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Informing climate adaptation: A review of the economic costs of natural disasters

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ABSTRACT

This paper reviews the empirical literature on the economic impacts of natural disasters to inform both the modeling of potential future climate damages and climate adaptation policy related to extreme events. It covers papers that estimate the short- and/or long-run economic impacts of weather-related extreme events as well as studies identifying the determinants of the magnitude of those damages (including fatalities). The paper also reviews the small number of empirical papers on the potential extent of adaptation in response to changing extreme events.

1. Introduction

A growing consensus in the scientific community holds that climate change could be worsening certain natural disasters. The Intergovernmental Panel on Climate Change (IPCC) released a special report in early 2012, which notes that climate change could be altering the frequency, intensity, spatial extent, duration, and/or timing of many weather-related extreme events (IPCC, 2012). Even nonexperts are perceiving a trend toward more or worse extreme events: a 2012 poll of US residents found that, by a margin of 2:1, people believe that the weather is getting worse, and a large majority believe that climate change contributed to the severity of several recent natural disasters (Leiserowitz et al., 2012).

This paper reviews what we know about the economic impacts of natural disasters to inform both the estimation of potential climate damages using integrated assessment models and the potential extent of climate adaptation to extreme events. The paper limits focus to empirical estimates of the economic costs of natural disasters and findings on the determinants of economic damages and fatalities. The paper then also provides an overview of the handful of empirical papers to date on the likely extent of adaptation in response to changes in extreme events. Given the focus on informing climate scholarship and policy, the paper looks specifically at hydrometeorological (or weather-related) disasters and not geophysical disasters, since confidence in the impact of climate change on hydrometeorological events is greater.[1] The review is focused on the empirical literature; it does not cover the theoretical literature on the economic impacts of disasters or simulation- and modeling-based studies. The focus of this review is also limited to economic impacts. While natural disasters can have profound social and political impacts (e.g., Lindell and Prater, 2003), those are not covered here.[2] Finally, as a further limit to the scope, this review is largely focused on literature published within the past couple of decades, a period during which new data sets and improved understanding of disaster losses has emerged. Recent working papers are included, in addition to peer-reviewed studies.

Estimating the full range of economic costs from natural disasters is difficult—both conceptually and practically. Complete and systematic data on disaster impacts are lacking, and most data sets are underestimates of all losses. Best estimates for the average annual cost of natural

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[1] There are some papers that group all natural hazards together, and those papers are included in this review.

[2] This paper also does not cover the public health literature examining health outcomes after a disaster or engineering studies, although reviews of both these areas would be useful complements to this review.

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disasters worldwide between 2000 and 2012 ranges between $94 billion and a little over $130 billion (see Section 3). The work reviewed here suggests negative consequences of disasters, although communities tend to have a lot of resilience, recovering in the short- to medium-term from all but the most devastating events. The worst disasters, or multiple disasters close in time, can have very long-term, negative economic consequences. Natural disasters generate many transfers and can have substantial distributional consequences, with some groups suffering devastating losses and others coming out ahead, even if overall impacts are close to neutral. Consequences are less severe in higher-income countries, countries with better institutions, and those with a higher level of education. Risk reduction options are available, but predicting increases in adoption in response to climate change is difficult. The occurrence of a disaster has been shown in some cases to increase investments in reducing risks. In addition, some evidence suggests that areas more prone to hazards invest more in reducing their impacts, providing some limited insight on potential future adaptation. Recent research is attempting to move beyond correlations, particularly by addressing the endogeneity of many disaster measures, and more work on this is needed.

The next section of the paper discusses the difficulties with obtaining empirical estimates of the total economic costs of natural disasters and summarizes the approaches taken in the literature. Section 3 provides an overview of annual disaster costs worldwide and trends over time. Section 4 is the heart of the paper summarizing the work on the economic impacts of weather-related disaster events in the short and long run. Section 5 then briefly discusses the question of whether and when natural disasters can have positive impacts. Section 6 reviews the work on the determinants of both disaster fatalities and damages. Section 7 provides a short overview of potential adaptation to changes in extreme events. Section 8 offers a brief comment on future research directions suggested by this review. Section 9 concludes.

2. An overview of the issues

The theoretically correct measure of economic impacts from a natural disaster is the change in welfare that occurred as a result of the event. Welfare can be evaluated ex post, as the compensation required to avoid loss, or ex ante, which accounts for uncertainty (Rose, 2012). Although thinking in terms of hypothetical welfare measures can be instructive, a complete welfare analysis is usually quite difficult empirically and would require making a number of assumptions and simplifications in the analysis.[3] If society were risk-neutral, ex ante welfare could be evaluated with the expected economic loss (Rose, 2012). Scholars interested in empirical estimates (as opposed to modeling results, which can be useful in estimating welfare calculations) have attempted to measure observable disaster damages and follow-on economic impacts as a rough approximation of the net economic costs of a disaster.

Various lists and typologies of disaster impacts have been created. Most scholars of disasters have broadly classified disaster impacts into direct and indirect impacts. Direct impacts refer to the physical destruction from a disaster, and indirect impacts (some authors prefer the term higher-order impacts) are considered to be the follow-on consequences of that destruction (National Research Council, 1999). Note that although it is convenient to speak in the shorthand of losses, costs, or damages from a disaster, in practice, this review—like the work it summarizes—focuses on the net impact of disasters (ECLAC, 2003). Section 5 investigates the question of whether and when disasters can have a positive economic impact.

Table 1 presents a categorization of direct and indirect disaster impacts.[4] Direct impacts include damages to homes and contents, which can include nonmarket items like family heirlooms or old photographs. Firms may also sustain damage, including damage to buildings, contents, and other productive capital. This category also includes damage to the agriculture sector, such as damage to crops, livestock, or farm equipment. If production is interrupted from physical damage, this is also a direct cost. Infrastructure like roads and bridges can sustain direct damage. People can be killed or injured directly by the disaster. The disaster could also cause environmental degradation of various sorts—both market and nonmarket damages. Finally, I include as direct damages the costs of emergency response, such as evacuation and rescue, and clean-up costs, such as clearing debris from streets.

Indirect losses include business interruption costs to those businesses that did not sustain direct damage but may not be able to operate because, for example, their supplier was damaged, their workers evacuated, or they lost power. It also includes the multiplier effects from reductions in demand or supply (more on these below). In addition to causing business interruption, loss of infrastructure or other lifelines (e.g., power, sewage, or water) can lead to utility loss to households in terms of a diminished quality of life or could cause both households and businesses to adopt costly measures (such as increased commuting time as a result of damaged roads or the extra costs of running a private generator when the electricity is out). There could also be mortality and injury or environmental degradation, not from the impact of the hazard, but from follow-on impacts. For example, if dirtier generators are run due to power outages, the air pollution from those would be an indirect impact.

In theory, it should be possible to sum up all direct and indirect losses to generate a measure of the total economic costs of a disaster. Two overarching complications arise when trying to measure the full economic costs in each of the categories in Table 1.[5] First, it is necessary to be very clear about the spatial and temporal scale being examined because different boundaries for analysis can generate different results. For example, consider the economic costs of a disaster from the point of view of a homeowner who lost her home. Some direct losses, such as the home, are reimbursed by insurance or aid from government or other groups, and some losses are borne fully by the victims. If the individual receives aid, the economic cost of the disaster to that person will be the value of the lost home minus the amount of the aid. From the perspective of society, however, the aid is just a transfer from one taxpayer to another and thus should not be added or subtracted from the damage.

Temporal boundaries can also matter. As an example, it has been shown (see below) that construction sectors can experience a boom right after a disaster as people rebuild. A couple of years afterward, however, they may face a lull because people undertake upgrades during the post-disaster reconstruction that they would have otherwise deferred. Looking only one year post-disaster may suggest a benefit to the construction sector, but looking over three years might diminish this benefit. And although the construction sector may get a benefit, had the disaster not occurred, the funds spent on rebuilding would have been spent elsewhere in the economy, with a higher utility to the homeowner; thus, post-disaster spending should not simply be counted as a benefit of the disaster.

[3] Limited welfare analyses have been done, such as Garcia Valinas (2006), which estimated the welfare impact of water rationing policies due to a drought.

[4] Adam Rose has suggested drawing a distinction between stock and flow losses. Business interruption to damaged firms would be a direct flow loss and property damage would be a direct stock loss. Indirect flow losses would be general equilibrium effects. This is a more useful distinction when examining impacts to firms or running input-output or computable general equilibrium models, two methods common to this field but not covered in this review. Some categories of losses, however, such as emergency response spending or reductions in utility from losing power or having to evacuate, however, do not fall as neatly into stock or flow categories (see: National Research Council (2011)).

[5] For a discussion of related issues specific to drought, see: Ding et al. (2011).

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