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An economic analysys of the impacts of natural disasters. A literature Review

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An Economic Analysis of the Impacts of Natural Disasters

A Literature Review

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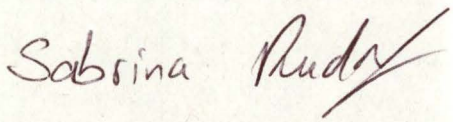

Sabrina Rudorf

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Abstract

This paper analysis the impact of natural disasters on the economy. In relation to economic growth theories, the paper tries to link the empirical results with the predicted outcome of theory and tries to explain why authors still not reached a consensus. In the second part the lack of insurances in developing countries is highlighted as an important role for the recovery process after a disaster and the paper tries to give reasons for that. Especially developing countries are more vulnerable to natural disasters and thus the growth process of a developing country can be harmed considerably taking the rising risk of natural disasters into account.

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Glossary

Biological disaster:	A natural disaster subgroup that includes epidemics, insect infections, and animal accidents.
Climatic disaster:	A natural disaster subgroup that includes droughts, glacial lake outbursts, and wildfire. These disasters are especially affected by climate change.
Disaster:	A disaster is a sudden, abrupt or unpredictable event that causes human, material, economic or environmental losses and that exceeds the ability of the affected region to cope with the impacts.
Natural Disaster Risk:	Is composed of Natural Hazard, Vulnerability and Elements at risk and describes the expected damage.
Elements at risk:	Lives, objects, output, assets, etc.
Extraterrestrial disaster:	A natural disaster subgroup that includes space weather, and impacts.
Geophysical disaster:	A natural disaster subgroup that includes earthquakes, mass movements, and volcanic activities.
Hydrological disaster:	A natural disaster subgroup that includes floods, landslides, and wave actions.
Meteorological disaster:	A natural disaster subgroup that includes extreme temperatures, fog, and storm.
Natural disaster:	A natural disaster that is caused by nature and not manmade.
Natural hazard:	Natural hazard events can be characterized by their magnitude or intensity caused by natural disasters and which endanger persons or objects. For instance, a drought is a prolonged disaster and often affect a wide region whereas a hurricane has a short duration and effect mostly a smaller region.
Vulnerability:	A community, system or asset that is sensible to the damaging effects of a hazard, in the following context a natural hazard.

1. Introduction

Climate change and global warming are the most challenging topics of our world. No country of the world can secure oneself against the risks. Fatalities, crop failure, famine, destroyed houses, economic losses, etc. are some of the risks resulting from natural disasters. The total number of people dying due to natural disasters has decreased, but the number of people affected has increased: "[...] 800.000 people died from natural disasters in the 1990s, compared with 2 million in the 1970s [...] (and) the total affected by natural disasters has tripled to 2 billion." (IRIN, 2005). The newspapers are full with reports about disasters and the potential risks of global warming and climate change. Natural disasters are not a recent phenomenon but due to climate change, natural disasters occur more often.

An alarming fact is that especially poor households and least developed countries suffer most from the negative impacts caused by hurricanes, floods, and droughts, only mentioning some types of natural disasters. Households might lose all their belongings and the economy experience a cut in GDP. The world is encouraged to fight against climate change but it also has to help countries which suffer most from the negative impacts of natural hazard events. In particular Africa will be confronted by the negative impacts of natural disasters even though it is not a major contributor to climate change.

According to Munich Re[1], the overall loss of disaster damages in 2015 were 100 billion USD among which 30 billion USD were covered by insurances. The disaster causing the highest costs as measured by the total overall losses was the earthquake in India, Bangladesh, China and Nepal. Here the overall losses were 4.800 million USD from which 210 million USD were covered by insurances. Looking at more disaster events and their losses it becomes visible that in least developed countries only a small share of the overall losses are insured. In developed countries the picture is reverse. For instance, the winter storm in the US and Canada in 2015 caused overall losses of 2.800 million USD, but 2.100 million USD were covered by insurance policies.

The following questions arise: To what extend do natural disasters harm the growth process of developing countries? Can an economy be negatively affected after a natural disaster in the long-run or can a natural hazard event be seen as an accelerator of growth?

The review is structured as follows: In section 2 I highlight the impacts of natural disasters on growth. I try to link the impacts with the neoclassical growth model of Solow and Swan and give an overview of the empirical literature and their results. In section 3 I present the impacts

[1] A global insurance and reinsurance group

on trade and in section 4 I focus on the impacts on households and enterprises. Section 5 concludes.

2. Impact on growth

This section provides a more detailed view of the impacts of natural disasters on growth. Most of the evidence on the macroeconomic effects of natural disasters in countries focus on the impact these disasters have on growth. In section 2.1 I highlight the theoretical links between natural disasters and growth, using insights from the basic growth model of Solow. In section 2.2 I present results of empirical studies on the impacts of natural disasters on growth and in section 2.3 I discuss the mitigating effect that aid may have on economic growth after a natural disaster.

2.1. Natural disasters and growth theory

To analyse the impacts of natural disasters from the theoretical side, Okuyama (2003) and Loayza et al. (2009) use the Solow Growth Model. The Solow-Swan Growth Model (Solow (1956) and Swan (1956)), often referred to as the Solow Growth Model, is one of the most important and most famous models in economic growth theory. The Solow Model is a dynamic neoclassical growth model, which analyses the growth of capital and output per worker. Solow allows in his model for substitution between labour and capital and assumes diminishing returns to the use of these inputs. The two main outcomes of the model are that in the long-run countries will be in a steady state of constant growth rates and that the growth rates between countries should converge.

Okuyama (2003) uses in his paper the standard version of the Solow-Swan Growth Model where the production function includes labour and capital. Due to the fact that the Solow Model assumes constant returns to scale and decreasing marginal returns, the production function can be written as following:

$$\gamma Y = F(\gamma K, \gamma L) \qquad (2.1)$$

Where γ can be any positive real number. An increase of all inputs of the same amount will lead to an overall increase of output by the same amount. An increase of 5 % in labour and will lead to a 5 % increase in output. The most important equation is the capital-labour equation or also called the Solow equation, which measures the change in capital stock over time:

$$\Delta k = sf(k) - (\delta + n)\, k \qquad (2.2)$$

Where s stands for the saving rate, δ is the capital depreciation rate, n the population growth rate and Δ represents the changes.

To find the steady state of the economy, the situation where growth rates are constant over time, equation 2.2 has to be set to 0. Which will equal the following notation:

$$sf(k^*) = (\delta + n)k^* \qquad (2.3)$$

Where k* means the level of capital per worker at its steady state. k* is a stable equilibrium, saying that if k is higher or lower than k*, the economy will move back to the steady state. In the case of $k < k^*$, the capital per worker is lower than the steady state, therefore we know that $(\delta + n)\, k$ is smaller than sf(k). With regard to the capital-labour ratio (2.2) we know that Δk is larger than 0 and therefore, k is growing and moving back to the equilibrium k*. On the other side, when $k > k^*$, we know that $(\delta + n)\, k$ is larger than sf(k) and therefore, the growth rate, Δk, is smaller than zero, to allow k to turn back to its stable equilibrium k*. At the steady state, the economy is growing at the population growth rate, n. Figure 1 shows the dynamics in the transition to the steady state. In area A the economy experiences higher growth rates whereas in area B the economy experiences lower growth rates to come back to the stable steady state of k*.

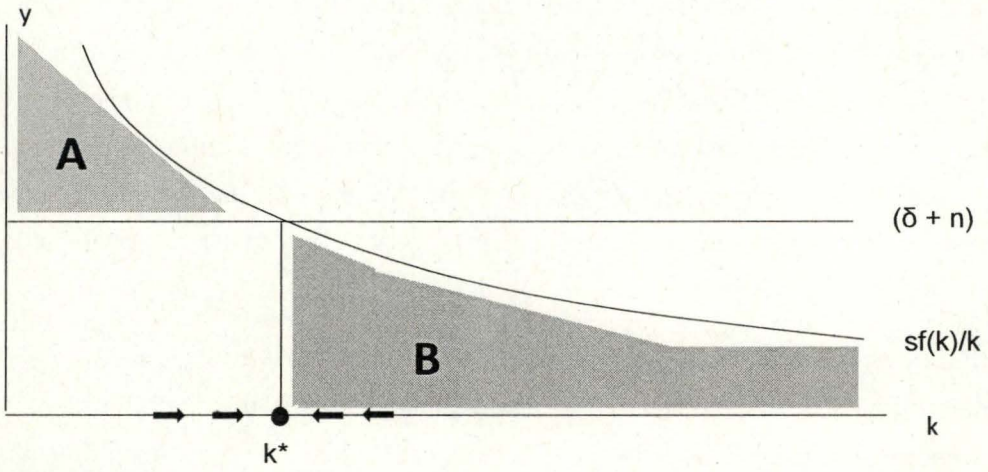

Figure 1: The transition to the steady-state[2]

Okuyama (2003) says that disasters mainly destroy or damage the capital stocks but not the labour population. Due to that, a disaster decreases K resulting $k_d < k^*$ which leads to a new state that is not a stable equilibrium. To move back to the stable steady-state k*, the growth rate has to increase. Furthermore, the saving rate, s, might increase during the recovery process leading to an upwards shift of sf(k) and to an additional acceleration of the growth rate. While the economy recovers the saving rate will most probably go back to normal and because of that the growth rate of k* will also normalize. Figure 2 shows graphically how the Solow Model can include a disaster scenario, which damaged the capital stocks but not the labour population. Before the disaster occurred, the economy was in its steady state A. Due to the

[2] Adapted from: Loayza et al. (2009), p. 7

natural disaster the capital per capita decreased to k_d and is no longer at its steady state A. The distance between B and C shows now the space which is given for growth of per capita accumulation during the recovery period before coming back to the steady-state A. In other words, the gap between C and B can be seen as the speed of recovery. When we assume as well a higher temporarily saving rate during the recovery process, sf(k) will shift upwards and the speed of recovery is faster. The gap for growth widens and is now between C and D. This leads to an acceleration of the recovery growth rate. While the economy recovers, the saving rate is expected to decrease to its before-the-disaster-rate and the economy comes back to the former equilibrium A.

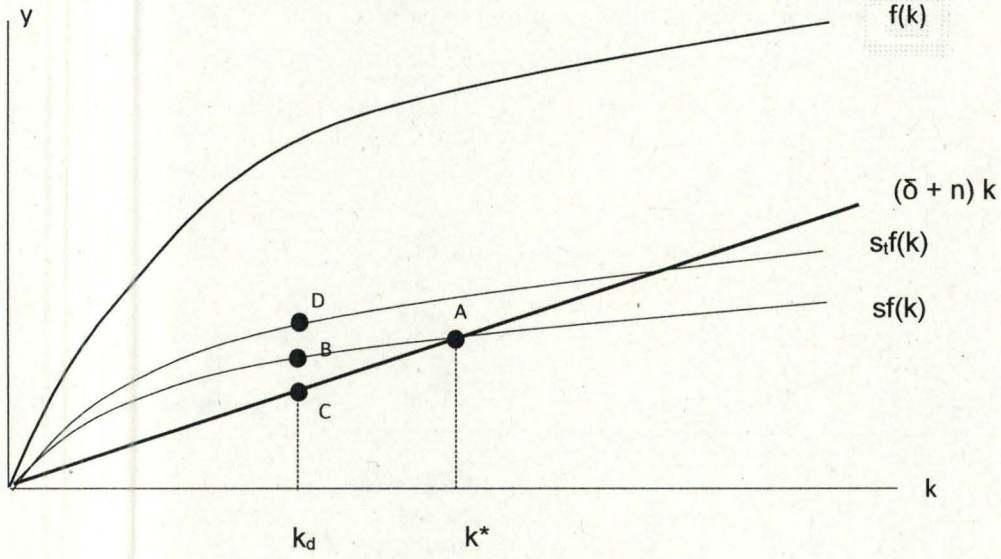

Figure 2: The Solow Model including a disaster[3]

One additional aspect Okuyama is considering is the technological process, which becomes important for the recovery process. Under normal circumstances the technology level grows at a constant rate, x, but can grow at a faster rate when technological replacement is happening during the recovery process. The Solow equation becomes now:

$$\Delta k = sf(k) - (x + \delta + n)\, k \qquad (2.4)$$

Where x is the technology growth rate. If a natural disaster occurs in the model with technology progress, part of the capital stock will be as well destroyed or damaged. Therefore, the economy will move away from the steady-state k* to the new temporary state that is smaller than k*. As in the model without consideration of the technology progress, the saving rate can be increased which leads to an upwards shift of sf(k) and again to an additional acceleration of the growth rate. With the technology progress it is now assumed, that the rate of technology can increase during the recovery progress. An increase in x is thus followed by an increase of

[3] Adapted from: Okuyama (2003), p.15

$(x + \delta + n)$ k. Due to the increase in x, the growth rate will be slightly slower during the recovery period than without the technology progress. Figure 3 shows graphically the mechanisms described above. Before the disaster event, the economy is in its steady state A but due to the disaster the capital per capita decreases from k^* to k and the economy is out of balance. The distance between B and C shows the positive growth rate after the disaster and when we assume again an increase in saving rates the speed of recovery will be faster (distance between B and E). Now we further assume the technology replacement. This replacement leads to a shift in the $(x + \delta + n)$-line. Due to this shift, the recovery speed will be a bit slower (distance between D and E) but the economy will come to a new equilibrium F. In the new equilibrium F the economy can produce more output than before.

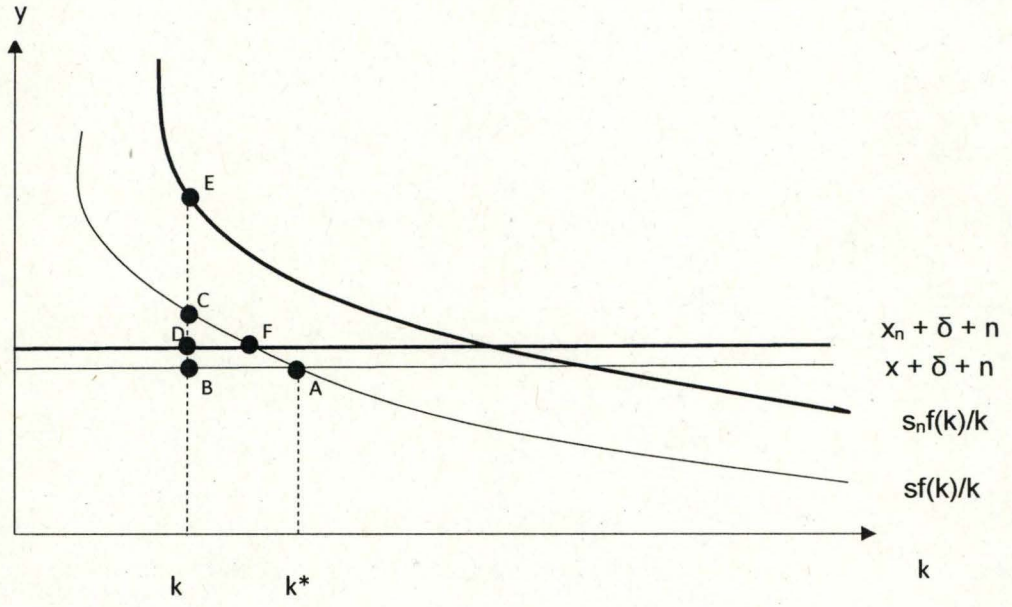

Figure 3: Economic Growth with technological progress x[4]

In contrast to Okuyama (2003) and in a more recent study from Loayza et al. (2009), the authors divide natural disasters into four different types to better estimate their impacts on the economic growth with regard to the theory at hand. They consider separately droughts, floods, earthquakes and storms and they assume that disasters can both harm the capital and the labour stock. With regard to the original Solow Model, Loayza et al. (2009) introduced a third production factor: materials and other intermediate inputs to highlight in their discussion the impacts of natural disasters on economic growth.

For further analysis, Loayza et al. (2009) calculate the growth rates for capital and the growth rate for labour which are similar to equation 2.2 seen before.

[4] Adapted from: Okuyama (2003), p.19

$$Gr(k) = (\Delta(k))/k = s\,(y/k) - (\delta + n) \quad (2.5)$$

$$Gr(y) = (\Delta(y))/y = \alpha Gr(k) \quad (2.6)$$

With the help of equation 2.5 we are able see that the growth rate of capital per worker depends on savings (s(y/k)), the depreciation rate (δ) and the population growth rate (n). Both growth rates, the capital growth rate (2.5) and the output growth rate (2.6), depend heavily on the average production of the worker (y/k).

According to Loayza et al. (2009), natural disasters can affect the growth rate through three channels. The first channel they mention is the total factor productivity (A), the second channel is the supply of materials and intermediate inputs (m) and the third channel is the relative endowment of capital and labour. If total factor productivity is partly destroyed after a natural disaster, meaning a lower A, the model predicts a decrease in growth. The same outcome is predicted if a natural disaster decreases the supply of materials and intermediate inputs. But the model predicts an increase in growth, when a disaster destroys more capital than labour.

Thus, **droughts** are predicted to have negative effects on agricultural growth because they mainly reduce the water supply which is an essential input for the agricultural sector. The decreased growth is also valid for the industrial sector because for this sector agricultural inputs are important which are now reduced and as well the supply of electricity may be limited especially when the economy relay on hydropower as a main source. This all leads to less industrial growth. We can say that droughts cause a decrease of materials and intermediate inputs (m) in both the agricultural and the industrial sector. A third aspect of droughts is the fact, that they affect more labour than capital which leads to an increased k and therefore to less growth.

A negative effect on agricultural growth is as well predicted by **storms** as they reduce the intermediate inputs in terms of seedlings and plants or harvest (decreased m). On the industrial side the effects look a bit different. If the negative effects on the agricultural side are not serve, the growth rate in the industrial sector can increase due to a decreased k (more capital than labour is destroyed). The growth rate could be even smaller when we take the probable technological replacement into account.

While predicting the outcome of **floods**, the authors were dividing the disaster according to their intensity. In general, they say that floods destroy and/or interrupt farming, transportation, infrastructure, and urban activities and affect the overall productivity negatively (decrease in A). When a region gets hit by a serve and long-lasting flood, the total factor productivity can be reduced even more while a moderate flood can lead to a higher growth. This is due to several reasons. Firstly, a moderate flood can increase the supply of water and land productivity. And secondly, due to an increase in growth in the agricultural sector, the industrial

sector is also benefiting of a higher supply of agricultural products. And if the country uses mainly hydropower, a flood can increase the supply of energy. This all leads to an increase of m for a moderate flood. Also the service sector experiences growth which might be due to inter-linkages with other sectors.

The last type of disaster considered by Loayza et al. (2009) are **earthquakes**. Earthquakes are predicted to have a positive impact on industrial growth. They tend to destroy more capital than labour, which leads to a decreased k and an increase in industrial growth. When the economy enters the reconstruction process, the average product of capital and the output increase.

The discussion up to now shows that it is important to distinguish between short-run growth and long-run growth. This is done descriptively by Chhibber and Laajaj (2008) who present four possible scenarios. The four resulting scenarios are seen in Figure 4. Chhibber and Laajaj (2008) do not propose a full theoretical model but they do a conceptual discussion about the different impacts of natural disasters. According to empirical results, they assume four possible scenarios after a disaster. Each scenario represents a different GDP per capita growth path. In the short-run, a reduction in GDP per capita is widely observed but the long-run impacts are still highly discussed.

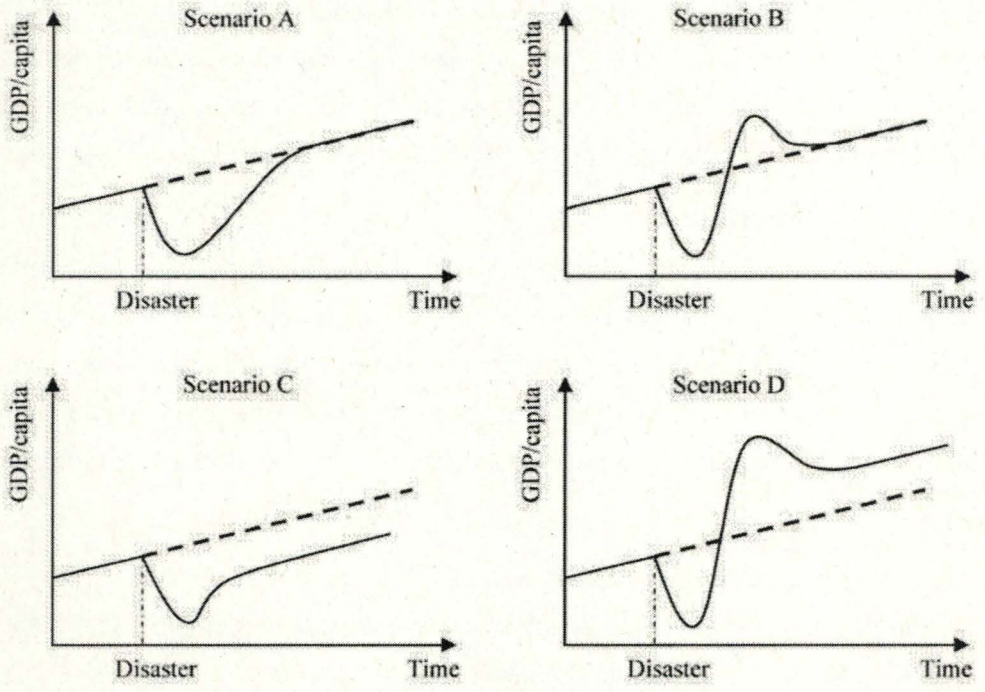

Figure 4: Possible Long-run Impact of a Disaster on GDP per Capita[5]

[5] Adapted from: Chhibber and Laajaj (2008), p. ii15

Scenario A and B represent the theory of the Solow Model where the growth rate will come back to the rate of the steady state. Different to these two scenarios are C and D where the economy is not coming back to its former steady state. In scenario C we see a long lasting decrease in growth rates while in scenario D the growth rates in the long run are higher than before. Possibilities A and B are assumed to occur in both least developed countries (LDCs) and in industrialized countries, whereas possibility C is supposed to only happen in LDCs and possibility D is only supposed to happen in industrialized countries.

Scenarios B and D are considered for instance with an earthquake in a developed country. Earthquakes normally destroy more capital than labour which increases industrial growth in the aftermath of the disaster. Due to foreign financial aid it is possible to have some overinvestment in the intermediate-term but at a certain point the financial aid stops and GDP will come back to its normal case like in scenario B or to a higher equilibrium due to technological progress during the recovery period, which is the case in scenario D. It is possible that the overall economy is getting more productive because of new technologies implemented after the disaster and thus it can shift to a higher stable equilibrium in the long-run. Scenario A is more related to a drought in a LDC. Droughts affect mostly the labour productivity and less the industrial productivity. Therefore, after a drought and after a recovery period for the labour productivity, the economy can produce the same number of products than before. Moreover, Scenario C can be related to a serve natural disaster in an LDC that affected both labour productivity and capital. If the disaster caused many victims, the economy cannot shift back to its normal equilibrium. It will need more time to rebuild the capital stock and especially the labour stock. The labour stock can only immediately increase with the help of immigration. If this is not happening, the economy has to wait for the next generation of workers. Due to the fact that LCDs often lack financial means, the recovery process of the capital stock will be slower than in industrialised countries. To boost the capital stock LDC have to rely on financial (foreign) aid.

Before turning to empirical results, let me summarize the conclusions of the theoretical models reviewed in this section. Okuyama (2003) is including the saving rates and the technological progress in the growth model to predict the growth pattern of an economy during the recovery process after a disaster and concludes that if a natural disaster destroys capital stock, the growth rate will be higher to come back to the steady state. Loayza et al. (2009) divide disasters into different types to better calculate the impacts in light of theory and came to the conclusion that the impact of a natural disaster highly depends on the type of the disaster. And Chhibber and Laajaj (2008) model four different scenarios according to empirical observations. This importance of considering different disaster types will become clearer when we look at the empirical results in the next section.

2.2. Impact on growth: Empirical Evidence

A lot of research was done in recent years to evaluate the impact of natural disasters on economic growth. The results find in recent empirical papers show no consensus whether natural disaster cause positive stimuli towards economic growth or negative ones. Simultaneously the size of estimated impacts vary widely. For example Skidmore and Toya (2002) find positive effects, Rasmussen (2004) finds negative ones and Cavallo et al. (2013) find no significant effects at all. In their meta-analysis review of this literature, Klomp and Valckx (2014) consider around 30 comparable studies that tried to link natural disasters with economic growth. They report that 40 % of the papers found significant estimates at the 10 % level, 25 % found a significant negative effect on GDP growth per capita while 15 % found a significant positive effect.

Table 1 provides a first overview of the main studies and their results which are used in the following part. The papers selected are either the most cited and cross-cited papers in the research field of natural disasters and their economic impacts or they provide an alternative perspective to enrich and broaden the thematic discussion. Klomp (2016) uses for example the light intensity approach and Felbermayr and Göschel (2014) use a different dataset.

In this section, I shortly present the main papers on the impacts of natural disasters on growth. I than discuss to the reasons that may explain the differences across studies. I focus in particular on five factors: a.) Type of data, b.) Type of natural disaster, c.) Country size, d.) Degree of development, and e.) Specialization of economy.

Table 1: Impacts of natural disasters on growth

Author (Year)	Title	Published in	Data source	Counties	Type of disaster	Methodology	Long-run/ short-run	Results
Cavallo et al. (2013)	Catastrophic Natural Disaster and Economic Growth	Review of Economics and Statistics	EMDAT	Worldwide (169 countries) 1970 - 2008	Emphasis on earthquakes, floods and windstorms	* Comparative event study approach * use comparative case studies instead of country fixed effects * difference-in-difference estimator	Short- and long-run	No significant effects – only look on large nat. disasters
Felbermayr and Gröschel (2014)	Naturally negative: The growth effects of natural disasters	Journal of Development Economics	GeoMet data	Worldwide (108 countries) 1979 - 2010	Earthquakes, volcanic eruptions, storms, floods and droughts and extreme temperatures	* Standard growth regression framework following Islam (1995) * Introduce lagged GDP per capita to estimate a dynamic model * Vector of control X includes: set of structural, domestic and external factors * Country specific fixed effects * Year specific fixed effects	Short-run	Negative impacts on growth
Klomp (2016)	Economic development and natural disasters: A satellite data analysis	Global Environmental Change	EMDAT	Worldwide (140 countries) 1990 – 2010	Hydrological disasters, meteorological disasters, geophysical disasters and climatic disasters	* Dynamic model * Light intensity approach * Dependent variable: night-time light intensity * Country specific intercepts * Time fixed effects * Vector of control X includes: set of structural, domestic and external factors	Short- and long-run	Short-term: negative impacts on growth Long-term: for geophysical disasters an increase in growth rates; for meteorological disaster no significant effect

Noy (2009)	The macroeconomic consequences of disasters	Journal of Development Economics	EMDAT	Worldwide (109 countries) 1970 - 2003	Hydro-meteorological, geophysical disasters and biological disasters	* Standard growth regression framework following Islam (1995) * Country specific effects * Assumes exogeneity of the disaster measure * Vector of control X includes: set of structural, domestic and external factors	Short-run	Negative impact on growth (on average 1%)
Peter et al. (2012)	Unmitigated Disasters? New Evidence on the Macroeconomic Cost of Natural Catastrophes	BIS Working Paper	NatCat	Worldwide (203 countries) 1960 - 2011	Emphasis on storms, earthquakes and volcanic eruptions	* Dynamic stochastic growth model – Autoregressive model * Approach benefits from strict exogeneity * panel fixed effects	Short-run	Negative impact on growth (on average 0.6 – 1.0 %)
Raddatz (2009)	The Wrath of God: Macroeconomic costs of Natural Disasters	Policy Research Working Paper 5039	EMDAT	Worldwide – developing countires Since 1950s		* Vector auto-regression (VAR) model → PVAR * Year and country fixed effects * error term is assumed i.i.d. * assumption of exogeneity of natural shocks	Long-run	Climatic disasters: negative impact → cumulative decline of 0.6% in GDP per capita Geological disasters: not significant → but slightly positive point estimate Other disasters: negative impact → cumulative decline of 2% but less negative than climatic disasters
Skidmore and Toya (2002)	Do Natural Disasters Promote Long-Run Growth?	Economic Inquiry	Historical data from Davis (1992) and EMDAT	Worldwide (89 counties) 1960 - 1990	Climatic and geologic disasters	* Simple regression model * Assumes exogeneity of the disaster measure * Vector of control X includes: set of structural, domestic and external factors	Long-run	Climatic disasters are positively related to growth; Geologic disasters are negatively related to growth

Summary of evidence on short run effects of natural disasters

In the literature, more studies are examining the short-run impacts of natural disasters rather than the long-run impacts. Therefore, I start presenting empirical results that focus on short-run growth, before I turn to empirical studies examining the long-run impacts.

The seminal paper examining the impacts of natural disasters on economic growth was written by Albala-Bertrand (1993). He was the first who described the macroeconomic dynamics of natural disasters. In his paper he analyses 28 disasters in 26 countries during 1960 – 1979. With the help of a before-after statistic he finds that GDP increases by 0.4 % after a natural disaster.

Since the 2000s there is a fast growing literature on the topic of natural disasters and their impacts. The reason for that might be the rising concern about the climate change and the fact that in the last decades the number of natural disasters increased considerable.

In the following, I will concentrate on the four papers from Noy (2009), Peter et al. (2012), Felbermayr et al. (2014) and Klomp (2016). All four papers find negative short-term effects on economic growth after a disaster event. I start presenting the paper and the results of Noy (2009) in detail and then summarize the subsequent literature of short-term growth effects after natural disasters.

In the year 2009 Noy published his paper: "*The macroeconomic consequences of disasters*" where he looks at the short-run impacts of natural disasters on growth. The main finding of his paper is that natural disasters do have a significant negative impact of 1 % on average on growth. For developing countries, the impact is higher than one and for developed countries it is lower than one. This goes hand in hand with the finding that developing countries experience much larger impact shocks with regard to their macro-economies than do developed countries.

Like most authors in the literature, Noy (2009) uses for his calculation the EM-DAT database which is provided by the Centre for Research on the Epidemiology of Disasters (CRED) and which is publicly accessible[6]. The EM-DAT database includes all kind of natural disasters, starting from geophysical to extraterrestrial disasters, from 1900 to present. According to CRED, a natural situation is considered as a disaster when it "overwhelms local capacity, necessitating a request to national or international level for external assistance"[7]. A disaster which is included in the EM-DAT database has to fulfil at least one of the following conditions: The disaster killed 10 or more people, the disaster affected 100 or more people, the

[6] www.cred.be

[7] Quoted from Centre for Research on the Epidemiology of Disasters (CRED), http://emdat.be/glossary/9#letterd

government declared a state of emergency and/or the government called for international assistance.

Due to the fact, that the EM-DAT database is only providing direct damages, Noy (2009) is calculating the indirect damages with the help of different measures of the magnitude of the disaster at hand using a per capita measure.[8] To have for each country the same amount of data he reduces the time span to 1970 – 2003. From a simple look at the mean and the median, Noy (2009) is able to conclude that disasters are costlier for developing countries than for developed countries and that natural disasters cost more in South-, South-East, and East-Asia than in the Middle East and in Latin America. Furthermore, it is visible that small island states are more vulnerable to disasters. To measure the macroeconomic consequences of disasters he uses the following regression:

$$y_{i,t} = \alpha_i + \beta y_{i,t-1} + \gamma DMS_{i,t} + \phi X_i + \varepsilon_{it} \qquad (2.7)$$

Where $y_{i,t}$ is the annual GDP growth rate and $DMS_{i,t}$ is the special magnitude to take into account, that a disaster that occurs in January has a bigger effect on the GDP growth rate of that year and that the magnitude depends on the size of the population. X_i are control variables for short-run growth and $y_{i,t-1}$ is the GDP growth lag. Moreover, Noy (2009) assumes exogeneity of the disaster measure because he does not see a reason that the disaster measure will face any causality from the GDP growth variables. The outcome resulting from this regression is that the amount of property damaged is negatively affecting the GDP growth rate, but neither number of people killed nor number of people affected have any influences on GDP growth rates. Noy (2009) assumes that this is the case because in the short-run mainly capital stocks are damaged which is in line with the theory explained by Okuyama (2003). By introducing control variables, Noy (2009) finds that better institutions, lower credit growth, a higher current account surplus, larger FDI flows and the absence of a financial crisis favour higher growth after a natural disaster. Not significantly important for GDP growth rates are however past investment growth, the government deficit, the inflation rate and imports. In the paper, the author is as well distinguishing between developed and developing countries and finds out that the macro economy in developing countries is suffering more after disasters than the macro economy in developed countries, but on the same time tropical countries are likely to experience higher growth rates compared to non-tropical countries. In addition to the damaged capital stock caused by the natural disaster, Yang (2008) finds in his paper that after a disaster countries experience a higher capital flight, which again decreases the capital stock. In line with that, Noy (2009) finds that countries who have open capital accounts have larger losses

[8] DMS = DM(12-OM)/12 where DMS stands for disaster measure; DM stands for cost measure; OM stands for onset months

in their output growth. Overall he finds negative impacts of natural disasters on short-run growth.

A more recent paper from Peter et al. (2012) confirms the findings of Noy (2009). Peter et al. find as well a negative relation between natural disasters and economic growth. They calculate a drop in growth of 0.6 – 1.0 % for a typical (median) natural disaster. The new aspect of the study of Peter et al. is the consideration of the insurance aspect. Different from the study of Noy is the separation between insured and uninsured catastrophes. The main finding of the paper is that the macroeconomic costs are driven by the uninsured part. Catastrophes which are well insured for example if all people affected by storm damages have a storm and tempest insurance, can be inconsequent or even positive for economic growth but uninsured disasters cause a drop in growth of 0.6 – 1.0 %. In contrast to the majority of papers, Peter et al. (2012) are not using the EM-DAT database. They are using NatCat data, which come from the NatCatService of Munich Re[9] and which is not publicly accessible. The time span of the NatCat disaster data used in the calculations is from 1960 to 2011 including 2,476 events worldwide.

With the following baseline regression, described by an autoregressive model, Peter et al. calculate the losses of uninsured catastrophes:

$$y_{it} = \alpha_i + \sum_{n=1}^{2} \beta_n y_{it-n} + \sum_{n=0}^{4} \delta_n N_{it-n} + [\text{Macro controls}] + \varepsilon_{it} \qquad (2.8)$$

Where N_{it} equals 1 if a natural disaster occurs in year t and country i. Without the occurrence of a disaster, N_{it} equals zero. The disasters considered in the regression are at least catastrophes of category 4 and above, meaning that the disaster caused at least 100 fatalities and/or $250 million in damages (constant 2011 US$). The negative growth trend after a disaster is continuing in the second year.

The research paper of Felbermayr and Gröschl (2014) finds as well that disasters decrease the GDP per capita and they cannot confirm on average that natural disasters lead to a temporary boom in the long run. The main conclusion of their paper is the same than the one of Noy (2009) and Peter et al. (2012). Felbermayr and Gröschl (2014) estimate that a natural disaster in the top 1-percentile, according to the disaster intensity, reduces GDP per capita by at least 6.83 %. For a disaster in the top 5-percentile they compute a reduction of at least 0.46 % and for the smallest 25-percentile the GDP per capita decreases by at least 0.01 %. Countries who can cope better with natural disasters mostly have higher institutional quality, higher openness to trade and higher financial openness that is in line with the earlier findings

[9] A global insurance and reinsurance group

of Noy (2009). In their paper, Felbermayr and Gröschl (2014) use their own GeoMet dataset. They collected the data from five primary sources that are usually used in geophysics or climatology. Similar to Noy (2009) and Peter et al. (2012), Felbermayr and Göschl (2014) use a standard growth regression as seen below:

$$\Delta \ln y_{i,t} = (\rho-1)\ln y_{i,t-1} + \alpha D_{i,t} + \beta \mathbf{X}_{i,t-1} + V_i + V_t + \varepsilon_{i,t} \quad (2.9)$$

Where $\Delta \ln y_{i,t}$ is the growth rate of real GDP per capita, $\ln y_{i,t-1}$ is the lagged log of GDP per capita and $D_{i,t}$ stands for the disaster intensity.

Klomp (2016) uses in his paper: "*Economic development and natural disasters: A satellite data analysis*" a different approach to measure the impacts of natural disasters on growth. Instead of using GDP per capita he uses the light intensity. Light intensity and economic activity are tightly linked and can therefore be used as a proxy for GDP per capita (see Doll et al. 2006; Ghosh et al. 2009). Moreover, light intensity is related to public goods provision especially in less developed countries (Min 2008). Klomp (2016) measures the impacts of large-scale natural disasters on economic development in a wider range of countries and the main finding of his study is that in the short-run, the amount of lights visible from outer space has significantly decreased. In his paper Klomp (2016) distinguishes between climatic, hydrological, geophysical and meteorological disasters and he comes to the conclusion, that both climatic and hydrological disasters reduce the light intensity in developing countries whereas geophysical and meteorological disasters cause a decrease in light intensity in developed countries. In his empirical analysis, Klomp (2016) finds for hydro-meteorological and climatic disasters an immediate drop in economic development in the short-run and no effects in the long-run. This equals scenario A in Figure 4. For geophysical disasters he finds out, that they are as well followed by an immediate drop in economic development in the short run, but in the long run, the annual growth rate will be about 0.06 percentage-points higher than the annual growth rate before the disaster. Consequently, geophysical disasters have a positive impact on annual growth rates in the long-run. This scenario equals scenario D in Figure 4. Beside Klomp (2016), Bertinelli and Strobel (2013) are also using the light intensity approach. With the light intensity approach, Bertinelli and Strobl (2013) find out, that hurricanes in the Caribbean decreased light intensity by more than three percent, which is in contrast to using GDP per capita for the calculation twice as large.

Noy (2009), Peter et al. (2012), Felbermayr et al. (2014) and Klomp (2016) find negative impacts of natural disasters in the short run. However, the magnitude of the drop in growth rate varies. Noy (2009) predicts a drop in growth rates on average by -1%, Peter et al. (2012) predict a reduction of growth by -0.6 to -1% of a medium size disaster, Felbermayr and Göschl (2014) predict a decrease in growth by -0.18 percentage points of a medium size disaster and

Klomp (2016) also predicts a drop in growth rates in the short-run. In the long-run the picture looks a bit different. The theory predicts faster growth rates while the economy recovers, to come back to its stable steady state.

Summary of evidence on long-run effects of natural disasters

Skidmore and Toya (2002) study in their paper: "*Do Natural Disaster Promote Long-Run Growth*" the long run growth effects and they find positive effects on growth. In contrast to the papers described before, Skidmore and Toya (2002) are looking at the long-term growth effects.

The key findings of the paper from Skidmore and Toya (2002) are that climatic disasters such as droughts increase economic growth, human capital investments and growth in total factor productivity while geologic disasters including earthquakes, mass movements and volcanic activities decrease the growth rates. They explain the negative and sometimes insignificant relation between geological disasters and economic growth with the fact that geological disaster often cause damages in human capital. With the help of standard growth regressions, they calculate an increase of the average annual economic growth rate of 0.47 for climatic disasters. For the calculation, Skidmore and Toya (2002) use historical data collected by Davis (1992) and the EM-DAT database provided by CRED. They are considering 89 countries in a time span from 1960 to 1990.

With regard to the latest research, the findings of Skidmore and Toya (2002) have been largely replaced by studies that came to the opposite conclusion. Noy and Nualsri (2007), Jaramillo H. (2009) and Raddatz (2009) find a negative correlation between disaster effects and the long-run economic growth rate and as well Felbermayr et al. (2014) cannot confirm on average that natural disasters lead to a higher growth rate following a natural disaster within a 5-year period.

The main findings of the research paper of Raddatz (2009) are that a climatic natural disaster leads to a cumulative decline of 0.6 % in GDP in the long run, a geological disaster leads to no significant decline but the point estimate is slightly positive and other disasters including famines, epidemics, insect plagues, wild fires, industrial accidents, transport accidents and miscellaneous accidents have a cumulative decline of 2 % but it is less significant than compared to climatic disasters. Different to the study of Skidmore and Toya (2002) Raddatz (2009) is looking at the cumulative loss in GDP and not at the GDP growth rates. But for climatic disaster we can assume a negative growth rate because we know that the cumulative loss in GDP in the disaster year was about 0.5 %. The fact that the loss increased in the following year to a cumulative GDP loss of 0.6 % we can expect a negative growth rate. For the analysis Raddatz (2009) is using the EMDAT database and he is considering disasters since the 1950s.

To calculate the output impact of natural disasters he uses a panel autoregressive distributed lags (PARDL) model. The baseline specification model is

$$y_{it} = \sum_{j=1}^{q} \alpha_j y_{i,t-j} + \sum_{j=1}^{q} B_j D_{i,t-j} + \theta_i + \theta_t + \varepsilon_{i,t} \quad (2.10)$$

Where y is the real GDP and $D_{i,t}$ is a vector of variables including the natural disasters. θ_i is the country fixed effects and θ_t includes the time fixed effects.

This review of the literature may suggest that a multiple equilibria scenario exists where we have two stable and one unstable equilibrium. When the shock of a disaster is too severe it might be possible, that the economy shifts to the lower stable equilibrium with lower growth rates and lower output. Chhibber and Laajaj (2008) as well consider such a scenario (Figure 1 Scenario C). Without a big push, it is mostly not possible to overcome this trap. Therefore, natural disasters might be one factor helping to explain why some countries are caught in a poverty trap.

So far, the introduced papers find either positive or negative impacts of natural disasters on economic growth. But it also exist literature that find no significant relation between growth and natural disasters at all such as Cavallo et al. (2013). In their paper: "*Catastrophic Natural Disasters and Economic Growth*", they find that natural disasters do not have an impact, neither positive nor negative, on economic growth rates. Only when a disaster is followed by a radical political revolution, negative and long-lasting effects on economic growth can be find. The approach by Cavallo et al. (2013) differs from the regression approaches we saw earlier in this section. Cavallo et al. (2013) use a comparative case study approach, where they were comparing the growth path of real GDP per capita from a country affected by a large natural disaster with a counterfactual series. With this approach, using the comparative case study, they are able to get rid of country fixed effects. The disaster data used for the calculation of the paper comes from the EMDAT database and the time span examined covers the years from 1970 to 2008.

Discussion of existing empirical evidence

The review of the literature shows that different authors point at different potential explanations for the diverse impacts of natural disasters on growth. The ones mentioned most often include: **First**, the data used to analyse the impacts. **Second**, the type of disaster and their intensity. **Third**, the size of the country affected. **Fourth**, the degree of development and **fifth**, the specialization of economy.

In the literature, there are a lot of discussions regarding the **type of data**. Therefore, the **first** aspect we have to consider is the data used to analyse the impacts of natural disasters on

growth. The majority of studies use the EM-DAT database, which is provided by the Centre for Research on the Epidemiology of Disasters (CRED). A similar database, but only partly publicly accessible is NatCatService from Munich Re. This database only includes natural disasters. A disaster is included in the NatCat database when any property or person is damaged and then the database divides the natural disasters into 6 categories from small-scale loss events to great natural catastrophes. The EM-DAT database is news-driven and the NatCat database is insurance-based but both face several problems: First, they face a selection bias and second, the intensity measures are probably correlated with the error terms in growth regressions (see Felbermayr and Gröschl, 2014). Often richer countries face higher monetary damages caused by a disaster and therefore, the disaster intensity measures from the EMDAT database might correlate with GDP per capita (dependent variable in growth regressions). A similar problem exists in the NetCat database. The inclusion of a disaster event into the database might correlate with the GDP per capita, if the insurance coverage correlates with GDP per capita.

A further critic concerning the two databases is that it seems that over time the reported natural disaster events increased which might be related to the increasing attention of natural disasters by the media due to global warming. In addition to that it might be problematic, that the allocation of information in the EM-DAT data comes from different sources which is concerning in terms of consistency. Few researchers use totally different databanks of natural disaster which is the case in the studies of Felbermayr and Gröschl (2014) and Strobl (2009). Other use beside the EM-DAT database metrological or geographical data like Noy (2009) or Strobl (2011). However, even if the different data sources are considered, the deviation in the results cannot be satisfactorily explained.

Beside the discussion of the right database for disasters, the quality of the GDP measures may also be put into question. Especially the data from developing countries lack of quality or are not complete[10]. One reason are the poor statistical systems but often there are no other ways to receive a full data set from different, more reliable sources, which is necessary for the analysis. In addition, another critic is that some governments are benefiting from exaggerated damages caused by natural disaster to receive international aid. With the problem of reliable data in mind, several authors tried to use light intensity instead of GDP as shown above.

Even though, the data source is important for the analysis and the results, the use of different sources cannot explain the differences in outcome especially when we want to understand why some find positive and others negative impacts of natural disasters on growth.

[10] See Jerven (2013)

Regarding the **second** aspect, **the type of disaster**, we find in literature a growing number of studies separating between the types of disasters and their impacts on a country's economy. Beside the analysis to predict growth after natural disasters in general, many authors start to divide between types of disasters and to analyse them separately. This movement is in line with the theory, which says that different types of natural disasters cause different effects on economic growth. Earthquakes for instance affect each year 142,000 people per reported event while drought affect each year around 3.6 million people per reported event. From this point of view, it appears that droughts are more interfering for countries but when we are looking at the economic costs, the picture is reverse. The damages caused by earthquakes are estimated with one billion dollars per event. The damages caused by droughts are estimated with 321,000 dollars per event.[11]

The division into different types of disasters or the consideration of only one disaster type seems to explain some differences in the results and is a good step forward. Sometimes, impacts of natural disasters on growth rates became first statistically significant when disasters are divided by their types. Hurricanes seem to have a negative impact on growth rates in most papers, but for droughts and floods the results are still mixed.

Loayza et al. (2012) and Felbermayr and Gröschl (2014) analyse the impacts of several different disasters. Strobl (2009) and (2011) is setting his main interest in the impacts of hurricanes similar to Yang (2008) who is as well focusing on hurricanes and Noy (2009) are dividing their sample in hurricanes and earthquakes. Different disasters affect different channels of growth, which leads to different growth paths and to different disaster driven impacts.

Loayza et al. (2012) look at four different types of disasters separately and their findings fit with the theory explained in 2.1. They are considering droughts, floods, earthquakes and storms. Huge disasters are only considered having a negative impact on growth, while some moderate disasters can have a positive impact. As the authors are calculating the impacts of natural disasters without dividing them into their different types, they are not finding statistically significant results but while dividing the disasters into their main types the results become statistically significant. In developing countries, both droughts and floods are statistically significant. While droughts decrease the GDP growth by 0.6 percentage points and floods increase GDP growth by almost 1 percentage point. The coefficients for earthquakes and storms are not statistically significant but both have a negative sign. The non-significance of

[11] See Loayza et al (2012)

storms is confirmed by Noy (2009) but in his paper he points out that the data he uses might not be suitable for such a calculation.

Felbermayr and Gröschl (2014) find out that an average earthquake reduces the GDP per capita growth rate by 0.16 percentage point, a moderate storm reduces the GDP per capita by 0.16, an average drought by 0.01 and by 0.05 percentage points when it is an average extreme temperature event. All the changes are statistically significant. Moreover, the 5 percent strongest events in their disaster database reduce the GDP growth per capita by 2.32 percentage points for earthquakes, 1.75 for storms, 0.34 for droughts and 0.09 for extreme temperature events.

With regard to hurricanes Strobl (2009) and (2011) find, that GDP growth rates are decreased by 0.84 respectively 0.45 percentage points. In 2009 he studied the macroeconomic impacts of hurricanes in Central America and in the Caribbean region and in 2011 he focused on the US costal countries. In both cases, hurricanes have a negative impact on GDP growth. In addition, Yang (2008) estimate a general average loss caused by hurricanes per event of 0.73 % of GDP. As well Noy (2009) find a negative impact of hurricane on GDP per capita.

The **third** aspect, **the size of the country affected**, is also crucial when we look at the impacts of natural disasters. The authors agree that smaller countries are more vulnerable to natural disasters. In theory, the country size is included with the population variable. In small countries, the possibility that a larger share of people is affected by the same disaster is higher than in huge countries where it might only effect one certain region. Therefore, the fact that in small countries the majority of people is affected by a disaster also effects a huge part of the economy.

A lot of papers point out, that small countries are more vulnerable. For example, Noy (2009) find that small economies and small island states are more vulnerable to natural disasters. The same disaster (relative to the size of the country) causes less damage in developed countries. Rasmussen (2004) examines the macroeconomic implication of natural disasters in the Caribbean where he is as well highlighting the importance of country size. In his paper he concludes, that due to the higher frequency of natural disasters, small island states are particularly vulnerable. Proportionately to their size, the disaster has a large impact on their GDP. These findings might explain why some researches only concentrate on island regions or small countries such as Strobel (2009).

By comparing the impacts of natural disasters over countries we therefore should consider the size of a country.

The **degree of development** can be seen as the **fourth** important aspect while analysing the impacts of natural disasters.

It was known before, that the initial costs of natural disasters are higher in developing countries than in developed countries. A new finding of Noy (2009) is that the indirect impacts of disasters are as well larger for developing countries than for developed ones. Furthermore, Noy discovered, that natural disasters cost more in South-, South-East, and East-Asia than in the Middle East and in Latin America.

Kahn (2005) find out that an increase of 1,000 USD in GDP decreases the risk of floods because several techniques exist to prevent regions of large damages caused by floods. Also it might be possible that when households have more money they could build better houses which could withstand a hurricane. Thus, some natural disasters may be endogenous and not exogenous like it is assumed in many research papers. But the risk for other disasters (extreme temperature or wind storms) stays the same and therefore they are not depending on the degree of development. However, depending on the degree of development is the amount of fatalities during a disaster. Kahn (2005) calculated for a country with 100 million inhabitants that an increase of GDP per capita from 2,000 USD to 14,000 USD will lead to 700 fewer fatalities caused by natural disasters. Also Strömberg (2007) identifies that the risk to die during an natural disaster is lower in developed countries. An increase in income of 1 % is linked with a decrease in fatalities of 0.4 %. More developed countries seem to better handle the risks of natural disasters. Rich people can move form high-risk regions to less affected regions and furthermore they can build their homes with stronger and long-lasting materials. Moreover, medical care facilities can be developed faster after a disaster in more developed counties (Athey and Stern 2000). In addition, early warning systems might be better in developed countries and people can be warned in time. Considering individual country development, Strömberg (2007) says that absent development fatalities would be 20 % higher nowadays. As well Toya and Skidmore (2007) say that more developed countries face fewer disaster related fatalities and less damages in relation to the GDP. At the time a country is developing and the income levels are rising, the people increase their demand for safety. Therefore, a higher income for individuals or countries helps to better respond to disaster risks by introducing post-ante measures (see Toya, Skidmore (2007)). Loayza et al. (2012) find out that by only considering developing countries, the impacts of natural catastrophes on growth are stronger in significance and sometimes as well in magnitude.

When we widen our definition of development and not only consider the degree of development in terms of income or economic development, we find that countries with high quality institutions and democratic structures experience less fatalities caused by disasters (Kahn,

2005). A higher degree of education, a higher degree of openness, a strong financial sector and a smaller government body reduce as well the negative impacts of natural disasters (Toya, Skidmore (2007)). These findings are again strengthened by Felbermayr and Gröschl (2014) who find out that countries with higher institutional quality, higher openness to trade and higher financial openness are in a better position to deal with natural disasters.

The degree of development matters in terms of disaster caused fatalities. Richer counties experience fewer fatalities than poorer ones. One explanation can be that richer countries can invest more money to early warning systems and they might be in a better position to absorb disaster driven costs.

The **specialization of the country's economy**, as the **fifth** aspect, is important to know because different disasters have different effects on either agriculture or industry. This aspect is closely linked to the third aspect, the degree of development.

The proportion of the agricultural sector in the overall economy decreases with the degree of industrialization and industrialization is linked to growth and development. While countries develop, they tend to reduce the share of agriculture towards services or industry and depending on the degree of diversification the impacts of natural disasters on the economy might decrease. Because of that, in countries where the agricultural sector makes up a huge share, the industrial production sector is often highly dependent on agricultural inputs like for example cotton for textiles (see Loayza et al. (2012)). In case of a disaster that destroys huge parts of the harvest it is not only effecting the agricultural sector but as well the production sector.

As mentioned in the first aspect, different types of natural disasters tend to have different effects. With the view of the specialization of the country's economy, Loayza et al. (2012) point out, that a median drought affects negatively agricultural growth and industrial growth, but does not have any effect on service growth. A median flood has a negative growth effect on all three sectors while earthquakes only effect the industrial sector in a positive way. The impacts of storms are a bit more mixed. They decrease the growth in the agricultural sector while increasing growth in the industrial sector and have no impact on service growth. With this outcome in mind we can say that for countries which are frequently hit by storms the division of the economic sector plays a major role, as storm effect negatively agricultural growth and positively industrial growth. Therefore, developing countries which tend to have a larger sector of agriculture will probably experience more negative impacts of storms than a developed country with a larger industrial sector.

2.3. Mitigation effect

In this section I discuss the mitigating effect that financial aid may have on economic growth after a natural disaster.

At least in the short-run, disasters have negative effects on the economy, on the financial budget and may cause fatalities, therefore a fast supply of foreign aid and/or additional financial aid flows can help to fill some of these losses and can reduce some of the negative impacts of natural disasters.

The majority of studies analysing the mitigation effect of natural disasters find no link between financial aid flows and a smoothing effect of the national level of consumption. However, Yang (2008) does find a positive correlation. He proofs that specific types of international aid flows do replace a large fraction of losses caused by natural disasters. For the poorer half of his country sample he shows that the total replacement rate is 82.4 % (statistically significant) with increasing amounts of Official Development Assistance (ODA) and migrants remittances and decreasing bank and trade-related lending in relation to the size of damage. In his research paper he divides international financial flows in: ODA, migrants' remittances, lending from multilateral institutions, bank and trade-related lending, Foreign Direct Investment (FDI) and portfolio investment to investigate the importance of financial flows as a mitigation tool. Yang (2008) shows that ODA and lending from multilateral institutions respond positively to hurricane exposure in developing countries. Furthermore, he discovers that migrants' remittances are less in richer countries which is not due to less international migrants but rather due to the facts that households in poorer countries do not have the possibility to use other sources of financial aid to smooth consumption. A hurricane occurrence in Latin America will lead to significant financial flows resulting from migrants' remittance, bank and trade-related lending and portfolio investment. When the hurricane occurs in Africa we will find migrants remittances and bank and trade-related lending but no portfolio investment. Moreover, Young (2008) find out that the more similar the effected country is with the US, Japan, France, Britain and West Germany in the years before the natural disasters occurred, the more likely is bank and trade-related lending. With regard to the poorer half of the sample it seems that ODA and migrants' remittances increase in the size of damage.

Post-disaster aid flows, national or international, are important for affected countries to fill some of the losses caused by natural disasters, because disasters cause a worsening of fiscal balances (see Rasmussen, 2004). In the paper: *"Understanding the Economic and Financial Impacts of Natural Disaster"*, Benson and Clay (2004) argue that these financial flows are not additional rather than reallocated. They observe that disasters have little impact on the overall size of financial aid. Their observation is based on three case studies, Bangladesh, Dominica

and Malawi. Moreover, the authors argue that for understanding the full dimension of financial aid, internal or external, it is important to know the whole public finances in a disaggregated form. Many developing countries receive financial aid from foreign countries which is part of public expenditures. When a disaster occurs the external financial payments often do not increase but the allocation of the budget changes. This fact may lead to an underestimation of the impacts of a natural disaster at a first glace. In the case of Malawi, Benson and Clay (2014) are highlighting how volatile the composition of expenditure can become. In years with droughts, the government reallocated a huge part of expenditure to agriculture and expenditures for other projects are postponed. Considering only foreign aid, the case of reallocation is the same. With the data of the three case studies, Benson and Clay (2014) show that disasters have little impact on the overall trend in financial aid flows. If a disaster hits a recipient's country, the donor nation mostly brings forward commitments under already existing multiyear country programs. Thus, total aid flows do increase in the year of a disaster or in the following years and the aid provides support for development. The main purpose of financial aid is meeting the direct costs of a disaster.

Apart of financial aid, which is a mitigation tool ex-post, the country can try to mitigate the disaster effects ex-ante. In the previous sector I mentioned already some mitigation effects which can lower the number of fatalities and therefore some of the negative effects of natural disasters. Under the fourth aspect, degree of development, it was said, that countries with higher income levels, a higher degree of education, a higher degree of openness, a strong financial sector and a smaller government body reduce the negative impacts of natural disasters. Therefore, improving these aspects can reduce the negative impacts of a disaster. These aspects are also important for the size of foreign financial aid. However, the allocation of financial aid is not following a transparent rule. Alesina and Dollar (2000) came to the conclusion that in general foreign aid depends on political and strategic considerations. Foreign aid responds positively to political openness, a democratic country can count on a 50 % increase in aid, while foreign direct investment (FDI) responds to economic openness (see Alesina and Dollar, 2000). Moreover, colonial ties play an important role for foreign aid but do not have a bearing on FDI. This is reasonable because FDI is made by private investors who mainly respond to economic incentives. Beside the colonial history, the fact that the donor and the recipient are "UN friends" increases as well the amount of aid. If aid really helps to promote growth cannot be taken for granted. The majority of researches say that at its best, aid only partially supports growth.

In terms of natural disasters, Strömberg (2007) concludes that financial aid flows increase with the magnitude of the disaster, measured by people killed and affected, but he also confirms most of the findings of Alesina and Dollar (2000). Therefore, aid flows after a disaster are not

only dependent on the disasters magnitude but also on secondary aspects such as colonial ties and trade patterns. In detail Strömberg (2007) examines that donors are more willing to give aid to countries with a common language, they are more willing to give aid to countries which are trading partners, they give more aid to countries with a colonial link and they give aid to countries which are closer in terms of distance. Having a colonial history for instance increases the possibility of getting financial aid by 8 % and having a colonial tie with France, Spain, Portugal or Italy increases the possibility of getting financial aid additionally by 10 percentage points. Also for the amount of aid the colonial history is of importance. The amount of the financial aid is 46 % higher when colonial ties exist and even three times higher when the donor is France, Spain, Portugal or Italy. Different to Alesina and Dollar (2000), Strömberg (2007) find little evidence that friendly governments receive more aid. Taken all the donor countries together, language is more important than the colonial past because the language connects the recipient to several donors at the same time. Also the news coverage is of importance for the size of aid. Smaller disasters in neighbour countries tend to be reported more often than smaller disasters in countries far away. To receive the same relief as a donor's neighbour country, a country on the other side of the world must have 160 times as many fatalities. Therefore, countries which are far away from the main donor countries lack systematically financial aid. Furthermore, it may be the case, that donor countries give aid only to countries who have high growth potential and do not consider giving aid to countries with less potential.

To summarize, natural disasters generate an increase in aid flows in the year when it occurs and/or in the following years but the amount of aid depends as well on other aspects such as colonial history or trade patterns. Financial aid helps to overcome some of the negative effects of natural disasters because it tries to fill some of the direct costs and consequently support development. Yang (2008) is examining the link between financial aid and the replacement rate and discovers that financial flows do have a mitigation effect. For developing countries this replacement rate is huge and statistically significant whereas for developed countries the replacement rate is small and not statistically significant. Nevertheless, we have to keep in mind, that the aid flows are not additional rather than reallocated. Financial aid flows are ex-post tools to mitigate the negative effects of a disaster but the governments can also try to mitigate the disaster effects ex-ante by increasing the income level, the degree of education or the degree of openness.

3. Impact on trade

Apart from studies analysing the impacts on growth, a smaller and weaker literature strand looks at natural disasters and their impacts on trade. In this section I shortly present the impact of natural disasters on trade.

When a country gets hit by a natural disaster it causes immediate direct losses but it also causes macroeconomic losses. Trade can be affected negatively but as well positively. Oh and Reuveny (2010) are discussing the different channels how natural disasters can have an impact on trade. According to them, they find two channels, which influence trade in a negative way. The **first** channel, which can affect the trade pattern negatively is a decrease in human and physical capital caused by a disaster. As a consequence, the economy experiences a fall in production, the income may decrease, which leads to a reduction in private spending and investments. Furthermore, tax revenues are probably going to decrease, which is followed by a decrease in public spending. Thus, aggregate demand and supply decline when the economy is hit by a disaster and this reduces the trade flows. The **second** channel mentioned by Oh and Reuveny (2010) is the cost of trade. Due to the destruction of infrastructure, trades might need to use longer routes, different airports and/or different harbours to reach the market. The result is higher trading cost and a transfer of some of the trade costs towards the product price, making the goods more expensive, which in turn will decrease the total quantity demanded.

On the contrary, disasters could also increase trade. To explain this scenario, Oh and Reuveny (2010) find four different channels. The **first** channel, which can explain an increase in trade is the fact, that foreign nations might increase their market share or new nations might enter the local market. Thus, they can offer more products to the local market which decreases the commodity price. The **second** channel that influences trade in a positive way is through new policies favouring bilateral trade. As an example, Oh and Reuveny (2010) cite that during the reconstruction process the economy often rely on imports of materials, skills and technologies from foreign countries. Moreover, the government can liberalize its export and import markets, leading to a further increase in trade flows. The **third** channel is price gouging. It may be the case, that suppliers increase their prices during and shortly after the disaster but if the price increase is larger than the decrease in quantity, the trade value rises. The **last** channel mentioned is the attraction of speculators and risk-loving traders. After a disaster risk-averse traders might exit but risk-loving traders are attracted. Therefore, if the number of speculators and risk-loving traders entering the market is higher than the number of traders leaving the market, the value of bilateral trade is likely to rise. (see Oh and Reuveny, 2010)

Imports and exports of goods and services are an important part of a country's economy. A natural disaster can increase or decrease trade flows. Few research was done to calculate the impact of a disaster on trade but some studies exist. There is general agreement among researchers that natural disaster harm trade in general. It is widely believed, that exports decrease when a country gets hit by a disaster. Once again many authors point out, that smaller countries are more vulnerable when it comes to the impacts on trade due to natural disasters. They state the same reason as they did for the impact on growth.

When we look at empirical studies we find that a decrease in exports and an increase in imports lead to a worsening of a country's balance of trade. Therefore, the macroeconomic consequences after a natural disaster causes a direct decline in output and a worsening of fiscal balances (Rasmussen, 2004).

Rasmussen (2004) examines the impacts of 12 large natural disasters in the Caribbean. In his comprehensive cross-country comparison, he finds out, after a large natural disaster (he took the median of the 12) the exports were declining and the imports were raising which resulted in an account deficit of 10.8 % of GDP. In detail, imports during the disaster year were increasing by 12.7 % and exports were declining by 4.9 % (on average). Furthermore, Rasmussen (2004) finds out that a disaster has to be sufficiently large to decrease the aggregate economic activity and in this case, the GDP has to be as well dependent on imports. In other words, the larger the share of trade affected by a natural disaster, the larger the trade impacts. This is in line with the arguments provided by Felbermayr and Gröschl (2013) who say that the size of the country's home market matters. Consumption smoothing is more likely the larger and more diverse the home market is.

Gassebner et al. (2010) are as well analysing the impacts of natural disasters on trade with the help of a standard gravity model with the following basic specification:

$$\ln(rimp_{iet}) = c_{iet} + \beta_1 \ln(gdp_{iet}) + \beta_2 \ln(gdppc_{iet}) + \beta_3 lock_{ie} + \beta_4 contig_{ie} + \beta_5 \ln(dist_{ie}) + \gamma' X_{ie} + e_{iet} \quad (3.1)$$

Where $rimp_{iet}$ stands for nominal imports of country i from country e in year t, gdp_{iet} stads for the real GDP of both countries and $gdpp_{iet}$ is the real GDP per capita of both countries. $Lock_{ie}$ represents the dummy variable which is one when at least one trading partner has no access to the sea. $Contig_{ie}$ is a dummy variable representing if the trading partners have a common border and $dist_{ie}$ is the distance between the trading partners. e_{iet} is the error term and X includes a set of variables such as a dummy for common language, colonial relationship, etc.

They are testing four hypotheses which could likely result out of a disaster. Their **first** hypothesis is: Disasters reduce exports, the **second** one is: Disasters reduce or alternatively

increase imports, the **third** one is: Disasters affect trade more the smaller the country is and the **last** hypothesis is: Disasters affect trade more the less democratic a country is. After running the gravity model, they are able to confirm hypothesis one and three. Disasters do reduce exports and disasters do affect trade more the smaller the country is. In Honduras, a small country, a disaster reduced exports by 1.8 %. The fourth hypothesis, disasters affect trade more the less democratic a country is, is also confirmed but only when we look at the effects on imports. The more democratic a country is, the less imports are lost. For exports, the type of governance seems not to matter. The second hypothesis and its alternative hypothesis cannot be really confirmed or rejected. In general disasters increase imports but only in very democratic countries. The more autocratic a country is the more imports are decreased. Furthermore, they find out that the level of development matters as well while determining the trade effects. For most developed countries the findings of the paper are not significant, therefore, the economic size of a country is important when evaluating the trade effects of natural disasters. The study shows that, between 1962 and 2003, disasters wiped out 2.5 % of world imports and thus the authors argue that disasters increasingly harm world trade.

To sum up, the main finding of Gassebner et al. (2010) is that both imports and exports get negatively influenced by natural disasters and the larger the affected share of the economy is, the larger are the trade impacts.

Oh and Reuveny (2010) are as well analysing the impact of natural disasters on trade. Similar to Gassebner et al. (2010) they use as well the gravity model to calculate the impact on trade.

$$\begin{aligned} \ln IMPORT_{i,j,t} = {} & \alpha_0 + \beta_1 \ln(CD_{i,t}) + \beta_2 \ln(CD_{j,t}) + \beta_3 \ln(PS_{i,t-1}) + \beta_4 \ln(PS_{j,t-1}) \\ & + \beta_5 \ln(PS_{i,t-1}) * \ln(CD_{i,t}) + \beta_6 \ln(PS_{j,t-1}) * \ln(CD_{j,t}) + \alpha_1 \ln(GDP_{i,t-1}) \\ & + \alpha_2 \ln(GDP_{j,t-1}) + \alpha_3 \ln(POP_{i,t-1}) + \alpha_4 \ln(POP_{j,t-1}) + \alpha_5 \ln(DIST_{i,j,t}) \\ & + \alpha_6 CBORD_{i,j,t} + \alpha_7 CLANG_{i,j,t} + \alpha_8 CCOL_{i,j,t} + \alpha_9 COLR_{i,j,t} \\ & + \alpha_{10} CURU_{i,j,t-1} + \alpha_{11} RTA_{i,j,t-1} + \alpha_{12} GD_{i,t} + \alpha_{13} GD_{j,t} + \mu_i \\ & + \nu_j + \varepsilon_{i,j,t} \end{aligned} \tag{3.2}$$

Where $IMPORT_{i,j,t}$ stands for the real value of the trade flow from country j, the exporter, to country i, the importer. The regression contains 6 independent variables: Climatic disasters (CD) in country i and in country j, political risks (PR) of country i and country j and two climatic disasters-political risk interaction terms for country i and j. Oh and Reuveny (2010) also include 13 control variables such as GDP, population size, common language, common boarder, etc. μ_i and ν_j stand for the country-fixed effect of i and j and $\varepsilon_{i,j,t}$ is the residual term.

They find out that a rise in geophysical disaster in the importer country will not have an impact on the imports. But a rise in geophysical disaster in the exporter country will increase the trade

flow. Without any mitigation effect Oh and Reuveny (2010) expect that trade will decline in the next decades due to an increase in disaster frequency. Furthermore, they expect that countries will have more problems helping each other to cope with disasters impacts due to the fact that natural disasters will appear more often. Empirical findings proof, that trade helps to withstand adverse shocks allowing countries to help out with commodities and aid.

To mitigate some of the trade effects, Gassebner et al. (2010) find out, that governance plays an important role. The more democratic a country is the less are the trade impacts of natural disasters. A reason for this is that more democratic countries tend to trade more and are less affected by country-specific shocks (see Felbermayr and Göschl, 2013).

In the empirical literature on natural disasters and their impacts on trade exists a wide consensus that disasters harm trade but only few research was made so far. We cannot distinguish between short-run impacts and long-run impacts. The fact that the world experiences more natural disaster than in earlier decades let us suggest, that the impacts on trade will be worsen in the following years when natural disasters appear more often due to climate changes.

4. Impact on households and enterprises

The previous sections were looking at the impacts of natural disasters on economic growth in general. In this section I present the impacts of natural disasters on households and enterprises. Section 4.1 highlights the impacts on enterprises and their recovery process whereas section 4.2 focuses on food prices and social unrest. Recent studies point at effects on prices and on the link between natural disasters and social unrest. Section 4.3 deals with the impacts of natural disaster on households and in the last section, 4.4, I briefly present the critical role of insurance markets.

Table 2 provides a first overview of some papers used in section 4. The papers corresponding to household studies are the most cited and cross-cited ones. The papers corresponding to the studies of enterprise and the microeconomic studies belong to a relatively new research field and are thus less cited.

Table 2: Impacts of natural disasters on enterprises and households

Author (Year)	Title	Published in	Data source	Counties	Type of disaster	Methodology	Enterprises/ Households	Results
Alderman et al. (2006)	Long term consequences of early childhood malnutrition	Oxford Economic Papers	Longitudinal surveys of households and children residing in three resettlement areas of rural Zimbabwe	Zimbabwe	Drought	* OLS * Maternal fixed effects and IV * Siblings as a comparable age * controls for year of observation and whether the child was born in the resettlement area	Households Long-term	* A child of 12 to 24 months during the drought is later: → 3.4 cm smaller and lag 0.85 grades of schooling than a median child in a developed country → lose 14 % of its lifetime earnings
Andergassen and Sereno (2014)	Natural disasters, mitigation investment and financial aid	Environment and Development Economics	FAO and EMDAT	St. Lucia	Hurricane	* Calculate a critical frim size at which the investment in mitigation is undertaken on the basis of their own model	Enterprises	* Financial aid flows lead to a delay in mitigation investments * Targeted aid increases the critical firm size more than cash aid
Carter et al. (2007)	Poverty Traps and Natural Disasters in Ethiopia and Honduras	World Development	Secondary data collected for a study on the impact of land market liberalization and asset accumulation	Ethiopia and Honduras	Drought and hurricane	* Standard growth model to test whether poor or rich hh respond asymmetrically * OLS/Tobit estimates * Model of post-shock asset growth * Poverty trap threshold with the Hansen's (2000) method	Households Longer-term	**Ethiopia:** * Poverty trap exists * Richer households do consumption smoothing **Honduras:** * Poverty trap exists * Poorer households need longer to recover

Cavallo et al. (2014)	Prices and Supply Disruptions During Natural Disasters	The Review of Income and Wealth	Billion Prices Project (BPP) by MIT	Chile and Japan	Earthquakes	* Comparison between the current situation with predictions of recent pricing models * Jevons geometric-average price index * Index for overall product availability * Hazard rates → Standard methods in Survival Analysis	Enterprises	* The margin of adjustment during the disaster event was in product availability and not in prices
De Mel et al. (2012)	Enterprises Recovery following Natural Disasters	The Economic Journal	Own data (608 enterprises)	Sri Lanka	Tsunami	* field experiment * standard regression * firm fixed effects → To measure the impact of access to capital in the recovery process	Enterprises Short-term	* Firms with financial aid were able to recover within two years * Firms in the retail sector benefited the most * Targeting of financial aid to poor business owners was performed poorly
Dercon et al. (2005)	Shocks and Consumption in 15 Ethiopian Villages	Journal of African Economies	Ethiopia Rural Household Survey (ERHS)	Ethiopia	Shocks divided in: Climatic, economic, political/social/legal, crime, and health shocks	* Standard regression * Village fixed effects * Robustness checks: → Including lagged (1999) consumption and change of dependent variable → Disaggregate shocks by degree of importance	Households Short-term	* Drought → drop in consumption by 20% * Illness → drop in consumption by 9%

4.1. Impacts on enterprises and their recovery process

In this section I present the impacts of natural disasters on enterprises and how does their recovery process looks like. Up to now little research exists about the microeconomic situation after a natural disaster especially looking at the recovery process of enterprises in developing countries. The literature provides us with descriptive analysis but with limited empirical evidence of the impacts of natural disasters on enterprises. The bulk of studies are not analysing the recovery processes but disaster risk mitigation measures. One of the few papers which examine the impacts on enterprises and their recovery process is: "*Enterprise Recovery following Natural Disasters*" from de Mel et al. (2012).

De Mel et al. (2012) analyse the recovery process from enterprises in Sri Lanka. They themselves call their paper a first paper in the field of microeconomic studies dealing with the recovery process of the private sector in a developing country. Starting with a descriptive analysis of the losses caused by the tsunami in December 2014 they find that, after a time period of three months, a large share of the tsunami damage was restored. In their paper, they want to find out if financial grants can boost the recovery process of enterprises hit by a tsunami in comparison with enterprises outside the impact zone and if grants fasten the recovery process. For their study, they use their own dataset. They divide their sample of Sri Lankan enterprises into three groups: Directly affected (205 enterprises), indirectly affected (208 enterprises) and unaffected (195 enterprises). Enterprises affected got the majority financial means for the recovery process from their own savings (51 %). 20 % of the affected enterprises received a loan or a grant from tsunami relief agencies, 15 % received a loan from family members or friends and 14 % received credits from suppliers such as microfinance organisations, moneylenders, banks and remittances from relatives abroad. After the tsunami event, many firms had access to financial means despite the normal constraints firms face within the financial market (De Mel et al., 2012). To test whether grants are useful or not and if the amount matters, the authors gave two different amounts of grants to randomly selected enterprises. Their main finding is that the grants allowed the enterprises to recover in the first two years after the tsunami in comparison to the firms who were not receiving a grant. Firms in the retail sector experienced the larges positive impact of grant receipts on recovery of capital stock and on profits. The grant receipt had less impact on firms in the manufacturing and service sector. The grant helped as well to increase the recovery of capital stock, but it does not increase profits. This can be explained by the fact that supply chain and customer/supplier relations are more important compared to the retail sector. In the manufacturing sector, the supply chains are very complex and if one part gets interrupted the whole production has to stop. The retail sector receives their products from outside and have a wider range of costumer. With the possibility of technology replacement in mind it would be

interesting to know how manufacturing firms proceed in the following years and if they can substantially raise their profits once they rearranged their supply-chain. Okuyama (2003) mentioned that technological replacements after a disaster could lead to a significant impact on the following growth path. To see the outcome of such a replacement a longer time-span analysis would be necessary. A further conclusion of de Mel et al. (2008) is that the targeting of financial aid flows to households was very well done and that the flows were quite large. This stands in contrast to the aid allocation to firms. Here the targeting was poor, there is no correlation between reported damage and aid receipts, and the flows were small. However, a better targeting process would not immediately lead to a faster recovery process because of the two different effects of grants for the retail sector and the manufacturer/service sector.

De Mel et al. (2008) raise the attention of two points of concern. The first concern is that the damages are self-reported and the second concern is that for the majority of enterprises no written accounts exist. These two facts could lead to an under- or over-estimation of the impacts.

The natural disaster event studied by de Mel et al. (2008) has a destructive character. The tsunami destroyed huge parts of buildings and infrastructure and caused a huge death toll. A hurricane can be associated with the same characteristics. It destroys as well huge parts of buildings and infrastructure and causes a death toll. Thus, by considering the similarity of these characteristics we might expect that a hurricane has the same impacts on enterprises. Whereas the impacts of a droughts on enterprises might be totally different. The impact of a drought on enterprises can perhaps be compared to the situation of the manufacturing sector in the tsunami setting. A drought is not destroying the infrastructure or buildings but it does harm the harvest. Enterprises who rely on inputs from the agricultural sector cannot proceed with the production because of missing intermediate materials and therefore the supply chain gets interrupted. A grant would not help to raise profits neither can it be used to replace damaged machinery or buildings because no physical damage exists. The only use of the grant could be for running expenses. In such cases, the type of grant is important, an immediate provision of intermediate inputs would help the enterprises to keep producing.

Relating the impacts of natural disasters on enterprises with the theory seen in section 2.1 we can once again confirm that it is important to distinguish between different types of disasters because they affect different channels and lead to different outcomes.

Grants seem to play an important role for the recovery process of enterprises and to mitigate some of the negative effects of natural disasters like we saw in the study of de Mel et al. (2012). However, the expectation of financial aid after a natural disaster affects the mitigation

investments[12] of enterprises. Andergassen and Sereno (2016) analyse these mitigation investments and the behaviour of firms when no insurance market exists and how financial aid flows affect the decision-making process of firms. The difficulty for firms is to find a balance between the optimal timing and the optimal size of a mitigation investment with regard to its value maximisation. After setting up a model to simulate the critical firm size for enterprises in St. Lucia the authors find that financial aid programmes[13] lead to a delay in mitigation-investments due to an increase in the critical firm size. By distinguishing the financial aid programmes, Andergassen and Sereno (2014) discover that targeted aid programmes increase the critical frim size more than cash aid programmes, thus leading to a delay in mitigation-investments. On the other hand, targeted aid programmes also increase the size of mitigation investment whereas cash aid programmes have no effect on the investment size. Therefore, if you want to increase the investments in mitigation of small enterprises governments should use cash aid programmes. However, if the government wants to reduce the average damage resulting out of natural hazard they should implement targeted aid programmes.

There is no doubt, that aid flows help enterprises to recover but when governments want to go one step further, meaning to encourage more enterprises to do investments in mitigation, the programme has to be carefully chosen.

4.2. Food Prices and Social Unrest

A smaller literature strand deals with the impacts of natural disasters on food prices and some try to link natural disasters with social unrest. The paper: "*Prices and Supply Distribution During Natural Disasters*" from Cavallo et al. (2014) deals with the pricing respond of supermarkets and companies. In an earlier paper Cavallo et al. (2013) conclude, that an important decrease in GDP per capita was caused when natural disasters were followed by radical political revolution. This leads to the probable assumption, that natural disasters have an impact on the likelihood of social unrest. Oh and Reuveny (2010) are analysing how international trade flows change when a disaster happens or the political situation worsens and a more recent paper from Bellemare (2014) tries to test the hypothesis if natural disasters have an impact on social unrest.

The paper from Cavallo et al. (2014) is analysing the pricing respond of supermarkets in Chile and Japan after a hurricane. In detail, they analyse both the demand and supply shock. They find out, that immediately after a hurricane people demand more non-perishable goods. In both

[12] Investments that mitigate the disaster effect such as reducing the exposure to disaster events or increasing the ability of structures to overcome disasters impacts.
[13] Cash aid programmes and targeted aid programmes

counties prices did not rise immediately after the hurricane, the adjustment was rather made through product availability. In Chile, non-perishable goods such as pasta, powdered milk or baby diapers revel an immediate drop in availability after the disaster but did not have any price changes. Perishable goods such as eggs, fresh vegetables or meat tended to have as well a significant drop in product availability, but they did have price increases quickly after the disaster. A third group including products like fish and batteries did not experience a drop in product availability but an increase in prices. In Japan, perishable goods like fresh fish and meat experienced a drop in product availability but not a change in prices. In the group of non-perishable goods like baby food, product availability fell dramatically and prices rose. Cavallo et al. (2014) mention two possible reasons for the combination of a large stock-out and stable prices within the first months after the hurricane. The first reason might be an interruption in the supply chain meaning that the supermarkets are unable to re-stock and thus to re-price and the second reason might be the fear of "customer anger" if they increase the prices. This is in line with the price change hazard calculated by the authors. During the months following the hurricane this rate remains low in both countries. The first increases in prices was made after 6 months in Chile and after 4 months in Japan.

Oh and Reuveny (2010) are trying to link natural disasters with trade as described in section 3. In one section of their paper, they consider both, natural disasters and political unrest as an exogenous shock and investigated how trade flows change. They did not link natural disasters to social unrest, but they detect that an increase in climatic disasters or political risk reduces bilateral trade. From that fact, we can conclude that with one of these shocks social unrest is more likely.

Bellemare (2014) goes one-step further and try to actually link natural disasters with social unrest. He links natural disasters with food prices and food prices with social unrest. He uses the variable natural disasters as an instrumental variable that is correlated with food prices and only affect social unrest through food prices. After plotting food prices with the LexisNexis[14] and including some covariates like a time trend and a set of monthly dummy variables the author finds that the food price level and the cereal price level are positively correlated with social unrest. After running the regressions, the main result is that food prices cause social unrest and that food volatility is either negatively correlated or has no effect at all to social

[14] As a measure of social unrest the authors did a LexisNexis Academic search of all news stories written in English in the time between January 1990 and December 2011. Stories entered the measure when they contained at least five appearances of the words "cereal/s", "commodity/ies", "food/s", "grain/s", or "staple/s" and at least five appearances of the words "demonstration/s", "mob/s", "protest/s", "riot/s", "strike/s", "unrest/s", or "violence/s"

unrest. With this outcome Bellemare (2014) indirectly connected natural disasters with social unrest.

Many research papers have the possible link between natural disasters and social unrest in mind, but few really test it. The research question and the focus of the papers vary a lot but when we take all the different results together we might say that natural disasters have a negative influence on social unrest. After a serve natural disaster, the risk of social unrest can increase, one possible transmission channel is through food prices as discovered by Bellmare (2014).

4.3. Impact on households

In developing countries, natural disasters often cause a higher death toll, higher direct costs and higher indirect costs. Poor households reflect this picture. Poor households are more vulnerable to natural disasters and experience higher impacts compared to rich households. In this section I present the impacts of natural disasters on households with a special focus on the risk of poverty traps.

The Developing Report of the World Bank (2003) outlined that poor households tend to settle in the most vulnerable areas and that their houses are often poorly constructed. Therefore, natural disasters such as hurricanes can destroy the houses more easily and due to constrained access to financial means, households cannot turn to a quick recovery process. Poor households need more time to recover, to come back to the before-the-disaster-state, and considering that a country/region and thus a household can be hit several times a year by a disaster, makes the recovery process to a long-lasting and difficult process. If households did not fully recover from the first disaster and then get hit by a second one, it can drag them into a downward loop and then into a poverty trap. By definition, a poverty trap is seen as a critical minimum asset threshold below that the household is no longer in the position to educate their children and to build up their productive assets (see Carter and Barrett, 2006). Poor households cannot report the damages to their insurance company because they do not have one and thus without external aid, the household is trapped in such an economic situation.

A conceptual discussion of impacts of natural disasters on households

Carter et al. (2007) are looking at longer-impacts of natural disasters on households. In their paper, they build a conceptual model of asset accumulation to analyse the reaction of households to an environmental shock. They distinguish between two different types of shocks affecting different channels of a household and leads to different outcomes. They consider: a.) Asset shocks caused by for instance hurricanes and b.) Income shocks caused by for example

droughts. An asset shock is associated with a drop in productive assets caused by a natural disaster such as a hurricane. The disaster is from a short-duration but quickly destroys livestock and assets, which can be seen in Figure 5. The different impacts on rich (A_{wp}) and poor households (A_{bp}) are dramatic. Poor households tend to lose much more and might fall under the poverty trap threshold where they are not able to recover by their own. Richer households are in a position to use different coping strategies that are unavailable for the poor. Richer households tend to have a better access to markets and other institutions and can borrow money to rebuild their houses and assets and to replace some of their losses.

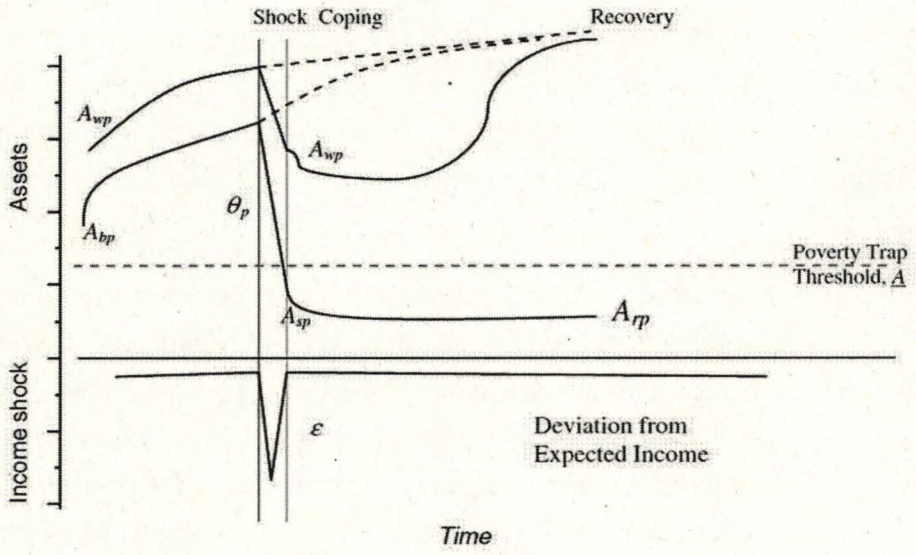

Figure 5: Asset shocks and poverty trap[15]

An income shock is associated with a drop in income caused by a natural disaster such as a drought. To consider only an income shock, the authors assume no changes in assets caused by a natural disaster. A drought is a good example for an income shock as it is considered to be a long-winded disaster that destroys parts of the harvest and therefore reduces the income. A richer household is expected to sell some of its assets to smooth its consumption and after the end of the disaster period they will rebuild the assets to come back to their initial state. Figure 6 shows graphically the impacts of an income shock on assets and income for rich (A_{bw}) and poor households (A_{bp}). According to the conceptual discussion, an income shock is less likely to drag households in a poverty trap.

[15] Adapted from: Carter et al. (2007), p. 837

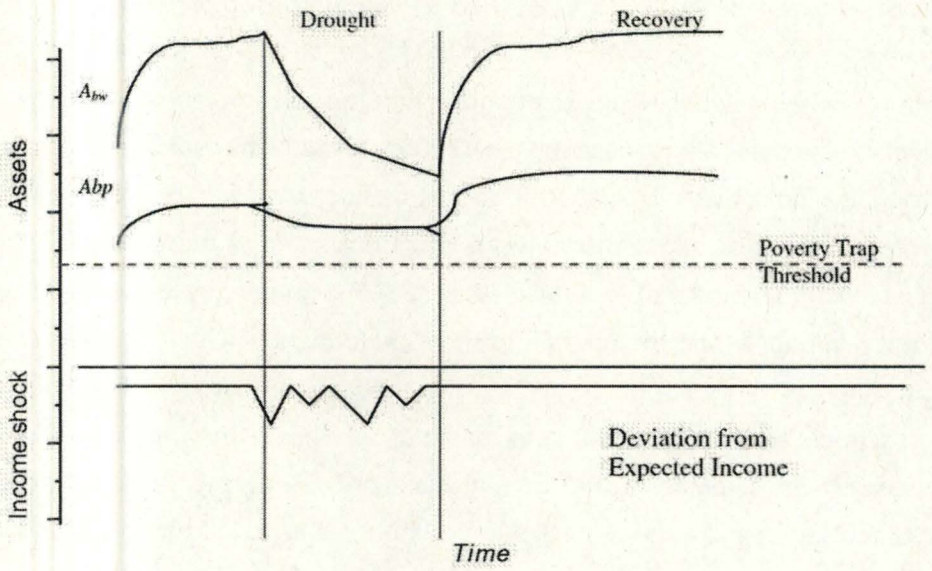

Figure 6: Income shocks and asset smoothing[16]

When we have a closer look at Figure 5 we see, that without a disaster shock, the asset stock of rich and poor households is assumed to converge (see the dotted lines in the figure). This convergence is in line with the growth theory in section 2.1. When we try to apply the growth theory of section 2.1, we should assume an increase in growth rates to come back to the before-the-disaster-state but as seen in Figure 5, this scenario is unlikely from the conceptual discussion point of view. This result may suggest that the growth process need to take more aspects into consideration which are not part of the standard growth model.

Summary of evidence on household effects of natural disasters

The empirical research on the impacts of natural disasters on households shows no common research question. Due to different research questions and consequently different methodologies, it is difficult to compare them with each other. Most often, the authors of microeconomic research papers use natural field experiments. They assume that natural disasters are exogenous and use panel data.

One paper who linked natural disasters with household reactions is from Dercon et al. (2005). In this paper, the authors are analysing consumption smoothing during a natural disaster. Their main finding is that droughts and illness shocks in Ethiopian villages are related with less consumption per capita. A household that experienced a drought at least once within the last 5 years (1999 – 2004) had a drop in consumption of 20 %. A household that experienced an

[16] Adapted from: Carter et al. (2007), p. 839

illness shock at least once within the last 5 years had a drop in consumption of 9 %. The impacts were even bigger when the household was headed by a female, when the head has no schooling or when the household belongs the bottom three quintiles of landing compared with the other households in their village. Dercon et al. (2005) conclude that uninsured risk, for example from a drought, is not only causing short-term welfare fluctuations. In an earlier paper Dercon (2004) conclude, that risk and shocks are an important factor of the persistence of poverty. This is in line with the results of Alderman et al. (2006) who analyse the connection between a drought in Zimbabwe and the following school performance. Their main result is that children with the age of 12 to 24 months during the 1982 – 1984 drought faced more problems at the preschool year than others due to malnutrition. This is one argument which can be taken to support the hypothesis that natural disasters favour the poverty trap of households. Without a disaster and thus with a higher probability to succeed preschool and to gain a better education, children might be in a better position to break free out of the poverty circle. Already short-lived aggregate shocks can have irreversible consequences on the future of next generations (Skoufias, 2003)

Dercon (2004) and Dercon et al. (2005) highlight the risk of natural disasters on poverty and their long-lasting impacts on households. In the paper of Carter et al. (2007) they are testing empirically the existence of poverty traps in Honduras and Ethiopia. With data selected before, during and after the hurricane Mitch in Honduras and the drought in Ethiopia, the authors test for poverty traps within the scenario of an asset shock resp. income shock as described earlier in this section.

In the case of hurricane Mitch in Honduras, the changes in assets were caused exogenously. The authors find that poorer households need longer to recover than richer households and they also find the existence of a poverty trap after the hurricane. The estimates, which were contained with the help of strong assumptions, show the existence of a poverty trap. Households which are under the threshold of $244 or which fall under this threshold during or after the disaster are expected to be trapped in a low equilibrium. To come to that finding Carter et al. (2007) are first testing if poor and rich households respond similar to the environmental shock (equation 5.1) before they were testing for poverty traps with equation 5.2. Only by running equation 5.1 it is less conclusive whether poorer households are really trapped in a lower equilibrium.

$$g_{bi} = A_{bi}\beta_A + \theta_i\beta_\theta (A_{bi}, L_i, K_i) + \varepsilon_i\beta_\varepsilon (A_{bi}, L_i, K_i) + \beta_i Z_i + v_i \qquad (5.1)$$

Where g_{bi} is the asset growth for household i covering the time from the pre-disaster situation to the post-disaster situation. A_{bi} is the households' initial asset level, θ_i measures the asset shock, β_i measures the income shock, L_i stands for the access to off-farm labour market and

K_i stands for the access to financial and/or social capital. Z_i includes control variables and v_i measures latent, random factors that can influence asset growth. The first term in equation (5.1), $A_{bi}\beta_A$, represents the idea of neoclassical growth theory seen in section 3.1., saying that there is one equilibrium level and that poorer households and rich households converge over time. Thus, if $\beta_A < 0$ it means that we have a convergence process. Poorer households grow faster than richer ones to catch up. This mechanism can also be seen in Figure 5 where the doted lines represent the predicted growth of households without a disaster. The doted lines seem to converge. This convergence process is interrupted with the existence of a natural disaster, a hurricane.

With a second equation, Carter et al. (2007) calculate the long-run asset equilibrium, separately for rich and poor households.

$$g_{si} = \beta^{l}_{A} A_{si} + \beta^{l}_{Z} Z_i + v^{l}_{i}, \quad \text{if } A_{si} < y,$$
$$g_{si} = \beta^{u}_{A} A_{si} + \beta^{u}_{Z} Z_i + v^{u}_{i}, \quad \text{otherwise,} \qquad (5.2)$$

Where g_{si} is again the asset growth for household i covering the time from the pre-disaster situation to the post-disaster situation. A_{si} is the households' initial asset level, y is the critical asset level, l is the parameter which shapes growth in the poor households and u is the parameter which shapes growth in the richer households. Households would be in a poverty trap when the poverty trap threshold moved to a lower equilibrium level where growth is zero. A low level equilibrium exists when either β^{l}_{A} is highly negative or $\beta^{l}_{Z}Z$ is low. Problematic is the fact that the poverty trap threshold y is unknown. To overcome this problem Carter et al. (2007) use the method proposed by Hansen (2000). In the case of Honduras, the data indicates the existence of a poverty trap. It appears that poor households grow slower after the hurricane.

The drought in Ethiopia represents an income shock, a shock which is prolonged and the changes after the disaster are endogenous due to of the fact that they depend on the individual chosen households' risk strategy. Carter et al. (2007) are analysing if assets change during the drought years and find that households who are part of the community and who have access to the labour market have higher growth rates of livestock, and households with more assets are decreasing their asset share during a crisis to smooth consumption whereas poor households stick to their assets. This behaviour, to stick to your assets, indicates the existence of a poverty trap. Indeed, the authors find as well the existence of a poverty trap in the case of Ethiopia. Households who have more than 0.59 livestock assets belong to the richer half and households who have less than 0.59 livestock assets belong to the poorer half of the sample. However, we have to consider that livestock assets of 0.59 cannot really exist because it is

less than one animal. To define the threshold of the poverty trap and to demonstrate the existence of a poverty trap the authors followed equation (5.2). The data predicts the existence of a low equilibrium for poor households.

The authors mention some constraints of the paper. One is, that the calculation of a threshold is always complicating and the second one is, that the time span is not really long-term. To really prove the existence of a poverty trap, a larger set of data would be needed. Now it might be the case, that poorer households grow slower but do catch up in a couple of years.

Summarizing the impacts of natural disasters on households, we can say that both, poor and rich households experience negative impacts of natural disasters and resulting out of possible insurances or coping strategies, the impact can vary. However, the impacts for poor households are worse and can lead to a poverty trap.

4.4. Critical role of insurance markets

Insurances are an important tool to mitigate some of the negative effects of natural disasters. In developing countries people have a households insurances, a collision damage insurances and a building insurances with which they cover losses that occur out of damages from heavy rain, storms, lightning, thunder and hail. With an elementary additional insurance households can further cover damages from floods, landslide and earthquakes. Difficult to cover are losses from droughts but also for that exist an insurance which is offered to farmers in developing countries.[17] Depending on the exposed risk, households can decide if they want an insurance and which type of insurance. Toya and Skidmore (2007) find that an increase in income rises the individual demand for safety. Higher incomes lead to more financial flexibility which allows households to take out insurances. In developed countries insurances are common for households whereas in developing countries the insurance sector is weak. Especially poor people suffer from the consequences caused by natural disasters because the formal insurance market constrain their possibility to get an insurance or a formal insurance market is not available. These constraints lead to informal risk coping strategies to smooth consumption after aggregated shocks such as a natural disaster. But these informal insurances are costly and as soon as all members of the risk-sharing community are effected the informal risk sharing strategy fails. (see Fafchamps, (1997). Missing financial means can prevent poor households from a quick recovery process and lead to a failure of consumption smoothing after a natural disaster. Thus, natural disasters have a bigger impact on households and enterprises in developing countries due to a lack of insurances.

[17] Insurance chamber Bavaria, https://www.vkb.de/content/versicherungen/

Peter et al. (2012) show that in their sample of 203 countries, covering a time span of 52 years almost 60 % of huge natural disasters are completely uninsured. As they were separately looking at hydrological and climatological events the number of uninsured disasters grew to almost 80 %. The most insurance claims come from North America, Europe, Japan and the Pacific Region. The highest insured losses were in 2005 with $116 billion and the highest uninsured losses were in 2011 with $386 billion (see Peter et al., 2012). This shows us, that it is useful to distinguish natural disaster events into uninsured and insured events to better understand the impact for households and enterprises. And this proofs again, that poor households are more effected by natural disasters.

5. Conclusion

After looking at the growth theory and recent literature we can conclude, that least developed countries and small countries do suffer more from natural disasters in terms of direct losses and economic losses. However, if the growth process is prolonged interrupted cannot be said because especially the long-run studies fail to find a consensus in terms of the impact on growth.

The standard growth model from Solow and Swan predicts an increase in growth rates but while distinguishing different kind of natural disasters the outcome is different according to the type of disaster and also empirical results show no consensus for long-term impacts of natural disasters. While analysing the impacts of natural disasters five factors seems to affect the empirical outcomes: The data used, the type of disaster, the size of the affected economy, the degree of development and the specialization of the economy. A further reason for the different findings might be the fact that insurances are often not considered as transmission channels. In developed countries insurances cover a huge part of direct losses caused by natural disasters but in developing countries the insurance market face usually huge constraints thus leading to the establishment of expensive informal coping strategies.

When we look closer at the household level we see that the existence of a poverty trap is very likely. The impacts of natural disasters can drag poor households in developing countries in a poverty trap, which affects the household over a long period or even over generations. This supports the conclusion, that natural disasters have negative impacts on the growth path in least developed countries.

Beside the bulk of research concerning the impacts on growth, less research was made on the microeconomic level. How do enterprises deal with natural disasters? With the help of financial grants, it seems that enterprises are able to recover but the allocations are poorly done. It would be interesting to further examine this question with the help of more field studies and also with the view of different disasters. With more firm results we would be also in a better

Publication bibliography

Albala-Bertrand, J. M. (1993): Political economy of large natural disasters. With special reference to developing countries / J.M. Albala-Bertrand. Oxford: Clarendon Press.

Alderman, Harold; Hoddinott, Johan; Kinseyz, Bill (2006): Long term consequences of early childhood malnutrition. In *Oxford Economic Papers* 58 (3), pp. 450–474. DOI: 10.1093/oep/gpl008.

Alesina, Alberto; Dollar, David (2000): Who gives foreign aid to whom and why? In *Journal of Economic Growth* 5 (1), pp. 33–63. DOI: 10.1023/A:1009874203400.

Andergassen, Rainer; Sereno, Luigi (2016): Natural disasters, mitigation investment and financial aid. In *Envir. Dev. Econ.*, pp. 1–23. DOI: 10.1017/S1355770X1500039X.

Athey, Susan; Stern, Scott (2000): The Impact of Information Technology on Emergency Health Care Outcomes. DOI: 10.3386/w7887.

Bellemare, M. F. (2014): Rising Food Prices, Food Price Volatility, and Social Unrest. In *American Journal of Agricultural Economics* 97 (1), pp. 1–21. DOI: 10.1093/ajae/aau038.

Benson, Charlotte; Clay, Edward J. (Eds.) (2004): Understanding the Economic and Financial Impacts of Natural Disasters. World Bank. Washington, DC: World Bank (Disaster Risk Management), checked on 7/2/2016.

Bertinelli, Luisito; Strobl, Eric (2013): Quantifying the Local Economic Growth Impact of Hurricane Strikes. An Analysis from Outer Space for the Caribbean. In *J. Appl. Meteor. Climatol.* 52 (8), pp. 1688–1697. DOI: 10.1175/JAMC-D-12-0258.1.

Carter, Michael R.; Little, Peter D.; Mogues, Tewodaj; Negatu, Workneh (2007): Poverty Traps and Natural Disasters in Ethiopia and Honduras. In *World Development* 35 (5), pp. 835–856. DOI: 10.1016/j.worlddev.2006.09.010.

Cavallo, Alberto; Cavallo, Eduardo; Rigobon, Roberto (2014): Prices and Supply Disruptions during Natural Disasters. In *Review of Income and Wealth* 60, pp. S449-S471. DOI: 10.1111/roiw.12141.

Cavallo, Eduardo; Galiani, Sebastian; Noy, Ilan; Pantano, Juan (2013): Catastrophic Natural Disasters and Economic Growth. In *Review of Economics and Statistics* 95 (5), pp. 1549–1561. DOI: 10.1162/REST_a_00413.

Chhibber, A.; Laajaj, R. (2008): Disasters, Climate Change and Economic Development in Sub-Saharan Africa. Lessons and Directions. In *Journal of African Economies* 17 (Supplement 2), pp. ii7-ii49. DOI: 10.1093/jae/ejn020.

Dercon, Stefan (2004): Growth and shocks. Evidence from rural Ethiopia. In *Journal of Development Economics* 74 (2), pp. 309–329. DOI: 10.1016/j.jdeveco.2004.01.001.

Doll, Christopher N.H.; Muller, Jan-Peter; Morley, Jeremy G. (2006): Mapping regional economic activity from night-time light satellite imagery. In *Ecological Economics* 57 (1), pp. 75–92. DOI: 10.1016/j.ecolecon.2005.03.007.

Fafchamps, Marcel (1997): Rural Poverty, Risk and Development. In *FAO report*.

Felbermayr, Gabriel; Gröschl, Jasmin (2013): Natural disasters and the effect of trade on income. A new panel IV approach. In *European Economic Review* 58, pp. 18–30. DOI: 10.1016/j.euroecorev.2012.11.008.

Felbermayr, Gabriel; Gröschl, Jasmin (2014): Naturally negative. The growth effects of natural disasters. In *Journal of Development Economics* 111, pp. 92–106. DOI: 10.1016/j.jdeveco.2014.07.004.

Gassebner, Martin; Keck, Alexander; Teh, Robert (2010): Shaken, Not Stirred. The Impact of Disasters on International Trade. In *Review of International Economics* 18 (2), pp. 351–368. DOI: 10.1111/j.1467-9396.2010.00868.x.

Ghosh, Tilottama; Sutton, Paul; Powell, Rebecca; Anderson, Sharolyn; Elvidge, Christopher D.; Powell, Rebecca L. Powell L.; Sutton, Paul C. (2009): Estimation of Mexico's informal economy using DMSP nighttime lights data // Estimation of Mexico's Informal Economy and Remittances Using Nighttime Imagery. In *Remote Sensing* 1 (3), pp. 1–10. DOI: 10.3390/rs1030418.

IRIN (2005): Natural disasters – a heavy price to pay. Available online at http://www.irinnews.org/feature/2005/05/26-4, checked on 8/3/2016.

Jaramillo H., Christian R. (2009): Do Natural Disasters Have Long-Term Effects on Growth? In *SSRN Journal. DOI:* 10.2139/ssrn.1543453.

Jerven, Morten (2013): Comparability of GDP estimates in Sub-Saharan Africa. The effect of Revisions in Sources and Methods Since Structural Adjustment. In *Review of Income and Wealth* 59, pp. S16-S36. DOI: 10.1111/roiw.12006.

Kahn, Matthew E. (2005): The Death Toll from Natural Disasters. The Role of Income, Geography, and Institutions. In *Review of Economics and Statistics* 87 (2), pp. 271–284. DOI: 10.1162/0034653053970339.

Klomp, Jeroen (2016): Economic development and natural disasters. A satellite data analysis. In *Global Environmental Change* 36, pp. 67–88. DOI: 10.1016/j.gloenvcha.2015.11.001.

Klomp, Jeroen; Valckx, Kay (2014): Natural disasters and economic growth. A meta-analysis. In *Global Environmental Change* 26, pp. 183–195. DOI: 10.1016/j.gloenvcha.2014.02.006.

Loayza, Norman V.; Olaberría, Eduardo; Rigolini, Jamele; Christiaensen, Luc (2009): Natural Disasters and Growth. Going Beyond the Averages. In *Policy Research Working Paper* 4980.

Loayza, Norman V.; Olaberría, Eduardo; Rigolini, Jamele; Christiaensen, Luc (2012): Natural Disasters and Growth. Going Beyond the Averages. In *World Development* 40 (7), pp. 1317–1336. DOI: 10.1016/j.worlddev.2012.03.002.

Mel, Suresh de; McKenzie, David; Woodruff, Christopher (2012): Enterprise Recovery Following Natural Disasters. In *The Economic Journal* 122, pp. 64–91.

Noy, Ilan (2009): The macroeconomic consequences of disasters. In *Journal of Development Economics* 88, pp. 221–231.

Noy, Ilan; Nualsri, Aekkanush (2007): What do Exogenous Shocks Tell Us about Growth Theories? University of Hawaii, Manoa, Department of Economics.

Oh, Chang Hoon; Reuveny, Rafael (2010): Climatic natural disasters, political risk, and international trade. In *Global Environmental Change* 20 (2), pp. 243–254. DOI: 10.1016/j.gloenvcha.2009.11.005.

Okuyama, Yasuhide (2003): Economics of Natural Disasters: A Critical Review. In *Regional Research Institute, West Virginia University*.

Peter, Goetz von; Dahlen, Sebastian von; Saxena, Sweta C. (2012): Unmitigated Disasters? New Evidence on the Macroeconomic Cost of Natural Catastrophes. In *BIS Working Paper* (No. 394).

Raddatz, Claudio (2009): The Wrath Of God: Macroeconomic Costs Of Natural Disasters. DOI: 10.1596/1813-9450-5039.

Rasmussen, Tobias N. (2004): Macroeconomic Implications of Natural Disasters in the Caribbean Working Paper No. 04/224.

Skidmore, Mark; Toya, Hideki (2002): DO NATURAL DISASTERS PROMOTE LONG-RUN GROWTH? In *Economic Inquiry* 40 (4), pp. 664–687. DOI: 10.1093/ei/40.4.664.

Skoufias, Emmanuel (2003): Economic Crises and Natural Disasters. Coping Strategies and Policy Implications. In *World Development* 31 (7), pp. 1087–1102. DOI: 10.1016/S0305-750X(03)00069-X.

Solow, Robert M. (1956): A Contribution to the Theory of Economic Growth. In *The Quarterly Journal of Economics* 70 (1), p. 65. DOI: 10.2307/1884513.

Strobl, Eric (2009): THE MACROECONOMIC IMPACT OF NATURAL DISASTERS IN DEVELOPING COUNTRIES: EVIDENCE FROM HURRICANE STRIKES IN THE CENTRAL AMERICAN AND CARIBBEAN REGION.

Strobl, Eric (2011): The Economic Growth Impact of Hurricanes. Evidence from U.S. Coastal Counties. In *Review of Economics and Statistics* 93 (2), pp. 575–589. DOI: 10.1162/REST_a_00082.

Strömberg, David (2007): Natural Disasters, Economic Development, and Humanitarian Aid. In *The Journal of Economic Perspectives* 21 (3), pp. 199–222. Available online at http://www.jstor.org/stable/30033741, checked on 4/18/2016.

Swan, T. W. (1956): ECONOMIC GROWTH and CAPITAL ACCUMULATION. In *Economic Record* 32 (2), pp. 334–361. DOI: 10.1111/j.1475-4932.1956.tb00434.x.

Toya, Hideki; Skidmore, Mark (2007): Economic development and the impacts of natural disasters. In *Economics Letters* 94 (1), pp. 20–25. DOI: 10.1016/j.econlet.2006.06.020.

Yang, Dean (2008): Coping with Disaster. The Impact of Hurricanes on International Financial Flows, 1970-2002. In *The B.E. Journal of Economic Analysis & Policy* 8 (1). DOI: 10.2202/1935-1682.1903.

World Bank (2003): World Development Report 2003: Sustainable Development in a Dynamic World--Transforming Institutions, Growth, and Quality of Life. World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/5985 License: CC BY 3.0 IGO.