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Ilan Noy and William duPont IV

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Further enquiries to:

The Administrator  
School of Economics and Finance  
Victoria University of Wellington  
P O Box 600  
Wellington 6140  
New Zealand

Phone: +64 4 463 5353

Email: [alice.fong@vuw.ac.nz](mailto:alice.fong@vuw.ac.nz)

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# The Long-Term Consequences of Natural Disasters – A Summary of the Literature

Ilan Noy (Victoria University of Wellington)

William duPont IV (College of Saint Benedict | Saint John's University)

## Abstract:

The long-term economic impact of natural disasters is a subject that is highly debated among scholars. Several factors should be taken into consideration: These include the type and severity of natural disaster, the underlying wealth of the economy, and the total area of country impacted. Additionally, the way that researchers choose to define long-term impact, look at direct and indirect damage, and the availability of data also matters. Regardless of the method used there is still not a clear consensus concerning the long-term economic consequences of disasters. To discuss the long-term economic impact of natural disasters, one must first define impact. A common way to determine this impact is to compare the economy post disaster to the level it was at prior to the disaster. Some researchers argue that an economy has recovered when it returns to pre-disaster levels. This approach can be useful when comparing the impact in the short-term; however when analyzing the long-term impact it becomes problematic. Economies are constantly changing, and over long periods of time these changes will accumulate. Therefore one of the biggest challenges for researchers is to estimate what the level the economy would be at had the natural disaster not occurred. The way in which researchers go about doing this, can have a large impact on the results they find. Researchers have not reached consensus concerning the long-term consequences to natural disasters. Several authors have found very little to no impact, of natural disasters in the long-term, especially when using country level data. There have been some notable exceptions. Poor countries as well as small island nations have been found to be less resilient in the long-term. Studies using data collected at regional and local, have found a much more nuanced set of results regardless of wealth, income, or size.

Keywords: Economic impact, long-run, long-term growth, recovery, socio-economic

Contact details: ilan.noy@vuw.ac.nz

## **1. The Typology of Natural Disasters: Damages and Long-Run Losses from Disaster Events**

A natural disaster occurs when a natural hazard interacts with a population, causing harm to people and/or damaging property. Natural hazards come in many forms, but generally result from meteorological events (such as hurricanes and floods) or geological events (such as earthquakes and landslides). They can occur quickly and sometimes without warning, or they can occur slowly, over the span of days, weeks, months, or even years. By themselves, natural hazards are not disasters. A hurricane raging in the middle of the ocean that does not make landfall, and does not otherwise interact with humans, does not have a meaningful impact on society. Furthermore, a society's ability to cope with natural hazards is vitally important in determining whether a hazard turns into a disaster. If a river floods, but its waters do not breach any levees and consequently the flood harms no people or property, then society would not consider it to be a disaster.

A common typology of disaster impacts distinguishes between direct and indirect impacts. Direct damages are the damage to fixed assets and capital (including inventories), damages to raw materials, crops, and extractable natural resources, and of course mortality and morbidity (injuries and sickness) that are a direct consequence of the natural hazard (phenomenon). Indirect impacts—frequently termed 'losses'—refer to the economic activity, in particular the production of goods and services, that will not take place directly following the disaster, and in the long term because of the impacts of the disaster. These indirect losses may be of a first order—directly caused by the immediate impact, or of a higher-order—caused by impacts that were themselves caused by the direct effects of the hazard. Higher-order impacts, for example, can be caused because post-disaster reconstruction pulls resources away from the usual production practices, and thus damages suppliers. The loss of production that occurs because of these re-alignments of economic activities would constitute a higher-order loss (see figure 1).

Figure 1: Typology of Disaster Impacts



While damages are in theory easy to count, the losses can in principle also be accounted for, at least in the aggregate. This can be done by examining the overall performance of the economy, as measured through the most relevant macroeconomic variables such as the national income accounts (e.g., GDP), the fiscal accounts (e.g., tax revenue), and the balance of payments (e.g., the trade balance). Losses can also be examined at the microeconomic level, for households, firms, businesses, or local authorities.

The disaster losses, as they take shape during the reconstruction and recovery process, can also be further divided between the short-run (from a few months up to several years) and the long run (typically considered to be at least three to five years, but it can sometimes also be measured in decades). Here, we are concerned with understanding the long-term recovery of a country, a region, or even a household, from natural disasters. However, if we are to understand the long-term recovery, we need firstly to understand the economic dynamics that transpire during this recovery process, starting with the direct disaster damages themselves.

The conventional way to consider disaster risk is as a combination of three factors: (1) The **hazard** profile faced by the country or region: This hazard profile is largely a function of the geographical location, the geo-physical characteristics, and the climatic conditions faced by that region. This hazard profile can largely be viewed as pre-determined. (2) The **exposure** of population and assets to these hazards: Exposure is largely determined by the location of people and assets. So, for example, movement to urban centers, and especially to the more exposed areas in cities like steep hillside neighborhoods or ones in flood plains, will increase exposure. (3)

**Vulnerability** is the ability of the exposed population to withstand the hazard and reduce its social, economic, and personal impacts. One can further differentiate between vulnerability to the short-term impacts of an event, and to the event's long-term consequences.<sup>1</sup>

Risk is thus the combination of hazard events that endanger exposed communities, and societies that are vulnerable to these events. Risk is viewed as the intersection of hazard, exposure, and vulnerability. As policy has no immediate impact on the pattern of hazards, the focus of disaster risk reduction efforts, and of this paper, is on reducing exposure and vulnerability.<sup>2</sup> Before we examine the long-term recovery from disasters, we need to briefly survey our knowledge about the ways exposure and vulnerability are related to direct damages and short-term losses.

Since vulnerability plays a large role in determining the direct impact of a natural hazard, it comes as little surprise that high-income countries tend to suffer fewer fatalities from natural disasters than middle- and lower-income countries. Populations in rich societies possess more resources to protect themselves. However, since industrialized nations tend to possess more expensive assets - buildings and equipment - they tend to suffer from larger damages than the developing world. While these damages are typically larger in absolute terms for high-income countries, they are typically smaller relative to the size of the impacted economies. From a global perspective, much of the direct damage to assets occurs in high-income countries. But, overall, we see that low-income countries, because of their higher degrees of vulnerability and exposure, face much bigger direct impacts, and it is very likely that these bigger direct impacts will lead to larger losses in the short-term, and possibly also in the longer-term.

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<sup>1</sup> Crichton (1999) provides an explanation of this 'risk triangle.' In many cases, vulnerability is defined as the opposite of resilience, though there is a lively debate about the definition of these terms.

<sup>2</sup> We use the term 'disaster risk reduction' (DRR) broadly as referring to any action that aims to reduce or improve the management of disaster risk. Some distinguish between DRR and disaster risk management or disaster risk mitigation (DRM). We follow the practice adopted by UNISDR and in the United Nations' international agreement signed in March 2015: the *Sendai Framework for Disaster Risk Reduction 2015-2030*, and use these terms interchangeably.

This inequality of impacts is not limited to comparisons between nations, but can be observed within nations as well. One of the ways this is most evident is by examining the rural-urban divide. Wealth is not spread evenly within countries, and it tends to be more heavily concentrated in and around cities. With limited resources, countries are generally faced with having to decide which areas to protect and with how many resources. Since cities have a much greater concentration of both people and property, resources tend to be allocated towards protecting cities, sometimes at the expense of the surrounding rural areas. For example, levees can be put in place to protect a city, yet the water still needs an outlet somewhere.

Cities, however, are not necessarily safer than the countryside. Urban areas, where both people and property are tightly packed, face much higher exposure. So, even if they are less vulnerable, the disasters resulting from hazard events can still be large. Urban areas which are unable or unwilling to use the resources necessary to protect from natural hazards can create areas within cities that are more vulnerable. Since these places are riskier, they are typically cheaper and end up attracting politically and economically marginalized groups. These dynamics further exacerbate this inequality in vulnerability (Gaillard and Cadag, 2009).

These inequalities indeed seem to be exacerbated when we consider the indirect losses, both in the short-term, and during the longer-term recovery process – on which there is a lot less research. For example, the disadvantages experienced by marginalized groups are not limited to just the moment of occurrence of the disaster (given their heightened degree of vulnerability), but can be seen during recovery as well. Schultz and Elliott (2013), among others, find that the median income in many affected areas increased, while incomes among those in poverty remained unchanged - see Karim and Noy (2016) for a survey of the literature on disasters and poverty.

Besides the degree of vulnerability to direct impacts, the ability of countries, regions, cities, or even households to bounce back and recover from disasters also differs. In the short-term, the ability of the economy to return to grow at its previous trajectory is largely dependent on its ability to access resources for reconstruction; Klomp and Valckx (2014) and Lazzaroni and van Bergeijk, (2014) provide surveys of this short-run literature. These resources

can be obtained from existing financial and other wealth, from borrowing, from insurance payments, or from current savings.

The ways in which these available resources shape the proximate and short-run losses are quite complex. For example, insurance can finance recovery, but the presence of insurance arrangements can also lead to moral hazard dynamics in which insured property owners are less likely to invest in preventing damages to their insured properties. Michel-Kerjan (2010) provides a survey of the potential pitfalls of an insurance program, while Poontirakul et al. (2016) examines the potential adverse impact of insurance arrangements in a specific case. On the positive side, Sawada (2012) finds that insurance played a significant constructive role in the recovery of Yamakoshi village in the wake of a 2004 earthquake in Japan. Even if we conclude that insurance is beneficial and available (and the evidence on this is not yet that robust), our earlier discussion of the diversity of outcomes across income groups still applies. It is often the case that poor and marginalized groups are not able to afford comprehensive insurance, and their recovery may therefore lag (Kousky and Cooke, 2012).

Another way to cope with natural disasters is to self-insure against adverse shocks (what is often referred to as precautionary savings). While precautionary saving does little to prevent a disaster, it can provide the resources required to facilitate the recovery process. The evidence, however, suggests that there is typically less precautionary savings than is required. Sawada (2012), for example, notes that households typically underestimate the likelihood as well as the impact of a natural disaster, and are therefore unlikely to save enough to truly cope with it. He also finds that precautionary savings in the wake of the Kobe Earthquake of 1995 were only able to handle smaller replacement purchases and did not represent nearly enough to pay for damaged housing. Furthermore, precautionary savings further exacerbate the inequality of outcomes, as they are ultimately only available to those who can afford to save.

A common way for governments to handle disasters, especially with populations which are not insured or do not have sufficient precautionary savings, is for them to provide direct transfers to those who are affected by the disaster. This acts as *de facto* insurance, as it pays for the reconstruction. It also generates the same moral hazard problem (sometimes referred to



as ‘charity hazard’) as standard insurance. If the population expects the government to pay for the reconstruction, this reduces the incentives for individuals to pre-emptively protect themselves. This can become more and more apparent if the government continually pursues this policy in the wake of disasters (Sawada, 2012). Yet there are ways that the government can mitigate this issue and still take an active role in funding recovery.<sup>3</sup>

Access to credit also plays a role in the wake of a natural disaster, both contributing to the recovery process and potentially building resilience within communities. Sawada and Shimizutani (2008), for example, document how households that are not credit constrained can finance their consumption and investment, and maintain appropriate welfare in the aftermath of the 1995 Kobe earthquake, while households that cannot access credit experience welfare-reducing declines in consumption. McDermott (2012) describes how credit can assist in building resilience. He finds that access to credit enables household to maintain their educational plans, and continue with their acquisition of human capital. Lack of credit is therefore especially limiting the ability of marginalized groups to recover in the long-term as their access to credit is typically constrained. Access to credit and financial credit is also important for businesses in affected communities. De Mel et al. (2011) finds that a business’s access to capital influenced their ability to keep operating in the wake of a natural disaster.

The social and political institutions of the location where a natural disaster strikes are also important. Rodrik (1999) finds that the impact of external shocks (such as natural disasters) intensifies when an area is suffering from social conflict or weak governmental institutions. Neither of these extreme circumstances needs to be present in order for social and political structures to matter. Aldrich (2011) focuses on the aftermath of the 1995 Kobe earthquake, a location that suffered from neither circumstance. He finds that the amount of social capital (such as the strength of social networks) plays an important role in a community’s ability to recover from a disaster. In further work, he generalizes and argues that the more social capital a location possesses, the better able it is to cope with a disaster, and that

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<sup>3</sup> Useem et al (2015) provide a discussion of government considerations in the aftermath of the 2010 Bio-Bio earthquake in Chile.

government policies that effectively (and unintentionally) break communities apart inhibit that recovery process (Aldrich, 2012).

## **2. Identifying the Long-Run Impact of Disasters**

The indirect losses associated with disasters occur as a consequence of these events, but cannot be directly attributed to their physical impact. These include emergency costs (such as for first responders), business interruptions (such as supply chain disruptions), macroeconomic feedbacks, falls in demand, consequences for economic growth, consequences for health (such as psychological trauma), social and community network disruptions, impacts on poverty, and impacts on security and stability (Hallegatte, 2014). Additionally, indirect losses to households also include a loss of savings and/or household income, and a loss of the time required to cope with the aftermath of the disaster (Cavallo and Noy, 2011). Somewhat counter-intuitively, indirect losses can also generate benefits. For example, a demand surge for construction services or goods often leads to a boom in these sectors in the aftermath of a disaster. In any case, indirect losses can have long-term and far-reaching consequences, and therefore they are dynamics that should be considered especially important in post-disaster analysis and policy formulation.

The simplest way to look at the impact of a natural disaster is to compare economic variables directly to their pre-disaster levels. This can be a valid approach in the short-run. Horwich (2000) compares pre- and post-disaster data in the case of the 1995 Kobe earthquake, and finds that basic economic indicators had returned to pre-disaster levels within 2 years. Economies, however, are not normally stagnant over long periods and are not expected to continue in their pre-event trajectories. In order to identify the long-run consequences of natural disasters, researchers must predict what the affected region would have been like had the disaster not occurred. In other words, researchers must develop a counterfactual that includes these long-term dynamics.

One way to deal with this particular issue is to focus on the damages themselves and attempt to measure how long they propagate through the economy. While direct damage is

measurable by calculating reconstruction and replacement costs, indirect losses require statistical estimation. One approach that has been used relies on input-output tables (the IO approach). The IO method focuses on the supply-side of the economy. It acknowledges that production typically requires multiple inputs (both primary and intermediate). When these inputs become constrained in some manner, this affects the ability of producers to meet demand. As such, if the disaster leads to bottlenecks and reduced availability of inputs, the implications of that for the supply of outputs can be measured. This approach can be particularly useful if one would like to measure the effect of a supply shock on particular industries and sectors within an economy (Oosterhaven, 1988).<sup>4</sup>

The main strength of the IO approach is in that it enables the analyst to differentiate and quantify impacts in different sectors, through diverse channels of causality, and across regions, though the data required to accomplish that fully is quite extensive (Okuyama, 2004). One of the main concerns with the IO approach is that it does not account for possible substitution of inputs, either because some inputs are no longer available, or because of price changes. One of the core assumptions of the IO model is that the any affected input will propagate its scarcity throughout the entire economy, through all the goods for whose production it is used. This may be true to some degree in the very short-run, but eventually, and often quite quickly, companies will be able to find alternative suppliers or inputs from unaffected areas to be able to meet their production needs (Hallegatte, 2008 and 2014). This implies that the longer the time horizon the researcher is interested in, the more likely it is that the IO model will overestimate the disaster losses. Okuyama (2004) offers a critical analysis of the static IO model within the context of post-disaster analysis, and describes the sequential inter-industry model (SIM) that adds a limited dynamic dimension to the IO approach.

A different approach, one that does not require the full input-output tables as in the IO approach, is the computable general equilibrium (CGE) approach. In CGE modeling, the researchers need to model that exact ways in which inputs and output markets interact and in

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<sup>4</sup> Cochrane (2004) includes a very brief discussion of the various ways to estimate losses, and some analysis of attempts to measure them in one specific instance, the Twin Towers terrorist attack of 9/11/2001.

which prices and quantities adjust. Given the complexity of these interactions, CGE modeling can typically focus on fewer sectors than IO analysis can, but the CGE method can model the optimization response of individuals and firms to bottlenecks and supply constraints, and to general changes in market conditions caused by the examined event (Rose and Liao, 2005). As such, CGE modeling uses more assumptions about the functioning of markets than the IO approach, but generally requires less data. Both approaches, to a large extent, still assume 'business-as-usual' and thus cannot really be useful in measuring longer-term impacts when this assumption is unlikely to continue to apply.

Given the shortcomings of both IO and CGE, the most common ways of taking longer-term impacts into account rely on statistical tools used to construct counterfactuals and thus estimate longer terms deviations from them. The easiest way to create a counterfactual is to establish a trend line, and then check to see how the economy deviated from this trend in the aftermath of the disaster.

The standard theory behind this approach comes from Solow (1956), who predicts that countries should travel on some steady-state growth path. Within this framework, a natural disaster would represent a negative capital shock. The model predicts, following this shock, that the economy will rebuild and see accelerated growth until it returns to its previous growth path. Thus, it predicts that in the long-run there should be no impact from the natural disaster. Over the years, there have been many challenges and expansions to the Solow Model. For example, Barro (1991) finds that the levels of human capital, political instability, and price distortions also influence long-run growth. Ultimately, these models serve as a reasonable theoretical basis to check whether an impacted area returns to trend, as well as how long it takes.

The most common approach employed in assessing the impact of any negative shock (such as a natural disaster) is to use statistical-econometric techniques to check whether or not a country has returned to its trend line. The most common example of this would be to use some form of difference-in-difference estimation (see Cerra and Saxena, 2007, Belasen and Polachek, 2009, and Husby et al., 2014). This diff-in-diff approach is sometimes complemented

by other methods, to account for various statistical biases; for example, the propensity score matching as used in Deryugina et al. (2014). Interpretations of results are often also based on the foundation of the Solow model; Cerra and Saxena (2008), for instance, find that countries that faced several negative shocks did not converge back to trend, as each shock pushed them further and further away.

An alternative approach focuses more on the process of formation of capital and knowledge. This approach allows us to conceive of situations in which the disaster's impact is eventually positive (i.e., beneficial). This is usually termed 'creative destruction.' The concept of creative destruction revolves around the idea that when the natural disaster destroys buildings, infrastructure and other related capital goods used in production, they are replaced by newer, more productive items that might, in the long-run, allow more productive use of available resources, and thus higher income. Okuyama (2003) discusses the possibility of technological innovation speeding up during the reconstruction phase, ultimately leaving an economy at a higher steady state path in the long-run. This theory, however, is not without its detractors and is not easily supported by the available evidence. Hallegatte and Dumas (2008) embed this possibility in a theoretical model, but find that an increase in technological innovation will not lead to this improved outcome. In theory, positive long-term impact can occur not only from technological innovation but also from 'build-back-better' policies that allow for improved reconstruction (maybe through better planning). However, as Hallegatte and Dumas (2008) note, this approach entails taking time during the reconstruction phase to work out a better plan. They caution that this may deepen the short-run impact of the disaster and can increase the chance that the short-run adverse effects can turn into longer-run difficulties as individuals fall into poverty traps and firms and businesses are unable to operate optimally.

Another approach has been to compare the affected city/province/state/country with one or more regions that are deemed similar to it but were not affected by the disaster. One version of this approach is matching. Xiao (2011) uses pair-wise matching at the US county level to determine the impact of the severe Midwest floods of 1993. Likewise, De Mel et al. (2011) compare businesses in Sri Lanka in the wake of the 2004 Indian Ocean Tsunami. Instead of matching that is ad-hoc or relies on one dimensional comparison (geographical location,

income, etc.) some papers devise matching algorithms based on statistical procedures. Fujiki and Hsiao (2015) develop such a method, one that relies on a weighted average of other regions, and on back-casting of post-reconstruction data, to construct counterfactuals and account for post-disaster trend changes, in their examination of the impact of the 1995 Kobe earthquake. An alternative method, synthetic control – in which a maximization algorithm guides the choice of observations used to construct the counterfactual – has been employed in several papers to examine several case studies (Barone and Mocetti, 2014, Cavallo et al., 2013, Coffman and Noy, 2012, duPont and Noy, 2015, and duPont et al., 2015).

A different approach to identifying the counterfactual is taken by Hochrainer-Stigler (2015), who creates counterfactuals for many disasters using time-series models and then attempts to explain the deviations between the counterfactual and the actual using measures of human, social and physical capital while accounting for hazard, exposure, and vulnerability.

### **3. Long-Term Impact: Arguments for no effect**

The long-term consequences of natural disasters can fall into four categories: no long-term impact, positive impact, negative impact, or mixed impact (where different aggregates are impacted differently). The traditional (neo-classical) view when it comes to the long-run impact of natural disasters is that there should be little to no effect; that the economy eventually converges back to its long-run equilibrium. This view can be traced back at least to the writings of Adam Smith (who wrote on floods in Switzerland). There is also a fair amount of empirical evidence in support of this case, especially at the national level.

The strongest support for this ‘no long-term impact’ view comes from papers focusing on data at the national level. Jaramillo (2009) finds that in the majority of cases, disasters have had no effect that has lasted more than 5 years. Cavallo et al. (2013) finds that there are no significant long-run impacts associated with natural disasters, both moderate and catastrophic, at the national level. Their results extend to 10 years beyond the disasters they study. They do identify a few cases, however, when the disaster may have led to institutional changes that did

cause dramatic long-term effects.<sup>5</sup> Even papers that do find that there are some effects in either direction tend to find that these effects are weak, or are focused in a sub-set of developing (lower-income) countries. Loayza et al. (2012), finds that developing nations are much more susceptible to natural disasters than industrialized nations (within a horizon of five years).

At the local and regional level, there is more disagreement about the claim that disasters have no long-term economic impacts. Brata et al. (2014) has found that the population of Northern Sumatra was able to completely recover in the wake of the Indian Ocean Tsunami and Xiao and Feser (2014) find that there appeared to be no longer-term local economic impact of the 1993 Midwest flood. Yet, even in this case, in a high-income country, Xiao (2011) finds that there were significant negative impacts on agriculture in some of the affected communities. More strikingly, even for a specific case - the 1995 Kobe earthquake, there is no agreement. Fujiki and Hsiao (2015) find a fall in incomes per capita in the affected prefecture that they attribute to structural change that is unrelated to the earthquake, but duPont and Noy (2015) argue that a comparison against a counterfactual that controls for these structural changes suggest that the fall in incomes is a direct consequence of the earthquake.

#### **4. Long-Term Impact: Arguments for Creative Destruction**

Some view the destruction wrought by disasters as an opportunity to pursue progressive change that can improve the economic outlook of the affected area. The most likely channel for this would be the ability to rebuild better infrastructure (transportation, communication, lifelines, etc.) after the old infrastructure is destroyed. This better infrastructure can thus lead to increases in productivity. The creative destruction argument is an optimistic one; that locations can be built-back-better in the long run.

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<sup>5</sup> Their proto-typical example is the earthquake in Iran in 1978 that was followed-up, less than a year later, by the Islamic revolution. At the time, many analysts pointed to the role the earthquake played in the rise to power of the revolutionaries.

There is some theoretical investigation of this creative destruction and the conditions that may make it likely (see Okuyama, 2003, Hallegatte and Dumas, 2008). A few papers find evidence in support of the creative destruction scenario, but these findings are typically nuanced, and the possible long-run positive effects appear to be limited only to fairly moderate natural disasters in higher-income countries or regions.

Skidmore and Toya (2002) are atypical in arguing that they identify long-run increase in human capital acquisition and total factor productivity in countries hit by frequent disasters. In their conclusions, countries do appear to grow more if face higher disaster risk, but this growth is mainly associated with climatic disasters, and not with geological ones. Loayza et al. (2012) find that developing countries are the most sensitive to natural disasters and that moderate floods can have positive effects, while severe ones typically do not. Fomby et al. (2013) also finds that floods (and only floods) have a positive effect on developing nations.

Other potential variables that can be examined for change, in the place of incomes (or GDP) are other aggregates that proxy for the wellbeing of the economy, like demographic measures. Husby et al. (2014) find that there was an increase in population in the areas affected by the North Sea Flood in 1953 in the Netherlands. They attribute this impact mainly to the actions taken by the government (in the form of supporting increased disaster resilience) that led people to migrate to what were traditionally perceived as riskier areas.<sup>6</sup> Similarly, Boustan et al. (2012), focusing on disasters in the U.S. during the early 20<sup>th</sup> century, find that there was an inward migration to areas susceptible to floods. As in the Dutch case, they suspect this was due to work done by the Army Corps of Engineers to protect against future flooding. Schultz and Elliott (2013) also look at disasters in the United States, and find that population increased in the long run; they also suggest that government programs were responsible for this effect.

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<sup>6</sup> The authors don't necessarily see this as a positive effect, as this movement of people to riskier areas builds up future exposure and future disaster risk. As most other papers interpret a decline in population as a negative effect and an increase in population as a positive effect, we decided to include this paper in the creative destruction section.



At the local level there is also some support for creative destruction scenarios. Hornbeck and Keniston (2014) find that there were long-run positive effects associated with the Great Boston Fire of 1872. They argue that neighborhood externalities were the main drivers of these positive impacts, stating that simultaneous construction led to higher building quality. Similarly, Hornbeck and Naidu (2014) find that the Great Mississippi Flood of 1927 led to a modernization of agriculture in the area, due in part to an outward migration of the black population. In their interpretation, it was the shortage of available labor that drove farmers to adopt new technologies; areas in which there was no labor shortage as a consequence of this flood-driven emigration had weaker incentives to adopt new productivity-enhancing technologies.

Schultz and Elliott (2013) describe scenarios in which there were increases in population in areas in the U.S. impacted by disasters, and associated increases in the median income. However, they suggest that those who tended to benefit were at the top of the income distribution, and that the poor did not, to a large extent, experience these beneficial dynamics. Deryugina et al. (2014) find that individuals impacted by Hurricane Katrina, who emigrated elsewhere as a consequence of the flooding of New Orleans, had more than recovered their incomes within 5 years of the storm. However, they also note that many of the households displaced by the storm opted not to return, so that while households benefited, the impacted region did not.

The support for creative destruction appears to be limited to moderate natural disasters, and especially floods. The evidence also suggests that the increase is, for the most part, not due to technological innovation, but rather post-disaster governmental policies put in place to increase local resilience. There is also evidence that even when we observe a more than full recovery at the macro level, it is households with more income that are best able to withstand the disaster and benefit from its long-run aftermath.

## **5. Long-Term Impact: A lack of recovery.**

We find increasingly robust evidence that there can be significant negative effects associated with natural disasters. In particular, very poor countries, very small countries, and regional economies can experience prolonged difficulties in the wake of severe natural disasters. These adverse developments can take several forms.

While natural disasters generally do not have any impact at the national level, there are a few cases worth noting. Some studies have found, on average, small persistent negative effects on GDP (Hochrainer, 2009, Raddatz, 2009). An outlier in this literature is Hsiang and Jina (2014). They find very large and long-lasting negative effect on incomes (GDP) associated with the occurrence of tropical cyclones.

Households in developing countries are particularly susceptible to natural disasters, even if the aggregate data at the national level does not show much long-term impact. Hallegatte and Dumas (2008) caution that it is possible for poor households in developing countries to fall into a poverty trap, leading to a permanent decline in incomes. Carter et al. (2007) find evidence that this occurred in the wake of cyclones in Honduras and droughts in Ethiopia.

Potentially, natural disasters can also have a more long-lasting negative impact, through their impact on education and health. McDermott (2012) finds that human capital can be negatively affected, especially when there is limited access to good credit. Cas et al. (2014) reach a similar conclusion while studying the impact on children who lost parents in the 2004 Indian Ocean Tsunami. They find that older children who suffered this loss subsequently completed fewer years of schooling, though younger children were not as adversely affected. They speculate that older children have to assume parental roles, which then disrupts their schooling, while younger children do not have to. With less education, the long-term ability of these affected children to earn income is diminished and we expect to observe other permanent negative impacts that measure wellbeing. Most troubling are the findings of Caruso and Miller (2015). They find that education acquisition (years of schooling completed) is diminished for kids who were even in-utero during the catastrophic Peruvian earthquake they examine. This negative impact on educational attainment persists into the second generation,

so that the children of mothers who were affected while in-utero also experience lower achievement.

It is well documented that the most vulnerable countries are small island developing states (SIDS). Pelling and Uitto (2001) identify this increased vulnerability as a result of the small size, lack of diversification, insularity, remoteness, large exposed coastal zones where most of the population resides, and limited resources of these states. These factors not only lead to higher damages, but also impede the ability of the state to recover in the long-term. There is little empirical evidence to support this view, as there are no research projects focusing on long-term trajectories in SIDS. By far the most catastrophic disaster of recent times occurred in one of the SIDS, Haiti, in 2010. This disaster is indeed likely to cause long-term harm to the prospects of the Haitian economy, though the current evidence only focuses on the very short-term impact of the event (Cavallo et al., 2010).

As researchers begin to focus on regional economies within countries, they have begun to find evidence of permanent effects. In particular, they have found evidence of permanent population movements, declines in income and asset prices, and apparent permanent shifts in sectors of economic activity. Many of these effects are absent from the country level data, since these movements are contained within the countries themselves.

Just as some papers have documented migrations into areas in the wake of floods, other papers have identified migrations out of areas due to other, typically more severe, natural disasters (e.g., Coffman and Noy, 2012). Smith and McCarty (1996) find that of the 353,000 individuals forced to leave their homes due to Hurricane Andrew, 11% did not return. Boustan et al. (2012) notice not only the inward migration due to floods throughout areas within the early twentieth century United States, but also identify outward migration in areas that were affected by more destructive tornados. Large migrations have occurred in more recent times as well. In some locations, only select members of households migrate away from the affected areas, rather than households *en masse*. Gröger and Zylberberg (2015) find that rural households in Vietnam cope with disasters by sending family members into urban areas, as does Halliday (2012) for the case of El Salvador after an earthquake.

Hurricane Katrina has had a particularly large and enduring impact on the local population of New Orleans. Deryugina et al. (2014) find that over one-fourth of households were displaced by the hurricane, and that five years later most have remained dispersed. There have also been studies that focus on the motivations of displaced residents to return (Landry et al., 2007, Groen and Polivka, 2010). They find that income plays a significant role in households' decisions as to whether or not to return, with higher-income households more likely to move back to New Orleans. They also find that proxies for 'connection to place' played little role in determining who returned after the disaster. In particular, Groen and Polivka (2010) find that the black population was less likely to return than other ethnic groups, though they attribute this to the higher damages in traditionally black areas of the city. The impact of Katrina was not limited to demographic quantities; many local businesses were impacted and did not recover (Basker and Miranda, 2014). Though Katrina is well studied, these results are not limited to this specific hurricane. Strobl (2009) reports findings of general, though small, long-term adverse economic growth impacts affecting U.S. coastal regions due to hurricanes.

There is also evidence that natural disasters can significantly impact household income. duPont and Noy (2015) find that the GDP per capita for Hyogo prefecture in the wake of the 1995 Kobe earthquake was 12% lower than it would have been had the earthquake not occurred.<sup>7</sup> Ohtake et al. (2012) also find that job placements for part time workers fell in the long-run in the quake-hit city. duPont et al. (2015) provide a more nuanced mapping of these adverse impacts, and note both towns and city wards within the Greater Kobe area that seem to have 'lost' or 'gained' both population and incomes in the long-term aftermath of the earthquake.

In addition to the loss of population and income, another piece of evidence of long-term declines in the economic fortune of an affected region can be found in a decline in the price of land. Hornbeck (2012) studies the effects of the 1930s American Dust Bowl on local counties. He finds that the environmental damage that was caused by large-scale soil erosion in the Great

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<sup>7</sup> Fujiki and Hsiao (2015) also found a similar drop in GDP per capita (8%), though they attribute it to structural change in the years after the earthquake and not to the earthquake itself.

Plains led to persistent economic effects: not only did the Dust Bowl lead to a mass displacement of people, but it also caused the value of farmland to permanently decline by 30% in high-erosion counties compared to low erosion counties, even though the soil quality recovered within a much shorter time period. This decline also led to decreased access to credit and to a decline in the number of banks in these affected counties. Given the importance of finance in growth, it may not be surprising that these effects lasted for half a century or more.

duPont et al. (2015) also note that the overall decline in economic fortunes of Kobe City after its 1995 earthquake was also associated with a shift from manufacturing to services that is directly attributable to the earthquake (when compared to other regions in Japan experiencing similar external pressures, but no earthquake). Cole et al. (2014) follow up with an examination of specific plants and production facilities in Kobe City, and note that heavily damaged plants were significantly less likely to resume operations in the long-term (7, years in their framework).

## **6. Conclusion**

There is still significant disagreement about the long-term consequences of natural disasters. This disagreement most likely arises because post-disaster experiences are different in different cases, and are probably affected by the nature of hazard, the nature of exposure and vulnerability, and by post-disaster policy decisions at the levels of the households, the local authorities, national governments, and maybe even the international community's ability and willingness to assist in recovery. Several case studies document long-term declines in the economic fortunes of areas that experience catastrophic events. Since the present value of these long-term declining trajectories is very large, this risk should be factored into disaster risk management decisions both in terms of prevention and mitigation, and during the recovery process. Once these long-term declines are taken into account, the cost-benefit calculations of many disaster risk reduction policies suggest that many more potential actions should be undertaken to reduce and mitigate risk, and more efforts need to be expanded after an event,

to make sure that, for example, that the declines observed in Kobe do not repeat in the Tohoku region affected by the 2011 earthquake-tsunami-nuclear disaster.

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