth.[17] Total population affected, economic damage and the number of disasters give significant estimated coefficients (see table 13, 17 and 19).[18] Interpretation of these coefficients gives a remarkable strong and consistent negative effect of droughts on GDP p.c. growth. In table 13 the estimations of total population affected are visible. In column 13.1, you can see that this measurement has a coefficient of -0.045, significant at the 5 percent level. For especially African countries, as Mali and Mauritania were droughts are of frequent occurrence, these estimations have important implications.

Next, I compare this effect with the effect on agricultural p.c. growth. This sector is very sensitive to disasters. Therefore, not surprisingly, I find a stronger effect than on GDP p.c. growth. Total population affected has an estimated coefficient of -0.131 (table 13, column 13.2). The estimated coefficients of people killed, economic damage and the number of disasters are respectively -1.16 (table 15), -3.368 (table 17) and -66.495 (table 19).[19]

The effect of droughts on industrial growth is inconclusive. The significant (both at the 5 percent level) estimations of disasters are people killed and economic damage but they have positive respectively negative estimated coefficients (see appendix, table 15 and 17). I do not want to interpret these findings to much. One possibility is that labor is relatively less important than capital as input factors for the industrial sector. Labor can be more important for other sectors like the agricultural sector. Droughts can however also destroy the inputs for industrial growth. There is a linkage effect between the agricultural and the non-agricultural sector. In an agricultural based economy, this shall be bigger than in a more industrialized economy. However, when there is damage to inputs for the industrial sector it is possible that there is a negative effect on industrial growth.

Finally, I turn to the effect of droughts on service growth. All the measurements are significant but they have opposite signs. The most significant estimation is of economic damage, namely 0.942 (see appendix: table 17, column 4). An explanation of this finding is

[17] This confirms also the IPCC conclusion that some regions in the world experienced more intense and longer droughts (IPCC, p. 19).
[18] Table 13 is visible on the next page, the other tables are visible in the appendix.
[19] All these tables are reported in the appendix.

the possibility of more demand for relief and assistance in the service sector to overcome problems like destruction by droughts. I will however also stress this finding not too much.

Table 13 Different disaster types (measurement total population affected)

	Dependent variables			
Disasters	(13.1) GDP p.c. growth	(13.2) Agricultural growth	(13.3) Industrial growth	(13.4) Service Growth
Droughts	-0.045** (-2.102)	-0.131** (-3.687)	-0.042 (-1.260)	-0.035* (-1.775)
Floods	-0.204*** (-2.878)	-0.236*** (-2.677)	-0.121 (-1.144)	-0.307*** (-3.624)
Earthquakes	-0.060 (-0.386)	-0.191*** (-3.234)	0.046 (0.492)	-0.007 (-0.173)
Storms	-0.207* (-1.786)	-0.823*** (-3.233)	-0.369* (-1.733)	0.099 (0.986)
Controls				
Education: Secondary school enrolment rate	-0.024** (-2.213)	-0.011 (-0.308)	-0.046* (-1.767)	-0.022* (-1.655)
FDI: Net inflows/GDP	0.021 (1.577)	-0.053 (-3.937)	0.045* (1.923)	0.008 (0.995)
Inflation: % growth CPI	-0.003*** (-8.146)	-0.001 (-1.198)	-0.004* (-1.876)	-0.002*** (-2.709)
Government Burden: Government consumption/GDP	-0.156*** (-5.054)	-0.002 (-0.052)	-0.228** (-2.490)	-0.070 (-0.966)
Trade Openness: (Exports + Imports)/GDP	0.024*** (4.015)	0.008 (0.148)	0.048** (2.185)	0.022*** (2.735)
Gross capital formation: % growth capital output	0.094*** (21.132)	0.053*** (3.699)	0.124*** (5.090)	0.082*** (6.384)
Output per capita in logs: Initial output per capita	1.214*** (3.833)	0.131 (0.163)	2.092** (2.132)	1.041 (1.600)
Observations	2215	2075	2104	2052
Number of countries	121	115	117	115
R^2	0.424	0.09	0.280	0.297

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

6.2.2. Floods

There were 1606 floods reported in the period 1980 – 2012. The three disaster measurements total population affected, people killed and economic damage give all a significant negative effect on total GDP p.c. growth (see tables 13, 15 and 17). However, the number of disasters has a positive estimated coefficient (see appendix: table 19, column 1). Total population affected is highly significant with an estimated coefficient of -0.204

(column 13.1). The coefficient of people killed is also highly significant, but have an extremely high coefficient of -138.133 (column 15.1). Not surprisingly because a rise of 1 percent in the size of the population killed over the total population is exceptional. Economic damage has an estimated coefficient of -0.811 (column 17.1), which is also a big negative effect on economic growth. In short, floods have a negative effect on total GDP p.c. growth.

Intuitively you would expect that floods have a significant effect on agricultural growth. Total population affected indeed has a strong, negative and significant effect of -0.236 (column 13.2). The coefficient of people killed is again extremely high, as was also the case with total GDP p.c. growth.[20] The other two measurements, economic damage and the number of disasters, give no notable significant information.[21]

The effect of floods on industrial growth is unclear. I find in the baseline results significant effects for people killed, (see appendix: table 14, column 3) and economic damage, (see appendix: table 16, column 3). However, when I include controls, the significance disappears. The service sector is sensitive to the consequences of floods: Both total population affected and economic damage have highly significant estimates.[22]

6.2.3. Earthquakes

Earthquakes are sometimes in the news for the enormous consequences they could have. However, studies who explore the effect on economic growth fail to find any significant relationship.[23] I have found some remarkable results:
First, people killed shows in the baseline results and with controls a significant effect on GDP p.c. growth (see appendix, table 14 and 15). This is in line with the fact that earthquakes are the type of the disasters with the highest mean of people killed.[24] It is therefore more realistic that the ratio of people killed would rise with 1 percent. This is also visible in the estimated coefficient of -10.426 in table 15 column 1 (see appendix).

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[20] The coefficient in the relation with agricultural growth has a value of -261.757.
[21] Only the baseline result of economic damage gives a significant result, see appendix: table 16 column 2.
[22] See table 13 column 4 and in the appendix table 17 column 4.
[23] See the literature section in this paper.
[24] See appendix table 3, where I report a mean of 0.00046.

Besides people killed the other measurements have only significant estimates in the baseline results.[25]

Secondly, I find that the coefficient of population affected has a (highly significant) effect on agricultural p.c. growth. I find an estimated coefficient of -0.191, which indicates a decrease of 19.1 percent in agricultural p.c. growth if there is an increase with 1 percent in the ratio of total population affected (see table 13, column 13.2). I mentioned that also the numbers of disasters have a significant but positive effect on agricultural growth (see appendix, table 18).

Thirdly, I cannot found any effect of earthquakes on industrial growth. Furthermore, the effect of earthquakes on the service sector is weak. The only significant variable is the number of disasters. I find a positive estimated coefficient of 47.514 (see appendix: table 19, column 4). Realize that this coefficient implicates that there is one additional earthquake in an area of 1000 km^2. Probably the story behind this great positive effect is the boost in government and foreign aid operations.

In short, the disaster measurement, people killed, is in the case of earthquakes a reliable variable. This gives a negative effect on total GDP p.c. growth. Furthermore, the ratio of population affected indicates a negative effect on agricultural p.c. growth. That the number of disasters shows significant results will I not stress too much because of the possibility that this measurement has only his effect through the consequence variables (I use this measurement also as an instrumental variable).

6.2.4. Storms

Storms have destroying power on harvest and buildings. From the descriptive statistics, you can see that both population affected and economic damage have high means and big maximum values.

The reported effect on GDP p.c. growth in table 13 is again negative and significant. This is also the case with people killed in table 15, column 1 (see appendix). Remarkable is that the effect on agricultural p.c. growth is much bigger than the effect on total GDP p.c. growth: total population affected has an estimated coefficient of -0.823 (column 13.2). I

[25] See appendix, table 12 for total population affected, table 16 for economic damage and table 18 for the number of disasters.

think an important factor that plays a role is the insurance possibility. One of the data sources in EM-DAT are insurance companies. Damage of storms is by insurers (normally) covered under the insurance policy. Farmers will insure their properties when there is a high risk of storms.

You can see column 13.3 that storms are the only disaster type that has a significant effect on industrial growth. This finding confirms the facts about the destroying power of storms on the industrial sector. Possible and realistic is also that heavy storms hinder industrial traffic and activity.

Looking to the results of the service sector, I find no significant effect of storms. The signs of the estimated coefficients of total population affected and economic damage are positive, while the two other measurements have negative signs.[26] I think storms are a type of disasters that the service sector can quite easily manage.

6.3. Instrumental variables

As already mentioned in section 4.4 there are possible endogeneity problems concerning the used consequence measurements of natural disasters. I therefore use the number of disasters as an instrument for total population affected and economic damage. I exclude people killed from the IV regressions because it shows no significant first stage results.

Panel A of table 20 reports the two-stage least squares estimates of the two variables of interest (see appendix). Both shows no significant effect, while the coefficient of economic damage is greater than the one of population affected.

The first-stage regressions (reported in Panel B) reports positive significant effects on the disaster measurements affected (column 20.1) and damage (column 20.2). The number of disasters has a significant effect on total population affected: the coefficient is significant at the 5 percent level. The effect on population affected is stronger than on economic damage. This is in line with the descriptive statistics reported in table 20: the mean of population affected is bigger than the one of economic damage. The table also reports diagnostic statistics on weak instruments. The F-statistic for both first-stage regressions is not above

[26] See table 13, column 13.4 for total population affected and in the appendix table 15 for people killed, table 17 for economic damage and table 19 for the number of disasters.

the threshold of 10 suggested by Staiger and Stock (1997). Therefore, the used instrument is not as strong as expected.

In addition, I look to the two-stage results of disasters on agricultural growth (see appendix: table 21, panel A). In column 21.2, you see that there is one significant effect: economic damage has a coefficient that is significant at the 10 percent level. The coefficient of population affected has a coefficient of -4.177 but is still not significant.

Investigating the effect of disasters on industrial and service p.c. growth gives no significant results. The effect of natural disasters on industrial growth show only positive coefficients while the effect on service growth appears to be negative.

In table 22 (see appendix) the two-stage results of different disaster types are reported. As is visible the sign of the disaster types is different: Storms always have a negative sign while floods and earthquakes have positive signs. The effect on agricultural p.c. growth is greater than on overall GDP p.c. growth. Droughts have a very significant coefficient in column 22.3, were the disaster types are measured in economic damage. Droughts were the type of natural disasters that was already significant in section 6.2.1: I report in that section a coefficient of -3.368. The other types of disasters show no significant estimations.

In short, using a TSLS technique gives less significant results than the previous Panel Least Squares estimations. However, the findings confirm that disasters have the biggest impact on agricultural growth. Droughts show a significant impact on that sector.

6.4. Interaction with institutional and structural characteristics

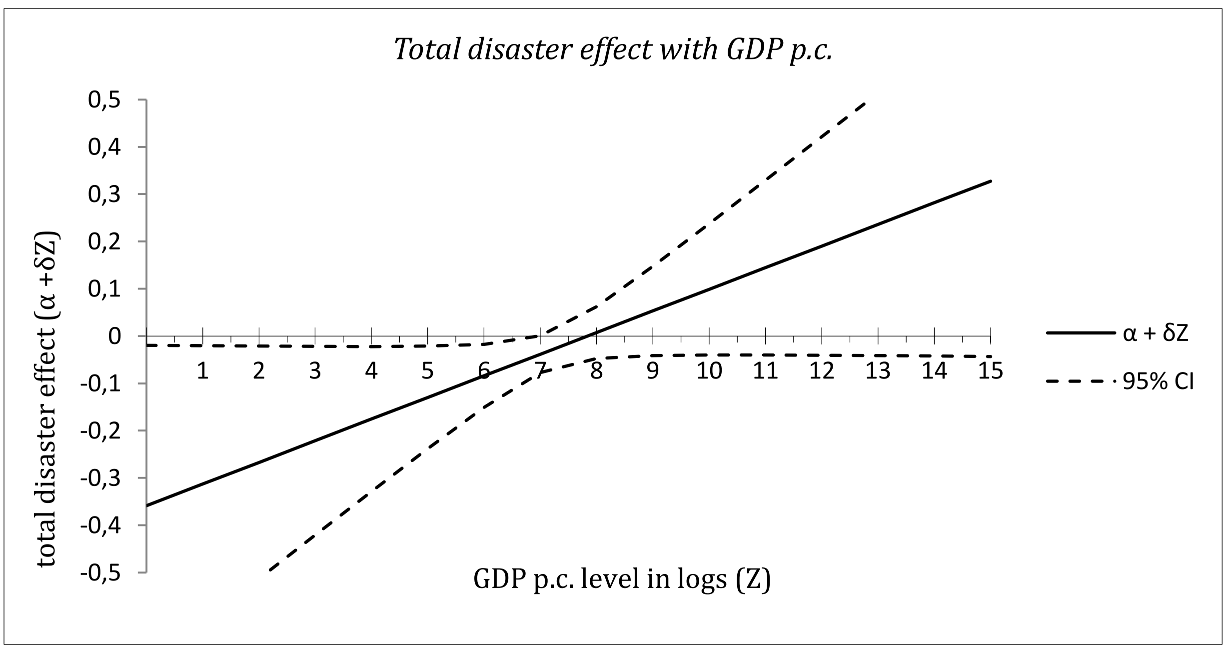
One of the most important indicators of welfare is the amount of GDP p.c. An interesting question is of the impact of disasters on economic growth would be less in countries with a higher GDP p.c. level, better institutions or high aid inflow. In this section, I use interaction terms to analyze the impact of disasters in relation with welfare, institutions and aid inflows. First, I use GDP p.c. in interaction with natural disasters. Thereafter I use the Polity Index and finally I introduce a measurement for aid inflows. I only interact with some significant findings from the previous sections. I illustrate the impact with graphs.

In table 23, column 23.1 (see appendix), the reported coefficients confirm the reasoning that a higher level of GDP p.c. reduces the negative impact of disasters on GDP p.c. growth. I measure disasters with total population affected: the coefficient of -0.359 is bigger than the one reported in table 10, column 10.1.[27] The interaction term has a positive value and is significant at the 10 percent level. The coefficient on the interaction term has a positive significant value of 0.045. That indicates that, given the negative impact of natural disasters, an increase in GDP p.c. undo those negative impact on economic growth. In other words, GDP p.c. growth will – ceteris paribus – increase with 4.5 percent if the level of GDP p.c. (in logs) increases with one unit.

The total effect of disasters on GDP p.c. growth is -0.359 + 0.045*GDP p.c.[28] I visualize this formula in graph 1. As you can see, the impact of a disaster is -0.359 when the GDP p.c. level is zero. At a level of $2922, per capita, disasters have no negative effect. In table 3, the descriptive statistics, I report for GDP p.c. a mean of 7.996. This is equal to $2969, per capita. In the graph, the 95 percent confidence intervals are visible.

Besides the effect of GDP p.c., I also investigate the impact of institutions. I measure institutions with the Polity Index. This index has no significant effect and has the wrong sign (column 23.2).

Graph 1 Interaction with GDP p.c.



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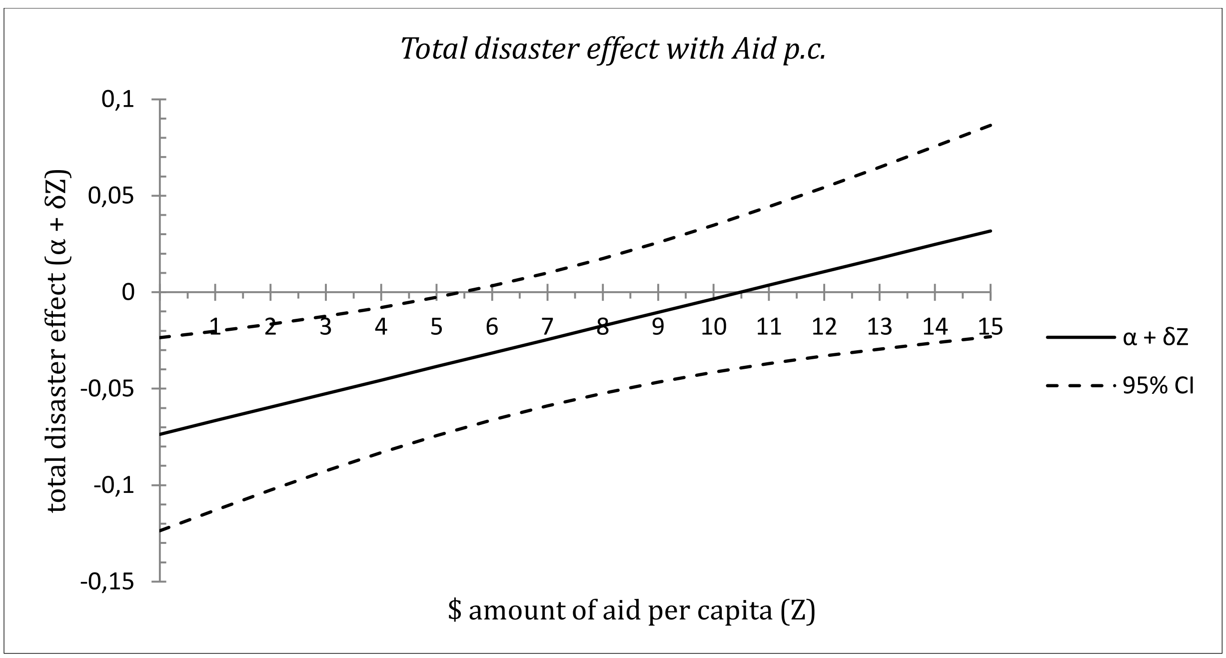
[27] In section 6.1, I report in table 10 a coefficient of -0.045.

[28] This is the partial derivative to disasters of equation 5 in section 5.

Another important factor is the aid inflow after a disaster event. In figure 1, section three, I refer already to these indirect effects. I focus on aid inflows from various UN organizations.[29] Again, I use the amount of aid per capita in interaction with total population affected. Total population affected has a negative coefficient of -0.074 and is significant at the 1 percent level. However, the interaction term has a positive coefficient of 0.007. This coefficient, which is significant at the 1 percent level, indicates that an – ceteris paribus – increase in Aid inflow p.c. with 1 dollar increases GDP p.c. growth with 0.7%. In graph 2, I plot the linear formula of the total disaster effect. From an aid level of $10.54, per capita, disasters have no negative effect on economic growth. Given that the mean aid flow is $1.91, per capita, it is clear that the aid inflows are often insufficient to undo all the negative effects of disasters. In graph 2, the 95 percent confidence intervals are visible.

Graph 2 Interaction with Aid p.c.



[29] In the choice for UN organizations, I ignore aid flows from other organizations but I think the UN organizations are representative and big enough to capture aid inflows. For the used UN organizations see section 4.3.

7. Conclusion

This paper has investigated the impact of natural disasters on economic growth. The central hypothesis was that natural disasters have a negative effect on economic growth. By splitting up economic growth to agricultural, industrial and service p.c. growth, I followed the study of Loayza et al (2012). However, I explored the one-year period effect using a different measurement of disasters and a broader sample.[30] I also engage the study of Noy (2009) in using an interaction terms analysis. Building on this and other literature, several new insights emerge:

First, there is a consistent negative short run effect of all types of natural disasters together on GDP p.c. growth. The disaster measurement total population affected gives the best estimates. People killed and economic damage report negative signs but insignificant estimated coefficients. Observing the effect on different sectors, the agricultural sector is most sensitive to natural disasters: Besides total population affected, also the number of disasters per 1000 km^2 reports significant information. I have found no consistent negative effect of all types of natural disasters together on industrial and service p.c. growth.[31]
Second, amongst the different types of disasters droughts appears to be the most significant one.[32] However, storms show the greatest impact on economic growth. Their effect is again bigger on the agricultural sector than on overall GDP p.c. growth. The number of people killed through earthquakes shows a significant negative effect on overall GDP p.c. growth. Earthquakes have also a highly significant negative estimate on the agricultural sector, interesting because previous studies fail to find a significant effect of geologic types of disasters.
Thirdly, using the number of disasters per 1000 km^2 as instrumental variable for the consequence measurements of natural disasters, gives less information that supports the hypothesis that natural disasters have a negative effect on economic growth. Only droughts measured in economic damage has a negative, highly significant, effect on agricultural p.c. growth.

[30] The study of Loayza et al (2012) uses a logarithmic measurement of the average disaster cost over a five-year period.
[31] This is in line with the study of Loayza et al (2012).
[32] The types I distinguish in this study were droughts, floods, earthquakes and storms.

Finally, this study explores the impact of institutional and structural characteristics of countries in the relationship of natural disasters and economic growth. The level of GDP per capita and aid inflow per capita mitigate the negative effect of natural disasters. For the average country in the sample, the amount of aid per capita is insufficient to undo the negative effect of natural disasters. The polity index, measuring the level of democracy was not significant.

From a policy perspective, this paper gives interesting findings for a better understanding of the effect of natural disasters on economic growth. The information in this paper highlights the importance of disaster risk reduction and mitigation. An important area because through climate change the frequency and magnitude of (climatic-related) natural disasters increases. Especially the protection of agricultural based economies against natural disasters is urgent. Furthermore, the impact of droughts should not be underestimated. This is for example an issue in Africa. Lastly, this study proves the relevance of aid inflows from charity/UN organizations after a natural disaster event.

This paper is a piece of a broad and important topic. There are many suggestions for further research. The effect of different disasters types on sectors in the economy requires further in depth investigation: especially the needed protection in the agricultural sector is important. Another important issue is what the impact is of the insurance density in countries with natural disasters. This is nowadays in the Philippines an interesting question. There are several shortcomings in this study. For example, it can be argued that using one-year periods is too short to study growth effects. In addition, the less significant two-stage least squares estimations is an issue. I can only suggest the use of a new instrument. For example, the wind-speed of storms or the Richter-scale for earthquakes. I was not able to get these data. It would be interesting to see what the effect of storms and earthquakes are using these data.

8. Literature

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9. Appendix

Table 3 Descriptive Statistics

	N	Mean	St. dev.	Min	Max
Economic growth & controls					
GDP growth pc (%)	4771	1.686	5.761	-50.290	92.586
Growth agricultural sector (%)	4047	0.654	9.466	-53.584	75.433
Growth industrial sector (%)	4076	2.043	9.653	-75.899	136.206
Growth service sector (%)	3960	2.293	6.520	-57.679	96.840
Education (Gross enrollment rate %)	3452	66.723	32.732	2.344	162.349
Government Burden (% of GDP)	4389	16.334	6.815	1.135	69.543
FDI, net inflow (% of GDP)	4339	3.193	7.225	-161.240	172.716
Inflation (CPI, annual % change)	3988	28.229	267.868	-13.616	11749.64
Openness (% of GDP)	4617	79.135	45.546	0.309	447.001
Gross Capital Formation (%)	3491	5.360	21.146	-376.029	289.412
Initial GDP p.c. (in logs)	4701	7.996	1.533	4.171	11.645
Polity Index	4150	2.517	7.071	-10	10
Aid flow per capita	3710	1.907	3.610	-9.424	45.962
Natural Disasters					
All disasters (population affected)	5024	0.838	5.115	0.000	117.596
All disasters (people killed)	5024	0.001	0.033	0.000	2.069
All disasters (economic damage)	5024	0.289	3.817	0.000	152.214
All disasters (count)	5024	0.0001	0.002	0.000	0.143
Droughts (population affected)	5024	0.410	3.613	0.000	100.161
Droughts (people killed)	5024	0.0004	0.016	0.000	0.823
Droughts (economic damage)	5024	0.012	0.224	0.000	11.912
Droughts (count)	5024	3.45E-06	6.74E-05	0.000	0.0029
Floods (population affected)	5024	0.162	1.157	0.000	33.866
Floods (people killed)	5024	0.00004	0.0004	0.000	0.017
Floods (economic damage)	5024	0.047	0.860	0.000	54.248
Floods (count)	5024	9.51E-06	0.0001	0.000	0.0038
Earthquakes (population affected)	5024	0.026	0.649	0.000	34.383
Earthquakes (people killed)	5024	0.00046	0.029	0.000	2.068
Earthquakes (economic damage)	5024	0.048	1.653	0.000	113.339
Earthquakes (count)	5024	2.10E-06	4.78E-05	0.000	0.002
Storms (population affected)	5024	0.209	3.053	0.000	117.596
Storms (people killed)	5024	0.00012	0.003	0.000	0.172
Storms (economic damage)	5024	0.181	3.328	0.000	152.214
Storms (count)	5024	8.44E-05	0.002	0.000	0.143

Table 4 Correlation matrix of all disaster types

	Total population affected	People killed	Economic damage
Total population affected	1		
People killed	0.161	1	
Economic damage	0.410	0.374	1

Table 5 Correlation matrix of different disaster types – population affected

	Droughts	Floods	Earthquakes	Storms
Droughts	1			
Floods	0.0048	1		
Earthquakes	0.0037	-0.0005	1	
Storms	0.0008	-0.0015	-0.002	1

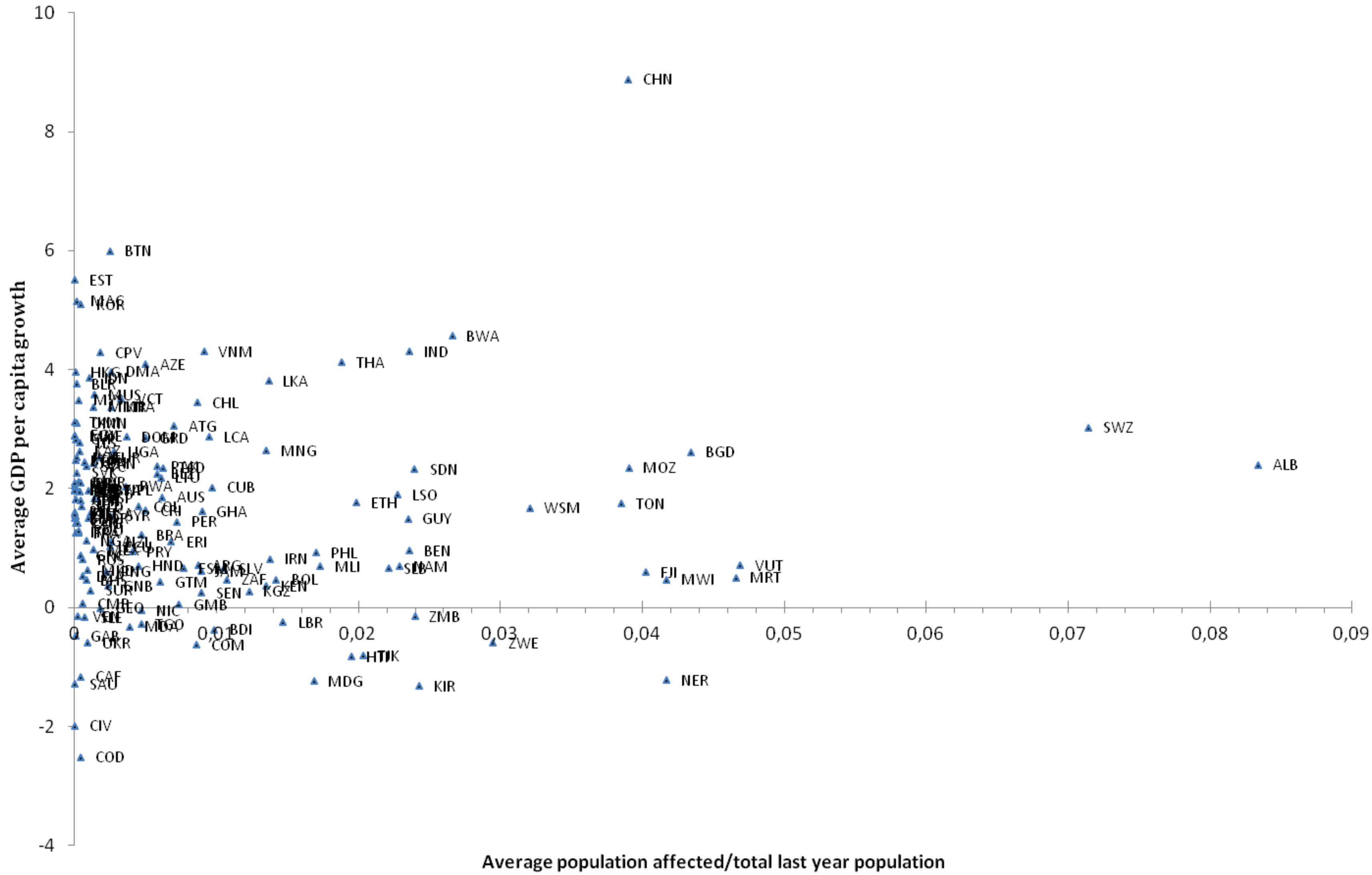
Table 6 Correlation matrix of different disaster types – number of disasters

	Droughts	Floods	Earthquakes	Storms
Droughts	1			
Floods	0.190	1		
Earthquakes	0.124	0.353	1	
Storms	0.157	0.454	0.247	1

Table 7 Correlation matrix control variables

	Education	Fdi	Inflation	Government burden	Trade openness	Capital formation	Log GDP p.c.	Polity index	Aid p.c.
Education	1								
Fdi	0,211	1							
Inflation	0,067	-0,043	1						
Government burden	0,13	0,121	-0,043	1					
Trade openness	0,281	0,313	-0,046	0,41	1				
Capital formation	-0,04	0,192	-0,058	-0,033	0,034	1			
Log GDP p.c.	0,731	0,15	-0,0003	0,126	0,296	-0,055	1		
Polity index	0,453	0,162	0,044	0,017	0,175	0,019	0,414	1	
Aid p.c.	-0,226	-0,009	-0,027	0,21	0,17	0,007	-0,078	-0,073	1

Scatterplot 1 Natural disasters and economic growth (1980-2012)



Scatterplot 2 Natural disasters and agricultural growth (1980-2012)

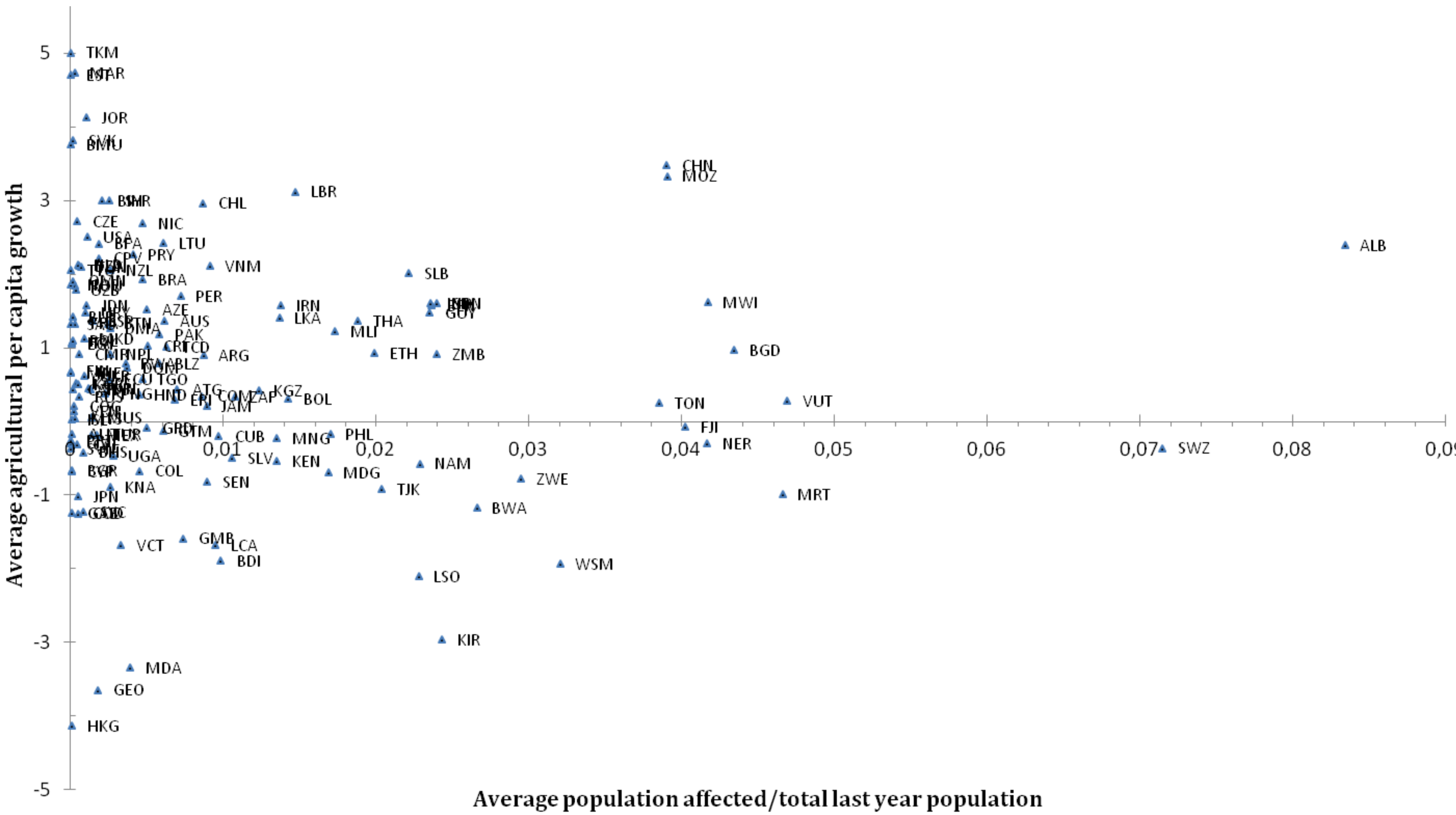


Table 8 Countries in the sample

Country	***Code***	**Country**	***Code***
Albania	*ALB*	Lithuania	*LTU*
Algeria	*DZA*	Luxembourg	*LUX*
Antigua and Barbuda	*ATG*	Macao	*MAC*
Argentina	*ARG*	Macedonia FRY	*MKD*
Australia	*AUS*	Madagascar	*MDG*
Austria	*AUT*	Malawi	*MWI*
Azerbaijan	*AZE*	Malaysia	*MYS*
Bahamas	*BHS*	Mali	*MLI*
Bangladesh	*BGD*	Mauritania	*MRT*
Belarus	*BLR*	Mauritius	*MUS*
Belgium	*BEL*	Mexico	*MEX*
Belize	*BLZ*	Micronesia Fed States	*FSM*
Benin	*BEN*	Moldova	*MDA*
Bermuda	*BMU*	Mongolia	*MNG*
Bhutan	*BTN*	Montenegro	*MNE*
Bolivia	*BOL*	Morocco	*MAR*
Bosnia-Hercegovenia	*BIH*	Mozambique	*MOZ*
Botswana	*BWA*	Myanmar	*MMR*
Brazil	*BRA*	Namibia	*NAM*
Brunei Darussalam	*BRN*	Nepal	*NPL*
Bulgaria	*BGR*	Netherlands	*NLD*
Burkina Faso	*BFA*	New Zealand	*NZL*
Burundi	*BDI*	Nicaragua	*NIC*
Cameroon	*CMR*	Niger	*NER*
Canada	*CAN*	Nigeria	*NGA*
Cape Verde Is	*CPV*	Norway	*NOR*
Central African Rep	*CAF*	Oman	*OMN*
Chad	*TCD*	Pakistan	*PAK*
Chile	*CHL*	Panama	*PAN*
China P Rep	*CHN*	Papua New Guinea	*PNG*
Colombia	*COL*	Paraguay	*PRY*
Comoros	*COM*	Peru	*PER*
Zaire/Congo Dem Rep	*COD*	Philippines	*PHL*
Congo	*COG*	Poland	*POL*
Costa Rica	*CRI*	Portugal	*PRT*
Cote d\'Ivoire	*CIV*	Puerto Rico	*PRI*
Cuba	*CUB*	Romania	*ROU*
Cyprus	*CYP*	Russia	*RUS*
Czech Rep	*CZE*	Rwanda	*RWA*
Denmark	*DNK*	Samoa	*WSM*

Dominica	*DMA*
Dominican Rep	*DOM*
Ecuador	*ECU*
Egypt	*EGY*
El Salvador	*SLV*
Eritrea	*ERI*
Estonia	*EST*
Ethiopia	*ETH*
Fiji	*FJI*
Finland	*FIN*
France	*FRA*
Gabon	*GAB*
Gambia The	*GMB*
Georgia	*GEO*
Ghana	*GHA*
Greece	*GRC*
Grenada	*GRD*
Guatemala	*GTM*
Guinea Bissau	*GNB*
Guyana	*GUY*
Haiti	*HTI*
Honduras	*HND*
Hong Kong (China)	*HKG*
Iceland	*ISL*
India	*IND*
Indonesia	*IDN*
Iran Islamic Rep	*IRN*
Israel	*ISR*
Italy	*ITA*
Jamaica	*JAM*
Japan	*JPN*
Jordan	*JOR*
Kazakhstan	*KAZ*
Kenya	*KEN*
Kiribati	*KIR*
Korea Rep	*KOR*
Kyrgyzstan	*KGZ*
Latvia	*LVA*
Lesotho	*LSO*
Liberia	*LBR*
Saudi Arabia	*SAU*
Senegal	*SEN*
Luxembourg	*LUX*
Seychelles	*SYC*
Sierra Leone	*SLE*
Slovakia	*SVK*
Slovenia	*SVN*
Solomon Is	*SLB*
South Africa	*ZAF*
Spain	*ESP*
Sri Lanka	*LKA*
St Kitts and Nevis	*KNA*
St Lucia	*LCA*
St Vincent and the Grenadines	*VCT*
Sudan	*SDN*
Suriname	*SUR*
Swaziland	*SWZ*
Sweden	*SWE*
Syrian Arab Rep	*SYR*
Tajikistan	*TJK*
Thailand	*THA*
Timor-Leste	*TLS*
Togo	*TGO*
Tonga	*TON*
Trinidad and Tobago	*TTO*
Tunisia	*TUN*
Turkey	*TUR*
Turkmenistan	*TKM*
Uganda	*UGA*
Ukraine	*UKR*
United Kingdom	*GBR*
United States	*USA*
Uruguay	*URY*
Uzbekistan	*UZB*
Vanuatu	*VUT*
Venezuela	*VEN*
Viet Nam	*VNM*
Zambia	*ZMB*
Zimbabwe	*ZWE*

Table 9 All disaster types and total economic growth

	Dependent variable is GDP per capita growth				Dependent variable is service per capita growth			
All disasters	(9.1)	(9.2)	(9.3)	(9.4)	(9.5)	(9.6)	(9.7)	(9.8)
Total population affected	-0.028 (-1.137)				-0.07*** (-2.869)			
People killed		-2.616** (-2.476)				0.475** (1.904)		
Economic damage			-0.036* (-1.842)				0.141 (0.865)	
Number of disasters				1.005 (0.089)				-0.597 (-1.135)
Observations	4771	4771	4771	4771	2012	2012	2012	2012
Number of countries	159	159	159	159	114	114	114	114
R^2	0.157	0.157	0.157	0.157	0.292	0.290	0.290	0.290

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included. For service p.c. growth are controls not shown to save space.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 12 Different disaster types measured with population affected (without controls)

	Dependent variables			
	(12.1) GDP p.c. growth	(12.2) Agricultural growth	(12.3) Industrial growth	(12.4) Service growth
Disasters				
Droughts *Total population affected*	0.005 (0.263)	-0.040 (-1.134)	0.025 (0.847)	0.012 (0.598)
Floods *Total population affected*	-0.117** (-2.146)	-0.150 (-1.410)	-0.105 (-1.097)	-0.107 (-1.225)
Earthquakes *Total population affected*	-0.132** (-2.183)	-0.107* (-1.668)	0.031 (0.188)	-0.077 (-0.770)
Storms *Total population affected*	-0.026 (-1.065)	-0.038 (-0.557)	-0.002 (-0.042)	0.009 (-0.77)
Observations	4771	4047	4076	3960
Number of countries	159	145	146	144
R^2	0.158	0.016	0.114	0.169

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 14 Different disaster types measured with people killed (without controls)

	Dependent variables			
	(14.1) GDP p.c. growth	(14.2) Agricultural growth	(14.3) Industrial growth	(14.4) Service growth
Droughts *People killed*	0.089 (0.725)	-0.195 (-0.704)	0.8552*** (3.762)	0.273* (1.691)
Floods *People killed*	-68.413** (-2.054)	-99.905** (-2.211)	-93.564** (-2.169)	-60.246 (-1.057)
Earthquakes *People killed*	-0.370*** (-11.388)	1.900 (0.240)	-22.138 (-1.617)	-1.487 (-0.236)
Storms *People killed*	-2.303** (-2.549)	-4.372 (-0.708)	5.179 (0.738)	-1.815*** (-0.650)
Observations	4771	4047	4076	3960
Number of countries	159	145	146	144
R^2	0.160	0.017	0.115	0.169

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 15 Different disaster types measured with people killed (controls)

	Dependent variables			
	(15.1) GDP p.c. growth	(15.2) Agricultural growth	(15.3) Industrial growth	(15.4) Service Growth
Droughts *Killed*	-0.011 (-0.060)	-1.160*** (-3.650)	0.989** (2.334)	0.502** (2.170)
Floods *Killed*	-138.133*** (-3.408)	-261.757** (-2.192)	-78.188 (-1.615)	-41.322 (-1.066)
Earthquakes *Killed*	-10.426* (-1.676)	-5.777 (-0.392)	-26.035 (-1.409)	-1.449 (-0.156)
Storms *Killed*	-140.436*** (-2.854)	-418.700*** (-3.432)	-121.026 (-1.563)	-48.797 (-1.092)
Controls				
Education Secondary school enrolment rate	-0.024* (-1.684)	-0.010 (-0.258)	-0.045* (-1.736)	-0.021 (-1.560)
FDI Net inflows/GDP	0.021** (2.302)	-0.044 (-2.230)	0.045* (1.930)	0.009 (1.027)
Inflation % growth CPI	-0.003** (-2.529)	-0.001 (-1.251)	-0.004* (-1.881)	-0.002*** (-2.704)
Government Burden Government consumption/GDP	-0.155*** (-2.991)	-0.051 (-0.534)	-0.227** (-2.486)	-0.067 (-0.931)
Trade Openness (Exports + Imports)/GDP	0.023*** (2.596)	-0.0001 (-0.013)	0.047** (2.164)	0.022*** (2.704)
Gross capital formation % growth capital output	0.094*** (7.266)	0.052 (3.655)	0.124*** (5.057)	0.082*** (6.309)
GDP per capita in logs Initial output per capita	1.198*** (3.032)	0.119 (0.147)	2.070** (2.1042)	1.021 (1.534)
Observations	2215	2075	2104	2052
Number of countries	121	115	117	115
R^2	0.428	0.05	0.281	0.293

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 16 Different disaster types measured with economic damage (without controls)

	Dependent variables			
	(16.1) GDP p.c. growth	(16.2) Agricultural growth	(16.3) Industrial growth	(16.4) Service growth
Disasters				
Droughts *Economic damage*	0.022 (0.084)	-2.735*** (-5.035)	-0.306 (-0.942)	0.953** (2.079)
Floods *Economic damage*	-0.162** (-2.411)	-0.295*** (-3.235)	-0.220*** (-3.163)	0.009 (0.145)
Earthquakes *Economic damage*	-0.068*** (-5.997)	0.025 (0.153)	-0.328 (-0.937)	-0.036 (-0.288)
Storms *Economic damage*	-0.015 (-0.672)	0.040 (0.277)	0.072*** (3.057)	-0.005 (-0.368)
Observations	4771	4047	4076	3960
Number of countries	159	145	146	144
R^2	0.158	0.022	0.114	0.169

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 17 Different disaster types measured with economic damage (controls)

	Dependent variables			
	(17.1) GDP p.c. growth	(17.2) Agricultural growth	(17.3) Industrial growth	(17.4) Service Growth
Disasters				
Droughts *Economic damage*	-0.357*** (-3.160)	-3.368*** (-4.644)	-0.679** (-2.394)	0.942*** (3.614)
Floods *Economic damage*	-0.811*** (-3.549)	-1.016 (-1.322)	-0.498 (-1.121)	-0.390** (-2.496)
Earthquakes *Economic damage*	-0.149 (-1.083)	0.193 (0.482)	-0.480 (-1.027)	0.076 (0.698)
Storms *Economic damage*	-0.103 (-0.571)	-1.322 (-2.147)	0.421 (0.795)	0.232 (1.1586)
Controls				
Education Secondary school enrolment rate	-0.025* (-1.738)	-0.012 (-0.335)	-0.045* (-1.742)	-0.021 (-1.600)
FDI Net inflows/GDP	0.022** (2.350)	-0.042** (-2.295)	0.046* (1.939)	0.008 (0.964)
Inflation % growth CPI	-0.003** (-2.527)	-0.001 (-1.230)	-0.004* (-1.882)	-0.002*** (-2.709)

Government Burden Government consumption/GDP	-0.156*** (-3.018)	-0.004 (-0.529)	-0.227** (-2.500)	-0.069 (-0.954)
Trade Openness (Exports + Imports)/GDP	0.023*** (2.646)	-0.007 (0.048)	0.048** (2.190)	0.022*** (2.644)
Gross capital formation % growth capital output	0.094*** (7.331)	0.053*** (3.774)	0.124*** (5.090)	0.081*** (6.272)
GDP per capita in logs Initial output per capita	1.234*** (3.115)	-0.566 (0.367)	2.110** (2.133)	0.999 (1.515)
Observations	2215	2075	2104	2052
Number of countries	121	115	117	115
R^2	0.427	0.057	0.281	0.296

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*: Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 18 Different disaster types measured with the number of disasters (without controls)

	Dependent variables			
	(18.1) GDP p.c. growth	(18.2) Agricultural growth	(18.3) Industrial growth	(18.4) Service growth
Disasters				
Droughts *The number of disasters*	-0.345 (-0.306)	-4.079*** (-2.665)	-2.593* (-1.778)	0.110 (0.073)
Floods *The number of disasters*	1.047 (1.605)	1.694 (0.843)	1.608 (1.352)	1.277*** (3.766)
Earthquakes *The number of disasters*	-1.985** (-2.111)	0.174 (0.296)	-1.785 (-0.636)	-2.471* (-1.791)
Storms *The number of disasters*	-0.000035 (-0.003)	-0.673 (-1.159)	0.0362 (0.147)	0.040 (0.348)
Observations	4771	4047	4076	3960
Number of countries	159	145	146	144
R^2	0.157	0.018	0.114	0.169

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
* : Significant at 10% **: Significant at 5% ***: Significant at 1%

Table 19 Different disaster types measured with the number of disasters (controls)

	Dependent variables			
	(19.1) GDP p.c. growth	(19.2) Agricultural growth	(19.3) Industrial growth	(19.4) Service Growth
Disasters				
Droughts *The number of disasters*	-11.809*** (-2.910)	-66.495*** (-8.156)	-7.844 (-1.036)	-7.573* (-1.665)
Floods *The number of disasters*	4.012*** (2.735)	11.205 (0.944)	-1.125 (-0.353)	1.849 (0.768)
Earthquakes *The number of disasters*	17.731 (1.261)	75.664** (2.031)	14.479 (0.542)	47.514** (2.324)
Storms *The number of disasters*	-0.026** (-1.965)	-4.190 (-1.617)	0.945 (0.870)	-0.346 (-0.558)
Controls				
Education Secondary school enrolment rate	-0.024* (-1.691)	-0.009 (-0.234)	-0.045* (-1.718)	-0.021 (-1.614)
FDI Net inflows/GDP	0.021** (2.292)	-0.048 (-2.452)	0.046** (1.981)	0.008 (0.987)
Inflation % growth CPI	-0.003** (-2.519)	-0.001 (-1.241)	-0.004* (-1.881)	-0.002*** (-2.698)
Government Burden Government consumption/GDP	-0.155*** (-2.975)	-0.045 (-0.471)	-0.228** (-2.483)	-0.066 (-0.920)
Trade Openness (Exports + Imports)/GDP	0.024*** (2.647)	0.004 (0.256)	0.048** (2.169)	0.022*** (2.754)
Gross capital formation % growth capital output	0.093*** (7.264)	0.052 (3.625)	0.124*** (5.0619)	0.081*** (6.333)
GDP per capita in logs Initial output per capita	1.227*** (3.120)	0.157 (0.198)	2.111** (2.134)	1.005 (1.526)
Observations	2215	2075	2104	2052
Number of countries	121	115	117	115
R^2	0.426	0.058	0.279	0.294

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*Significant at 10% **Significant at 5% ***Significant at 1%

Table 20 TSLS regressions all disaster types and GDP p.c. growth

Panel A: Two-Stage Least Squares		
	(20.1)	(20.2)
Total population affected *Multiplied by 100*	-3.618 (-1.287)	
Economic damage *Multiplied by 100*		-21.014 (-1.148)

Panel B: First stage for total population affected and economic damage		
	Dependent variables	
	Total population affected	*Economic damage*
Number of disasters Per 1000 square km land area	0.006** (2.558)	0.001* (1.800)
Observations	2163	2163
Number of countries	120	120
F-Statistic	2.059	4.690
R-Square	0.139	0.269

Notes: Panel A reports the two-stage least-squares estimates with GDP p.c. growth, and panel B reports the corresponding first stages. Controls are included but not shown to save space.
Observations are valid for the two stage results.
Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*Significant at 10% **Significant at 5% ***Significant at 1%

Table 21 TSLS regressions all disaster types and agricultural growth

Panel A: Two-Stage Least Squares

	(21.1)	(21.2)
Total population affected *Multiplied by 100*	-4.177 (-1.189)	
Economic damage *Multiplied by 100*		-7.516* (-1.733)

Panel B: First stage for total population affected and economic damage

	Dependent variables	
	Total population affected	*Economic damage*
Number of disasters *Per 1000 square km land area*	0.006** (2.558)	0.001* (1.800)
Observations	2043	2034
Number of countries	114	114
F-Statistic	2.059	4.690
R-Square	0.139	0.269

Notes: Panel A reports the two-stage least-squares estimates with agricultural p.c. growth, and panel B reports the corresponding first stages. Controls are included but not shown to save space.
Observations are valid for the two stage results
Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*Significant at 10%
**Significant at 5%
***Significant at 1%

Table 22 TSLS regressions different disaster types and economic growth

Panel A: Two-Stage Least Squares			
	Dependent variables		
	22.1 GDP p.c. growth	22.2 Agricultural p.c. growth	22.3 Agricultural p.c. growth
Droughts	0.152 (0.240)	-1.105 (-0.614)	-10.259*** (-3.595)
Floods	2.219 (1.128)	6.344 (0.901)	61.090 (1.065)
Earthquakes	0.191 (0.482)	0.919 (0.577)	1.584 (0.469)
Storms	-7.206 (-1.495)	-13.365 (-1.111)	-15.203 (-1.273)

Panel B: First stage for total population affected and economic damage			
	Dependent variables		
	Total population affected	Total population affected	Economic damage
Number of droughts *Per 1000 square km land area*	32.570 (1.257)	32.570 (1.257)	7.960*** (4.177)
Number of floods *Per 1000 square km land area*	1.855 (0.771)	1.855 (0.771)	0.235 (0.819)
Number of earthquakes *Per 1000 square km land area*	54.130 (1.147)	54.130 (1.147)	30.380 (1.391)
Number of storms *Per 1000 square km land area*	0.005 (2.709)	0.005 (2.709)	0.0007* (1.943)
F-Statistic	2.337	2.337	5.771
R-Square	0.157	0.157	0.316
Observations	2163	2034	2164
Number of countries	120	114	120

Notes: Panel A reports the two-stage least-squares estimates with GDP p.c. growth and agricultural growth. Panel B reports not exactly the corresponding first stages, there is regressed on total population affected (all types). Controls are included but not shown to save space.
Observations are valid for the two stage results.
Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*Significant at 10%
**Significant at 5%
***Significant at 1%

Table 23 Interaction terms with GDP p.c., Polity Index and Aid inflow p.c.

Dependent variable is GDP per capita growth			
	(23.1)	(23.2)	(23.3)
All disasters			
Total population affected	-0.359** (-2.073)	-0.051** (-2.431)	-0.074*** (-2.885)
Affected*GDP p.c.	0.045* (1.906)		
Affected*Polity Index		-0.0008 (-0.303)	
Affected*Aid p.c.			0.007*** (2.616)
Controls			
Education Secondary school enrolment rate	-0.024* (-1.672)	-0.017 (-1.175)	-0.095*** (-5.515)
FDI Net inflows/GDP	0.020** (2.182)	0.022** (2.300)	0.037 (1.000)
Inflation % growth CPI	-0.003** (-2.506)	-0.003** (-2.555)	-0.003** (-2.445)
Government Burden Government consumption/GDP	-0.158*** (-2.829)	-0.132** (-2.534)	-0.110** (-1.969)
Trade Openness (Exports + Imports)/GDP	0.025*** (2.634)	0.022** (2.129)	0.027*** (3.177)
Gross capital formation % growth capital output	0.094*** (7.218)	0.094*** (6.826)	0.081*** (7.014)
GDP per capita in logs Initial output per capita	1.179*** (2.946)		1.819*** (4.0336)
Polity Index		0.028 (1.024)	
Aid inflow per capita From UNDP, UNHCR, WFP, WHO			-0.066 (-1.273)
Observations	2163	2135	1521
Number of countries	120	116	99
R^2	0.423	0.413	0.425

Numbers in brackets are the corresponding t – statistics. Country and period fixed effects were included.
*Significant at 10% **Significant at 5% ***Significant at 1%