



## Analysis

Not So Natural: Unequal Effects of Public Policies on the Occurrence of Disasters<sup>☆</sup>

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## ABSTRACT

This paper assesses the effects of public policies on the occurrence of natural disasters related to extreme rainfall. By using a unique and geolocated database on natural disasters in the state of Rio de Janeiro, Brazil, I test whether variables related to public policies - e.g. forest cover and urban infrastructure - affect the occurrence of natural disasters, conditional on the existence of extreme rainfall. Results point to a significant role for public policies in order to mitigate effects of extreme weather events. More specifically, results point to an important role for urban infrastructure, as proper sewage and waste collection, and forest cover in reducing the impacts of extreme rainfall. Moreover, I discuss how these heterogeneous effects have distributional consequences and can be linked to the Environmental Justice literature. Finally, this paper reinforces the idea that adaptation policies to disasters are essential in reducing local vulnerabilities and can yield distributional and fiscal benefits.

Sans quitter votre sujet de Lisbonne, convenez, par exemple, que la nature n'avait point rassemblé là vingt mille maisons de six à sept étages, et que, si les habitants de cette grande ville eussent été dispersés plus également et plus légèrement logés, le dégât eût été beaucoup moindre et peut-être nul.

(Rousseau, 1756)

## 1. Introduction

Climate change and high levels of inequality constitute the main challenges for policymakers in the 21st century.<sup>1</sup> It is safe to say that these challenges, if not treated properly, may lead to disruptive changes, menacing the very form of organization of today's societies, especially Western societies, which are based on representative democracy (Burke et al., 2015; Chancel and Piketty, 2015; Milanovic, 2016).<sup>2</sup> These challenges have not been ignored by economists. Indeed, there is a growing interest that leads to increased economic research on both themes. Moreover, there is also an increasing attempt to reach a broader public with the publication of reports and policy proposals

based on recent research.<sup>3</sup>

Climate change is expected to bring an increase in the frequency and intensity of extreme weather events. As a matter of fact, climate change is a complex phenomenon, whose causes are not so obvious to the population. Yet, its most salient feature is the occurrence of more frequent and intense extreme weather events (The Asia Foundation, 2012; Stott et al., 2016).<sup>4</sup> Therefore, the concern with natural disasters and its welfare impacts have become a first order question (Seneviratne et al., 2012; McKibben, 2014).

Although extreme weather events raise the risk of natural disasters, this relationship is not necessarily unequivocal. According to Kahn (2005), rich nations do not suffer less natural disasters than poorer nations. Nevertheless, richer nations have less deaths related to those disasters. This might be due to investments in the capacity to deal with those hazards. Investments are also dependent on the political economy equilibrium: Anbarci et al. (2005) discuss how protection to earthquakes depends on the level of income inequality, since more unequal countries are less conducive to collective action.<sup>5</sup>

In this sense, natural disasters cannot be considered exogenous

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<sup>1</sup> The World Economic Forum has recognized these phenomena as global challenges: <https://www.weforum.org/agenda/2015/01/inequality-and-climate-change-twin-challenges-of-2015/>.

<sup>2</sup> Interestingly, Tirole (2017) treats climate change as a major macroeconomic challenge and inserts inequality within the discussion of the moral limits of the market.

<sup>3</sup> See e.g. the World Inequality Report (<http://wir2018.wid.world/files/download/wir2018-full-reportenglish.pdf>) on inequality and Gollier and Tirole (2017) on climate change.

<sup>4</sup> For instance, Spence et al. (2011) show that people in England who suffered with floods are more concerned to climate change and consume less energy than the non-affected population.

<sup>5</sup> Besley and Persson (2011) discuss the determinants of the creation of common-interest states.

events: there is a set of public policies that can act on the degree of vulnerability of a given region and, thus, help prevent the extension of damages related to natural disasters (World Bank and United Nations, 2010). Indeed, this discussion dates back at least to a controversy between Voltaire and Rousseau.<sup>6</sup> As can be seen on the epigraph above, Rousseau, in a letter to Voltaire, argues that the great 1755 Lisbon earthquake was not only a matter of nature: the design of buildings and urban planning were crucial to the extension of the damages witnessed.

As regards the effects of public policies on natural disasters, Healy and Malhotra (2009) show how expenditures with preparedness for disasters result in less damages. The portfolio of policies that can enhance resilience, however, is not constrained to specific adaptation investments. As Kellenberg and Mobarak (2008) assert, land-use policies are especially important regarding disaster risk. Indeed, land cover is considered a main component in stability analysis related to landslide susceptibility (Van Westen et al., 2008). In addition, urban infrastructure, as represented by proper drainage systems, sewage collection and waste disposal, is also crucial to determine the extension of damages when an extreme rainfall event strikes (Andrew, 2012).

Moreover, natural disasters entail different impacts along the population distribution. There is a growing research on the interplay between inequality and environmental economics that is now being explored empirically. Currie (2011), for instance, explores this link by examining whether the claims of the “Environmental Justice” literature are based on sound empirical evidence. Hsiang et al. (2017) provide a general framework for analyzing the distribution of environmental damages. The latter authors apply this framework to understand the economic effects of deforestation, air pollution and climate. Hallegatte et al. (2015) show how people living in poverty are relatively more vulnerable to shocks caused by natural disasters, such as floods and droughts.<sup>7</sup>

This paper assesses the effects of public policies on the occurrence of natural disasters related to extreme rainfall. In doing so, it contributes to these two strands of the literature: on the one hand, it provides an evidence of how public policies affect the occurrence of natural disasters related to extreme rainfall. On the other hand, it shows how those effects are heterogeneous among the territory: localities with a bad provision of public infrastructure are the hardest hit.

To investigate the relationship between hydrological disasters and public policies, this article makes use of a unique and geolocated database on natural disasters in the state of Rio de Janeiro, Brazil. Though geographically specific, Rio de Janeiro is considered a global hotspot related to floods and landslides (Dilley, 2005). Therefore, by building knowledge from this particular case, this study can shed light on the discussion of appropriate adaptation policies to increase resilience to climate change and its distributional impacts.

Though there is some evidence on the positive effects of preparedness spending on reducing damages related to natural disasters (Healy and Malhotra, 2009) and a somewhat vast literature in geology on the importance of keeping forests to reduce the risk of landslides and floods (Glade, 2003; Bradshaw et al., 2007; Van Westen et al., 2008), this paper provides evidence based on a detailed geographical scale how the interaction of triggering factors, namely extreme rainfall, with a set of public policy related variables, leads to less natural disasters.

## 2. Empirical Context

Brazil has had 2600 deaths and 600,000 unsheltered people due to hydrological disasters, from 2000 to 2015, according to EM-DAT (2010). In relation to monetary damages, CEPED/UFSC (2016)

<sup>6</sup> Voltaire wrote a poem on the relation between that natural catastrophe and God's providence. In a letter answering Voltaire, Rousseau remarked the human responsibility on the disaster (de Almeida Marques, 2005).

<sup>7</sup> Chancel (2017) provides a discussion on different forms of environmental inequalities. On the measurement of environmental inequality, see Boyce et al. (2016).

estimates that hydrological disasters caused a loss of BRL 72 billion during the period 1995–2014, or BRL 3.6 billion per year. Regarding the temporal distribution, however, damages are highly concentrated in the more recent years: since 2008, six out of seven years had damages above the mean.<sup>8</sup>

Among Brazilian states, Rio de Janeiro state, due to its geomorphological characteristics (with mountainous and lowland regions) and social vulnerabilities is prone to suffer hydrological disasters as landslides and floods. Despite having an area equivalent to only 0.5% national territory, Rio de Janeiro state has suffered severe monetary damages: during the 1995–2014 period, damages were valued at BRL 10.8 billion, or 15% of total Brazilian losses related to hydrological disasters.

In January 2011, the state of Rio de Janeiro, Brazil, suffered the worst natural disaster in country's history.<sup>9</sup> The occurrence of flash floods and landslides due to extreme rainfall led to a disaster with massive consequences. According to World Bank (2012), the disaster has caused the death of > 900 people and affected a total population of > 300,000 people. Economic losses amounted to R\$ 4785 million at 2010 prices. This is equivalent to 1% of the state of Rio de Janeiro's GDP. More impressively, this amounts to a loss of 28% of the GDP of the municipalities that were directly affected by the disaster.<sup>10</sup>

Those losses, both in terms of economic as well as welfare, were not evenly distributed between and within municipalities. Regarding disparity between municipalities,<sup>11</sup> the city of Nova Friburgo has concentrated 60% of the total affected population. Within municipality impacts were unevenly distributed as well: the parcel of population that has got unsheltered has varied from 3.1% to 21.9% in the municipalities that suffered with the flash floods and landslides (World Bank, 2012). In addition, the lion's share of those who suffered home losses was the poor who live in risky areas without a proper provision of public goods (Freitas et al., 2012).

From looking to this episode, one question arises almost immediately: why are the effects of extreme weather events so heterogeneous? This is a first-order question that links to two mounting problems: climate change and economic inequality. More specifically, it is important to better understand the distributional consequences of environmental degradation (Hsiang et al., 2017).

## 3. Data Description and Summary Statistics

### 3.1. Dataset Construction of Geolocated Natural Disasters

The Brazilian institutional framework related to natural disasters begins in 1969 with a Presidential Decree (DL 950/1969) that created the Special Fund for Public Calamities. In 1988, a new Decree (97274/1988) created the National System of Civil Defense. As of 2012, a new act (Act 12608/2012) established the current institutional framework and creates the National System of Protection and Civil Defense.<sup>12</sup> This new act has brought the idea of risk management and thus tries to improve actions of prevention.

Under this framework, when a natural hazard occurs, municipalities may claim for the recognition of two states: situation of emergency and public calamity. These states diverge in intensity, but they represent a situation where the municipality has suffered severe damages. Specifically, these damages encompass at least two spheres of: human,

<sup>8</sup> Prices are deflated to 2014 according to the GDP deflator.

<sup>9</sup> One day after the disaster has occurred, local media had already classified it as the worst climate-related tragedy in the country: <http://g1.globo.com/rio-de-janeiro/chuvas-no-rj/noticia/2011/01/chuva-na-regiao-serrana-e-maior-tragedia-climatica-da-historia-do-pais.html>.

<sup>10</sup> World Bank (2012) provides a list of these municipalities as well as a report of total losses and damages related to this megadisaster.

<sup>11</sup> The tragedy has affected seven municipalities at the Serrana Region of the state.

<sup>12</sup> Ganem (2014) provides a full description of the evolution of this institutional framework.

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