Natural disasters, remote sensing, and synthetic controls

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I. Extended Abstract

Satellite imagery has been used for decades to study changes on Earth's surface and understand the mechanisms that have shaped it as we know it today. Moreover, substantial improvements in computing power and the increase of data available in recent years have boosted interest for this kind of research. Pixel-based composites of large areas are easily accessible today thanks to the Google Earth Engine platform[1]. These are being used to study the evolution of different ecosystems such as forests[2], as well as the frequency of wildfires. Furthermore, technological advances over the last decades have enabled to precisely monitor variations in extreme weather events[3]. These weather phenomena seem to be larger now in quantity and size due to the increase of climate volatility[4].

The consequences of natural hazards have been mostly studied by comparing pre- and post-disaster conditions, or simple pair-wise comparisons between affected and non-affected areas, rendering inaccurate estimates[5]. We are interested in developing a system that, by means of a synthetic control approach, will enable us to causally evaluate the effects of disturbances over areas of interest using satellite imagery.

Resilience is another field of interest for the research community. The decrease in resilience of regions that are recurrently hit by these events might end up making certain places inhabitable. For example, extreme weather events already have their toll on life expectancy in the US[6]. Hence, large migrations may follow as a result in the long term.

A. Costs of natural disturbances

Natural disasters have become one of the main concerns of many developed and developing countries that are more prone to be affected by these. Specifically, Western US, Australia and Brazil are some of the regions that have experienced large wildfires in recent years. However, wildfires have historically played a fundamental role in regulating the cycles of wildlife around the globe[7].

It is hard to quantify or measure the extent, severity and the impact of these natural disasters as well as the economic effects of these events. Different sources of data can provide different insights of these events. Moreover, the large costs and low precision of human-made reports on observed wildfires calls for an accurate estimation of their effects. Aftermath costs calculated by insurers are an under-estimation of the real damage of wildfires. Sanitary and labor expenses, as well as other types of effects are usually not taken into account. There is acute need for quantifying the morbidity effects and medical costs in order to estimate the true economic impact of wildfires.

With regard to the specific case of ecosystem disturbances provoked by wildfires, previous research has focused on the analysis of satellite imagery [8] to evaluate the evolution of forest ecosystems, both before and after wildfires occur[9]. In addition, past studies have centered on the simulation of different temperature and climate scenarios and on the varying degrees of wildfire risks in California[10]. On the other hand, the aim of this study is to estimate the short and long term causal effects of wildfires.

B. Experimental Environment

Open access data to more than three decades of satellite imagery is available through the Landsat archive[11], as well as many other remote sensing data resources. This spatio-temporal data allows for a longitudinal analysis of these natural hazards before and after they take place. Figure 1 shows the state of vegetation, before, during, and after a large wildfire.

We can obtain proxies of vegetation health by observing various Landsat Surface Reflectance-Derived Spectral Indices (LSR-DSI), such as Normalized Difference Vegetation Index (NDVI), Normalized Burned Ratio (NBR) and other composite. Other sources of data such as satellite nightlight imagery can be good proxies of the socio-economic statuses of societies. The increase in size and frequency of these natural disasters urges the use of new methods in order to rapidly evaluate their extent. By controlling for spatial attributes, incident risk and land use we intend to thoroughly examine these effects.

The methodology proposed in this extended abstract is known as synthetic control. This approach is drawn from social and medical sciences literature[12]. It consists on the creation of a synthetic counterfactual for each treated unit, in order to assess the longitudinal effects of the event of interest. By means of using synthetic controls we intend to study the average causal effect of natural disasters on different regions

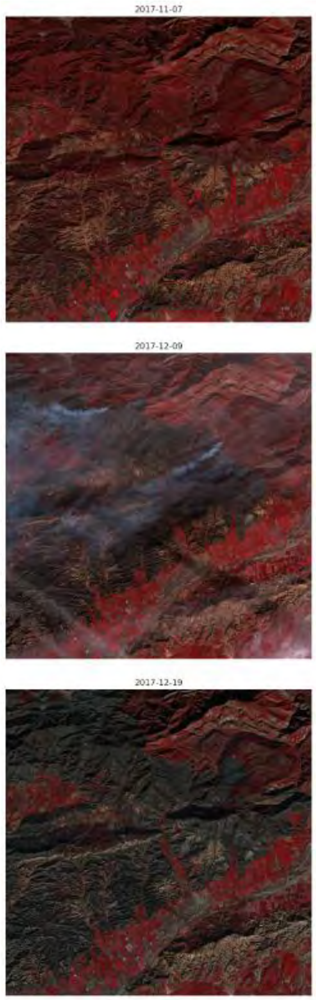

Fig. 1. Sample images capturing the Thomas Fire in California in December 2017. The images show the NDVI on surface reflectance over three Landsat 8 images. The images show the vegetation previous, during and after the wildfire. The second image depicts some smoke, meaning that the wildfire was still being controlled.

of the planet. In order to obtain estimates of the effects, we need to observe the characteristics of the affected areas, as well as their respective counterfactual regions. These are the areas that were found to be most similar to their counterparts before the impacts, but were unaffected by them.

C. Discussion

In this extended abstract we propose the use of remote sensing data, jointly with the use of synthetic controls to estimate spatio-temporal effects of natural disturbance events. By combining literature from econometrics, remote sensing, political science, and the vast amount of data at our disposal, in addition to adequate pre-processing, we can provide significant insights on the effects of these events and enable improvements in the field of mitigation planning, as well as in more efficient regeneration management.

II. Acknowledgment

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