Assessing the Urban Impacts of an Industrial Rock Salt Mining Disaster: The Case of the City of Maceió, Brazil

The range of natural disasters has expanded significantly over the years, primarily due to the increasing intensity of climate change, especially in recent times. As for Brazil, for example, Lima and Barbosa (2019) employed a flash flood occurrence in the Brazilian state of Santa Catarina in 2008 as a focal point for investigating spatial spillovers resulting from natural disasters within interconnected geographical areas. De Olivera (2017) showed that extreme climatic events reduce the growth rate of per capita GDP of municipal economies in the state of Ceará between 2002 and 2011 and Alves, Andrade Lima, and Emanuel (2022) investigated the economic consequences of the 2011 Rio de Janeiro landslides and evaluated the effect of the disaster on the business establishment performance. As a major exporter of minerals, however, Brazilian cities are not only affected by climate events, but also by disasters related to mineral exploration and industrialization. Recently, Castro and Almeida (2023), for example, evaluated the effect of the Brumadinho mining disaster on economic performance in Minas Gerais. Using synthetic control design as an empirical strategy, contrafactual trajectories for Minas Gerais were elaborated to obtain the effect of this technological disaster. This paper examines the economic impacts of an urban disaster in the city of Maceió, Brazil triggered by industrial rock salt mining on firms and families. The disaster occurred in 2018 with the subsidence of the ground in some neighborhoods near the mining sites, located in the city, capital of Alagoas, a northeastern state in Brazil. As a result, these neighborhoods had to be abandoned, with the relocation of businesses and families. In total, the area designated as vacant spans approximately 6.5 km^2, constituting 5.6% of Maceió total urban area according to the 2010 Census. Because it occurred in an urban center and a state capital, this disaster stands out from other mining related disasters in the country. The mandatory relocation directly affected an estimated 53,000 individuals, amounting to 5.5% of the city's total population. The event can be considered the largest natural resource extraction disaster to occur in a Brazilian capital in the 21st century. Despite its relevance, however, its economic and welfare consequences have not yet been explored in the literature. The present study aims to fill this gap. This research aims to provide a causal investigation into the economic consequences of the disaster in Maceió City, focusing on employment and income levels in affected areas. Understanding these effects is critical, as urban disasters of this scale and origin pose significant risks to local economies, which are often overlooked in disaster response strategies. Given the increasing frequency of disasters due not just human intervention but also related to climate change, this analysis is particularly relevant for informing both policy and economic resilience planning. This study, thus, contributes to the broader literature on disaster economics by shedding light on the labor market effects of a significant urban disaster in Brazil. To the best of our knowledge, this study is the first to evaluate the labor market impacts of Brazil's largest ongoing industrial urban disaster in Maceió using a causal inference approach. It contributes to the literature on disaster impacts, especially as environmental disasters may become increasingly frequent due to global warming. Furthermore, the study employs two distinct empirical strategies to assess these impacts, offering a nuanced analysis from both micro-regional and city-wide perspectives. First, using both static and dynamic (event study) difference-in-differences approaches, and official microdata sets of firms and households, we assess the impact of the disaster on firms' closure risk and employment levels, and households' income and working

conditions. To estimate impacts on firms located in the evacuated area, we used microdata from the identified RAIS (*Realação Annual de Informações Sociais*), from the Ministry of Labor and Employment (MTE). Such a database allows us to geocode and follow firms over the years and record their activity, including employee numbers and eventual closure. To assess the impact on families, we used microdata from Cadúnico (*Cadastro Único para Programas Sociais*), a database on vulnerable and low-income families maintained by the Ministry of Development and Social Welfare, Family and the Fight Against Hunger (MDS). We first assess the short-term, micro-local impacts on employment in affected areas, drawing on annual employer-level data to capture labor market disruptions. We then analyze household-level data from low-income populations to explore how the disaster affected household labor market outcomes. Second, we evaluate the broader economic consequences for the municipality by applying Abadie's Synthetic Control estimator to data from the PNADC (*Pesquisa Nacional por Amostra de Domicílio Contínua*), an annual national household sample survey from IBGE (*Instituto Brasileiro de Geografia e Estatística*), the Brazilian official statistic institute. This implied constructing a counterfactual scenario to assess Maceió's economic performance in the absence of the disaster. Our findings reveal significant labor market impacts and business disruptions in Maceió due to the disaster. Firms in affected areas experience a substantial decline in employment levels over time and a heightened risk of closure, particularly in directly impacted zones. Sectoral analysis shows that the service sector was the hardest hit, with reductions in both employment and business survival. While business closures in the industrial sector increases, employment levels remained stable. The agricultural sector shows no significant effects. Among low-income households, we found a significant reduction in income from work in larger households (with more than five members), while no substantial effects were observed in smaller households. Conversely, income and food expenditure increased after the disaster, likely due to support from disaster relief funds. Additionally, the likelihood of child labor decreased over time following the disaster shock. These findings offer key insights into the labor market effects of disasters, emphasizing the need for robust policy responses as climate change increases the likelihood of such events. The study highlights the importance of economic resilience planning and targeted policies for vulnerable urban areas. Our preliminary findings reveal statistically significant negative effects on employment levels among firms impacted by the disaster shock, with an average decline of approximately 6%. Additionally, we observe a 20% decrease in earnings from work attributable to the disaster's impact. Similarly, the estimated employment rate would be roughly 5 percentage points higher if the disaster had not occurred. In other words, the disaster has reduced the proportion of employed individuals by an average of 12.5%. The results of heterogeneities across economic activities indicated that the negative impact on employment and firm closure occurred mainly in retail, general services, and education activities. Overall, our main results are robust to different robustness checks, including different samples and controls. The implications of these findings are crucial for policy and resilience planning. It should be noted that impacts on educational services may have long-term effects on the formation of the city's human capital, particularly affecting the city's neediest population. As environmental disasters, both natural and human-induced, become more frequent in the context of climate change, it is essential for policymakers to incorporate economic resilience strategies into disaster response frameworks. In particular, urban areas vulnerable to industrial hazards should establish measures to protect employment and support income stability in the wake of such events. Additionally, further research on the social and economic impacts of industrial disasters in developing economies is necessary to inform more effective policy interventions.