Project Narrative:
A Global-Scale Investigation of Firm-level Economic Recovery from Natural Disasters

This project proposes a novel combination of economic and earth science data and methods to understand the mechanisms through which natural disasters can affect national economies around the world. Despite recent progress in demonstrating that these long-term economic effects exist, research has yet to fully identify the mechanisms that lead to them. A major challenge has been the lack of cross-disciplinary engagement between economics and the the physical sciences that aims to understand and model disasters. Economic theory suggests that if disasters cause long-term economic damage rather just a one-time shock to capital, then they must be affecting investment behavior in the economy. This project therefore investigates disaster effects at the firm-level, which is the driver of economic growth and investment within a country. Using extensive firm-level data from dozens of countries combined with novel, interdisciplinary data on disaster exposure, we will examine firm dynamics after a disaster hits. The project will focus on earthquakes and hurricanes, which are global in scope and affect roughly half of the countries on Earth. Understanding mechanisms is particularly important as this would guide policy responses to disasters in order to help society cope with these longer-run effects. This is especially true in lower income countries, where governments are less able to provide general insurance and safety net policies.

Historically, economists have believed that "disasters are good for business." This is due to an assumption that outdated, destroyed capital would be replaced and a building boom would ensue, as well as research on human-made disasters (e.g., war-time bombings in Davis and Weinstein (2002) and Miguel and Roland (2011)). Although observations and anecdotal evidence suggests recovery is actually slow, the economic literature has only recently begun to demonstrate that the prevailing theory – and the government policies that it informs – does not accurately reflect the reality. While early empirical evidence on natural disasters also seems to confirm the view that "disasters are good for business" (e.g., Toya and Skidmore, 2002; Noy, 2009; Cavallo et al. 2013), these papers suffer from a number of limitations that make their conclusions questionable. Notably, they used coarse, nationally-aggregated outcome variables and imprecise measures of hazard exposure, and their measures of disaster severity—usually reported monetary damages—were often endogenous. Additionally, disaster damage data are largely self-reported, and are thus both more accurate and more frequently reported in wealthier areas. The resulting correlation between wealth and disasters has often been misinterpreted as causal. Moreover, disasters of different types were grouped together and physical disaster intensity—e.g., windspeed or ground-shaking—was ignored.

In contrast, ground-breaking work by this PI used physics and earth science methods to reconstruct every tropical cyclone (i.e., hurricane or typhoon) that occurred since 1950. Climate scientists typically care about the tropical cyclone itself, and many measures of intensity aim to summarize the entire cyclone. What matters for people and the economy, however, is local intensity. For example, a hurricane that passes over farmland will have very different economic effects than a hurricane of identical intensity that passes over a major metropolis. Our insight was instead to use physics to reconstruct the windspeed and power dissipation of each cyclone and measure intensity in terms of people and assets exposed. This research showed that (when measured correctly) disasters actually suppressed economic growth for decades (Hsiang and Jina, 2014). Negative disaster effects have since also been documented by a number of recent studies (e.g., Deryugina, 2018; Basker and Miranda, 2018), but details on the mechanisms behind these effects remains elusive.

To address this critical gap, we will establish a set of empirical facts about how disaster recovery manifests at the firm-level and interpret the economic and policy implications of these facts through the lens of macroeconomic models of firm dynamics and business cycle recoveries. For instance, we plan to analyze how disasters affect firm entry and exit, within-firm labor productivity, allocative efficiency across firms and industries, the composition of entering and exiting firms, and the innovative investment decisions of surviving firms. Do losses during disasters and subsequent recovery trajectories differ across larger or smaller firms, more or less productive firms, more or less labor or capital-intensive firms, or firms in different industries? Do the effects of disasters differ across countries by level of income, by experience with a given disaster type, or by size of the country?

Earthquakes and tropical cyclones affect around half of the countries in the world, making this a truly global research question. Out of approximately 200 countries, 101 are affected by tropical cyclones and 41 are affected by severe earthquakes (over 4.5 on the Richter scale). The level of economic destruction caused by these two phenomena provides a rich trove of data to answer our research questions using the novel modeling methods developed by the research team. We use several decades of global exogenous natural hazard data at high spatial resolutions for earthquake shaking and hurricane wind speeds, introduced into the economics literature by the PI and one of the collaborators on this project (Lackner), to calculate firm-level hazard exposure. Earthquake data consists of the universe of global relevant ground-shaking for almost 5 decades at about 1km spatial resolutions from Lackner (2018). This level of detail is unprecedented for both social science and earth science investigations, and will allow us to look beyond merely Richter Scale measures of single events and examine the considerable spatial heterogeneity in damage that an earthquake is known to cause. Hurricane wind exposures are at a 0.1° by 0.1° global grid from Hsiang and Jina (2014) and extreme rainfall from the European Centre for Medium-range Weather Forecasting reanalysis of hourly rainfall data at 0.25° by 0.25° resolution. This will give us insight into two more disaster categories (flooding and tropical cyclones) that likely have different post-disaster dynamics than earthquakes. For firm data, in addition to manufacturing and service firm micro-data for 17 countries collected and assembled by one of the project researchers (Nath, 2020), we will also use manufacturing census data from 11 countries from Grover, Medvedev, & Olafsen (2019), and services census data from 20 countries from Nayyar, Hallward-Driemeier, and Davis (2021).

Progress on this research topic has typically been difficult, as economists and other social scientists were often consumers of earth science data that was ill-suited to answering societal questions. Uniquely, in the case of our earthquake and tropical cyclone data, this is an instance where the social science determines the features of the natural science methods, with two team members having graduate training in climate science and seismology as well as economics. The construction of ground shaking maps and wind speeds is done in such a way so as to capture the "social exposure" related to the disasters. This stands in contrast to the way in which these hazards are measured by earth scientists, which focuses on the physical characteristics (for example, total energy dissipated) with no regard to how people will be affected by the hazard. Instead, through collaboration with scientists in various fields, we are in the process of creating data that is expressly tailored to our economic question of disaster recovery, and in bringing these methods and data into the economics field. After the construction of these exposure datasets, the next major step will be to merge these together with the firm data. This is a considerable task, as there are hundreds of thousands of firms that need to be matched to environmental data by location, often requiring searching individual firm addresses. We will

attempt to automate this process with machine learning tools where possible. Another major aspect of this data construction will be to standardize the firm datasets, all collected idiosyncratically at the national level, across each country. Finally, we will empirically estimate the causal relationship between disasters and firm recovery, using statistical and econometric techniques that control for unobserved differences across firms and across locations, and trends through time.

For this project the PI will collaborate with Dr. Ishan Nath and Dr. Stephanie Lackner. Dr. Nath is an economist who holds a PhD from the University of Chicago, is currently a postdoctoral scholar at Princeton University, and will soon join the Federal Reserve of San Francisco. He has expertise in macroeconomics, having used firm-level data and censuses extensively in his prior work. Dr. Lackner is an interdisciplinary researcher with training in economics and seismology with a PhD from Columbia University. She is currently an assistant professor in IE University in Madrid. As an economist, she is uniquely trained in seismology and has produced a unique dataset on location specific ground-shaking intensity. She has written previously about the macroeconomic effects of earthquakes. The research assistant who would be supported by this grant would be responsible for cleaning and standardizing the extensive firm datasets across countries, creating a disaster intensity exposure dataset for each firm location, and running the preliminary analyses of disaster impacts. All three principals on the project are interdisciplinary environmental economists who have studied the effects of the environment on society and the economy.

References

Basker, E. and J. Miranda (2018). Taken by storm: business financing and survival in the aftermath of Hurricane Katrina. Journal of Economic Geography 18 (6), 1285–1313.

Cavallo, Eduardo, Sebastian Galiani, Ilan Noy, and Juan Pantano. "Catastrophic natural disasters and economic growth." Review of Economics and Statistics 95, no. 5 (2013): 1549-1561.

Davis, D. R. and D. E. Weinstein (2002). Bones, bombs, and break points: the geography of economic activity. American Economic Review 92 (5), 1269–1289.

Deryugina, T., L. Kawano, and S. Levitt (2018). The economic impact of Hurricane Katrina on its victims: Evidence from individual tax returns. American Economic Journal: Applied Economics 10(2), 202–33.

Grover, A., D. Medvedev, and E. Olafsen (2019). High-growth firms. Facts, fiction, and policy options for emerging economies. World Bank Group, Washington, DC .

Hsiang, S. M. and A. S. Jina (2014). The causal effect of environmental catastrophe on long- run economic growth: Evidence from 6,700 cyclones. Technical report, National Bureau of Economic Research.

Lackner, S. (2018). Earthquakes on the surface: earthquake location and area based on more than 14 500 ShakeMaps. Natural Hazards and Earth System Sciences 18 (6), 1665–1679.

Miguel, E. and G. Roland (2011). The long-run impact of bombing Vietnam. Journal of Development Economics 96(1), 1–15.

Nath, I. B. (2020). The Food Problem and the Aggregate Productivity Consequences of Climate Change. National Bureau of Economic Research.

Noy, Ilan. "The macroeconomic consequences of disasters." Journal of Development economics 88, no. 2 (2009): 221-231.

Nayyar, G., M. Hallward-Driemeier, and E. Davies (2021). At Your Service?: The Promise of Services-Led Development. World Bank Publications.

Skidmore, M. and H. Toya (2002). Do natural disasters promote long-run growth? Economic inquiry 40(4), 664–687.