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Unearthing the Economic and Social Consequences of Earthquakes

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The purpose of this paper is to offer a comprehensive overview of the socio-economic effects of earthquakes. We begin with a thorough literature review. Following this, we assess policy measures taken in response to major earthquakes, drawing on existing research to formulate insights and recommendations that policymakers can use to effectively navigate the risks in the aftermath of such disasters. In addition to reviewing the literature and analyzing policy interventions, we conduct an in-depth examination of the economic repercussions of earthquakes. Our analysis utilizes data from around 80 significant earthquakes across more than 30 countries. The findings indicate that, while the overall effect of major earthquakes on GDP per capita is generally small, the impact on fiscal accounts can be substantial, although this varies significantly between economies. External trade balances tend to weaken, with a considerable decrease in exports and an ambiguous effect on imports.

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1 Introduction

In the past 30 years, the world has witnessed a series of significant earthquakes that have not only claimed thousands of lives but also caused extensive economic damage, amounting to billions of dollars globally. Among these, some of the most impactful earthquakes include the 1995 Great Hanshin Earthquake in Japan, the 1999 İzmit Earthquake in Türkiye, the recent 2023 Kahramanmaraş Earthquake also in Türkiye, the devastating 2004 Indian Ocean Earthquake, the 2008 Sichuan Earthquake in China, and the 2015 Nepal Earthquake. Research by Hoeppe (2016) indicates that financial losses from natural disasters, including earthquakes, have seen a threefold increase since the 1980s. This surge in losses is attributed to factors such as population growth and the expansion of economic activities (see Botzen et al. (2019)). Moreover, the expansion of urban development in earthquake-prone areas has heightened the risks associated with seismic events, exacerbating potential damages and human casualties. These factors underscore the need for policies aimed at mitigating the economic and social repercussions of earthquakes.

In this context, the objective of this paper is threefold. First, we conduct a comprehensive review of the literature on the socio-economic and political effects of earthquakes, aiming to summarize key empirical findings. Second, we evaluate policy responses to major earthquakes, leveraging existing research to provide insights and recommendations for policymakers to effectively manage the risks and consequences of such events. Third, beyond reviewing literature and evaluating policy responses, we conduct a detailed analysis of the economic impacts of earthquakes. This analysis is based on data from approximately 80 large earthquakes, affecting over 30 countries.

Our empirical strategy leverages the synthetic control method, which constructs a credible counterfactual scenario to estimate what an economy's performance would have been had the earthquake not occurred. This is done by analyzing the growth patterns of similar economies that were not affected by natural disasters during the same period, serving as a benchmark. Initially, our analysis focuses on the impact of major earthquakes on gross domestic product (GDP) and GDP per capita. To provide a more comprehensive understanding of the economic impact of earthquakes, we extend our examination to fiscal balances, specifically investigating the earthquake-induced decline in revenues and the increase in reconstruction spending, and how these factors influence the trajectory of government debt expressed as a percentage of GDP. Given the extensive infrastructure damage and supply chain disruptions typically resulting from major earthquakes, we also explore the dynamics of exports and imports in the post-earthquake environment. This multifaceted approach enables us to capture the broad economic ramifications of earthquakes and the resilience mechanisms that come into play.

Our results suggest that historically, the impact of major earthquakes on GDP per capita has been relatively limited, as the economic stimulus arising from reconstruction efforts often compensates for the disruptions caused by the earthquakes. However, the experiences of reconstruction, as well as the trajectories of government spending and debt-to-GDP ratios, exhibit significant variation. Typically, the demand for reconstruction leads to an increase in imports, while damages to production capabilities and supply chain networks, alongside infrastructure destruction,

exert prolonged negative effects on exports.

Our findings are in line with the small average effects identified in previous research, which remains, for the most part, inconclusive. A wide variability in outcomes reflects differences in countries' initial conditions, such as their level of preparedness for earthquakes, as well as the efficacy of fiscal and monetary policy responses to the disaster. The interplay between local conditions—especially the quality of economic institutions—and the nature of fiscal interventions plays a crucial role in shaping the aftermath of earthquakes.

In our comprehensive analysis of the initial conditions and policy responses to significant earthquakes, based on available evidence, we identify key stylized facts. Wealthier, more open economies, those with well-developed financial markets and strong economic institutions, show a greater ability to absorb the economic impacts of earthquakes. This resilience is largely attributed to their advanced disaster preparedness strategies, which include effective risk assessment measures, stringent zoning requirements and building codes as well as diversified supply chains. These strategies are highly effective in mitigating economic damages of natural disasters.

Increased public spending during the reconstruction phase emerges as a double-edged sword. While it can significantly stimulate economic recovery, it requires careful targeting to prevent overheating of the economy and resulting in undue fiscal strain. Monetary policies must strike a balance between mitigating the inflationary pressures of reconstruction spending and bolstering the economy amidst the shock. Emphasizing the use of local resources during reconstruction can enhance both its immediate and long-term benefits, whereas drawing on external resources can expedite recovery where local capabilities are lacking. However, the scourge of poor governance and corruption can dramatically undermine the success of reconstruction efforts.

The remainder of this paper is organized as follows: Section 2 provides an overview of the literature on the social, political and economic impacts of earthquakes. Section 3 discusses the policy responses to major earthquakes, primarily focusing on fiscal policy, monetary policy and disaster preparedness, while also taking initial conditions into account. Section 4 introduces the synthetic control method, details the data used and provides estimates of the average impact of major earthquakes on economic activity, drawing on the experiences of over 30 countries. Section 5 evaluates the effectiveness of policy interventions in response to earthquakes, illustrated with three case studies: the earthquakes in Haiti, Japan, and Türkiye. Section 6 concludes.

2 Literature review

The studies reviewed in this paper employ various methodological approaches to examine the socio-economic effects of earthquakes. Many utilize quasi-experimental designs, leveraging the unexpected nature of seismic events to establish causal relationships. Difference-in-differences and synthetic control methods are commonly used to compare affected areas with similar unaffected regions. While earthquakes' timing is largely random, their geographic distribution is not, presenting a key empirical challenge. Regions prone to seismic activity often differ systematically from those that are not, potentially confounding analyses. Some studies address this by focusing on within-region comparisons or by carefully constructing control groups from areas with similar seismic risks. Others employ instrumental variable approaches or exploit

variation in earthquake intensity. Despite these efforts, the non-random spatial distribution of earthquakes remains a limitation in many studies. In the following literature review, we provide more detailed methodological discussions where relevant, highlighting how specific studies have addressed these challenges in their analyses of earthquake impacts.

2.1 Human capital and social effects of earthquakes

Exploring the societal effects of earthquakes offers vital insights into their broader impact on communities. This section delves into the key findings from the literature, particularly concerning the accumulation of human capital, shifts in risk preferences, and the evolution of trust, which are important for the sustained economic development of countries.

Studies across various contexts have consistently highlighted the profound impact of earthquakes on human capital accumulation, revealing nuanced effects influenced by timing, intensity, and socioeconomic status. Cipollone and Rosolia (2007) find that in Southern Italy that exemptions from compulsory military service for males affected by earthquakes led to higher high school graduation rates, indirectly benefiting female education through peer effects. Tian et al. (2022) show in China that prenatal exposure to the 1976 Tangshan earthquake resulted in lower educational attainment, with maternal psychological stress being a significant factor, especially in less affected areas, and females being disproportionately impacted. Torche (2018) investigates the consequences of prenatal exposure to a significant earthquake in Chile and finds that stress exposure during early pregnancy significantly impaired cognitive outcomes in children from disadvantaged families but not those from middle-class families. In Peru, Caruso and Miller (2015) document educational deficits among those exposed in utero to the 1970 Ancash earthquake, especially among females, and noted the inter-generational transmission of these effects, with children of affected mothers also achieving less education. Paudel and Ryu (2018) in Nepal found that infants from districts severely affected by the 1988 earthquake were significantly less likely to complete their schooling, with a stark difference between higher and lower caste groups. Together, these studies underscore the compounded challenges faced by socioeconomically disadvantaged groups and the critical need for supportive measures to address these disparities.

Several studies have explored the impact of earthquakes on individuals' risk preferences, showing varied effects across different contexts and demographics. Hanaoka et al. (2018) focus on the aftermath of the 2011 Great East Japan Earthquake, finding that males exposed to higher intensities of the quake showed an increased risk tolerance, an effect that persisted for up to five years, while women exhibited no significant change. Beine et al. (2020) find that individuals affected by the Tirana earthquakes became more risk-averse and impatient. Yuan et al. (2024), using data from the China Household Finance Survey, find that local earthquakes led to a temporary decrease in risk-taking behaviors, especially among wealthier households. Chang et al. (2023) investigate the inter-generational transmission of risk preferences, discovering that parents' experiences with earthquakes significantly heightened their children's aversion to risk. Gao et al. (2020) examine how nonfatal, large-scale earthquake exposures influenced household risk perceptions, revealing that such 'lucky' experiences reduced the perceived risk of earthquakes and decreased the likelihood of purchasing life insurance. Collectively, these studies highlight the nuanced ways earthquakes can reshape individuals' and households' attitudes towards risk.

Another strand of the literature has explored the trust-related effects of earthquakes. Carlin et al. (2014) analyze survey data from the earthquakes in El Salvador (2001), Haiti (2010), and Chile (2010) and find that the impact of natural disasters on interpersonal trust hinges on a state’s ability to uphold law and order, deliver aid, and provide essential services, thereby mitigating the adverse effects on trust. Similarly, Andrabi and Das (2017) examine trust dynamics between Pakistanis and Westerners following the 2005 earthquake in northern Pakistan, noting a significant, enduring improvement in the local Muslim population’s perception of Westerners, facilitated by the active involvement of Western relief groups. Furthermore, Pathak and Schündeln (2022) focus on the 2015 Nepal earthquake, highlighting how caste-based discrimination influenced aid distribution, with upper caste households more likely to receive help than lower caste ones, despite similar needs. Thus, these studies underscore the critical role that effective state response, inclusive aid distribution strategies, and international cooperation play in not only addressing the immediate aftermath of earthquakes but also in fostering long-term trust and positive social dynamics in affected communities.

2.2 Political effects of earthquakes

The political ramifications of earthquakes are complex and vary widely by region. This section delves into three key aspects frequently examined in scholarly research: political and electoral outcomes, public sector corruption, and conflict.

Rahman et al. (2016) examine earthquakes’ dual influence on political regimes, noting their potential to both promote democratic transitions through governmental accountability for disaster response and to facilitate shifts toward less democratic systems due to economic and opportunity cost factors. Belloc et al. (2016) provide a historical analysis, showing how earthquakes in medieval Italy affected the political landscape by influencing the transition from autocratic regimes to self-governance, especially in cities where political and religious leadership overlapped. Research by Cerqua et al. (2023) highlights the contrasting electoral responses to two devastating earthquakes in Italy, demonstrating how the 2009 L’Aquila earthquake led to a notable and sustained increase in authoritarian sentiment in the hardest-hit regions, unlike the 2012 Emilia earthquake. This divergence is attributed to differences in the post-disaster reconstruction efforts and shifts in public trust in institutions. Masiero and Santarossa (2021) investigate the impact of earthquakes on municipal election outcomes in Italy, particularly through the lens of media exposure. Analyzing over 13,000 electoral cycles from 1993 to 2015, they found that earthquakes significantly boost the reelection prospects and vote shares of incumbent mayors, largely due to the incumbents’ advantage in disaster recovery efforts and increased media visibility.

Another body of literature focuses on the exacerbation of earthquake fatalities due to public sector corruption and substandard construction practices. Escaleras et al. (2007) find a significant correlation between a country’s corruption level and the death toll from major earthquakes, analyzing data from 344 earthquakes worldwide between 1975 and 2003. Cao (2023) demonstrates that buildings constructed with connections to corrupt county officials were significantly more likely to collapse in the 2008 Sichuan Earthquake, underscoring the lethal consequences of compromised building code enforcement.

Additionally, earthquakes are shown to trigger intrastate conflict by exacerbating resource scarcity, particularly in developing countries where resource competition is fierce. Brancati (2007) identifies an increased conflict likelihood in densely populated, low-GDP countries with existing conflicts, based on data from 185 countries between 1975 and 2002. Eldemerdash and Landis (2023) explore how remittance flows after earthquakes can influence social welfare and political stability, suggesting that while remittances may stabilize consumption and reduce instability, they also have the potential to fuel dissent and anti-state activities.

2.3 Economic effects of earthquakes

Earthquakes stand out among natural disasters for their unpredictability and inevitability, presenting unique challenges to economic stability and development.¹ Unlike hurricanes and storms, the sudden onset of earthquakes leaves little room for preemptive measures, significantly affecting households and businesses, especially in countries with underdeveloped insurance and emergency management systems. This situation often results in exacerbated economic damages, highlighting the importance of robust disaster preparedness and recovery strategies.

Research has delved into how earthquakes affect economic growth, examining case studies across various countries. Barone and Mocetti (2014) focus on Italy’s earthquakes in 1976 and 1980 and illustrate the nuanced economic impacts of such disasters. They observe negligible short-term GDP effects but identify potential long-term negative consequences without financial aid, suggesting that earthquakes, coupled with aid, can either stimulate or hinder technical efficiency and social capital, depending on the pre-existing institutional quality. Porcelli and Trezzi (2019) look at the effects of 22 earthquakes in 95 Italian provinces from 1986 to 2011 and find that their net effect on output and employment can be positive as the stimulus from the reconstruction activities more than compensates for the destruction of physical capital.

Similarly, studies on the 1995 great Hanshin-Awaji earthquake by Fujiki and Hsiao (2015), and the 1995 Kobe earthquake by DuPont and Noy (2015), reveal the complex nature of earthquake impacts on economic growth. While the former finds no lasting effects on growth, the latter reports a significant long-term decrease in per capita GDP, lasting over a decade. Joseph (2022) assesses the impacts of the 2010 Haiti Earthquake on economic growth and finds a considerable short-term reduction in the nation’s economic growth. Furthermore, this downturn in growth was not just a transient issue; it persisted for a decade following the disaster.

Fabian et al. (2019) show that earthquakes globally reduce nighttime growth rates and light levels, with effects persisting for about five years, yet without long-term consequences. Aguirre et al. (2023) investigate the medium-term economic impacts of the 2010 Chilean earthquake using nighttime light intensity and firm-level data. They find that affected areas experienced faster economic growth compared to unaffected regions, with increased economic activity persisting for at least five years post-disaster. The study attributes this growth to reconstruction efforts and inflows of public and private resources, highlighting the potential for disasters to catalyze

¹Skidmore and Toya (2002) explore the relationship between natural disasters and long-run economic growth. They find evidence that climatic disasters are positively correlated with long-run economic growth, human capital investment, and total factor productivity improvements. The authors suggest that disasters may provide opportunities for rebuilding and updating capital stocks, potentially leading to positive long-term economic outcomes.

economic development under certain conditions. In contrast, Huang et al. (2024) study on China emphasizes the significant long-term negative impact of earthquakes on economic indicators, including per capita GDP, household savings, and innovation incentives. Their findings also highlight the mitigating effects of local fiscal autonomy, social capital, and infrastructure quality on earthquake damages.

Only a small subset of the literature on natural disasters examines variables beyond GDP. Xiao (2011) examines the local economic impacts of natural disasters using a quasi-experimental approach. The study finds that natural disasters can stimulate certain sectors of the local economy, particularly the construction industry, while negatively affecting others. Crespo Cuaresma et al. (2008) investigate whether natural disasters can act as a form of creative destruction in developing countries. They find evidence that catastrophic events can provide opportunities for updating the capital stock and adopting new technologies. However, the study also notes that these positive effects are contingent on the country's level of development and the specific nature of the disaster.

Freund et al. (2022) investigate the impact of the 2011 earthquake in Japan on global value chains, specifically in the automobile and electronic sectors. Contrary to the common expectation that such a disaster would lead to companies reshoring or diversifying their supply chains away from Japan, the study finds no significant shift towards reshoring, nearshoring, or diversification among non-Japanese suppliers. Instead, it was observed that trade in intermediate products remained relatively stable compared to final goods, which experienced more disruption. Carvalho et al. (2020) investigate the economic impact of the 2011 Great East Japan Earthquake through the lens of input-output linkages within production networks. It leverages the earthquake's exogenous and regional characteristics to quantify how such shocks propagate and amplify through supply chains, affecting both direct and indirect suppliers and customers of firms hit by the disaster. Employing a general equilibrium model of production networks, the study estimates the macroeconomic consequences, revealing that the earthquake led to a 0.47 percentage point reduction in Japan's real GDP growth in the year following the disaster. This analysis underscores the significant role of supply chain linkages in the spread and amplification of economic shocks from natural disasters. Finally, Nguyen and Noy (2020) use nightlight data to assess the impact of insurance on urban recovery after earthquakes in New Zealand. They find that higher insurance penetration is associated with faster recovery, particularly in residential areas. The study highlights the role of insurance in disaster resilience and recovery, suggesting potential policy implications for urban disaster management.

Inoue and Todo (2019) use an agent-based model applied to the actual supply chains of nearly one million firms in Japan and assess the direct and indirect effects of the 2011 Great East Japan earthquake. Specifically, in the scenario of the Nankai earthquake, the indirect effects amounted to 10.6 per cent of Japan's gross domestic product, compared to direct effects of only 0.5 per cent. The study further suggests that these indirect effects are more pronounced and persistent in supply chains characterized by scale-free properties, difficulty in substituting among intermediate products, and complex cycles within the networks. Lastly, Reinhardt (2022) shifts the focus to Indonesia, investigating how earthquakes influence inward foreign direct investment (FDI) across 416 districts through a dynamic difference-in-difference model.

This study documents a temporary but drastic reduction in FDI, noting a 90 percent decrease in the initial year following an earthquake, before a gradual return to baseline levels. This is primarily ascribed to disruptions in the upstream industries of the manufacturing sector’s supply chains, illustrating the broader economic vulnerabilities to natural disasters beyond immediate geographical impact zones. Finally, Gignoux and Menéndez (2016) study the long-term economic effects of major earthquakes in rural Indonesia since 1985, using individual-level data and ground tremor measurements. They find that affected individuals recover from initial losses within 2-5 years, even experiencing gains after 6-12 years. This recovery is attributed to asset reconstitution and infrastructure improvements, challenging the concept of poverty traps.

The following section outlines policy responses to major earthquakes, primarily focusing on fiscal policy, monetary policy, and disaster preparedness, while also taking initial conditions into account.

3 Policy responses to major earthquakes

3.1 Fiscal policy

Reconstruction after earthquakes requires actions to support livelihoods immediately following the disaster, alongside policies aimed at rebuilding the local economy over the long term. In the short term, measures encompass relief payments (such as cash transfers) to those affected, increased expenditures to repair water and electricity infrastructure, other public facilities, and to supply temporary housing for displaced individuals. Furthermore, temporary debt or tax relief for impacted businesses and individuals can be provided. Additional assistance may include concessional loans or equity injections to private entities responsible for crucial infrastructure and businesses engaged in housing reconstruction.

For instance, the March 2011 Great East Japan Earthquake led to substantial costs for Japan’s government, amounting to 4 percent of Japan’s 2010 GDP. Funding covered disaster relief, recovery, and reconstruction, utilizing general contingency budgets and supplementary budgets financed through bonds, expenditure cuts, and budget surpluses. The fiscal year 2012 saw additional financing, primarily through reconstruction bonds. Tax relief measures and incentives were part of the reconstruction strategy, sometimes supplemented by subsidies (OECD and World Bank (2019)). The Canterbury earthquakes (2010-11) also significantly affected New Zealand’s fiscal balances, with sharp expenditure increases for damaged assets and liabilities and decreased revenues from taxes and government services (OECD and World Bank (2019)).

However, to prevent inflationary effects and increases in government debt, support measures should target those most in need in directly affected sectors and areas. While average economic impacts of earthquakes are often small, they are concentrated in specific regions or among lower-income groups. Leveraging local resources for reconstruction can maximize benefits, but where local capacity is limited, external resources are crucial for swift rebuilding. Effective coordination across levels and sectors enhances resilience, though challenges exist, such as governance issues and organized crime, which can impede reconstruction efforts (Chen and Hsu (2016), Horwich (2000), Green (2005)).

Rapid disbursement of funds raises risks of corruption and misallocation, where public employees faced accusations of fraud (Leeson and Sobel (2008)). Earthquakes also lead to revenue drops and potential increases in public debt, with government borrowing terms worsening due to perceived fiscal risks. Governments' roles in insuring public or private assets necessitate monitoring fiscal risks closely, as seen in New Zealand's handling of the Canterbury earthquake costs through the Earthquake Commission and government resources (OECD and World Bank (2019), IMF (2016)).

3.2 Monetary policy

The aftermath of natural disasters, including earthquakes, poses a significant challenge for monetary policy. Such events often lead to increased production costs for domestic producers, exerting upward pressure on prices (Heinen et al. (2023), Parker (2018), Pereira (2009)). Consequently, monetary authorities are tasked with striking a delicate balance between mitigating the inflationary impacts of reconstruction efforts and supporting the economy amid the adverse shock (Felbermayr and Gröschl (2014), Fomby et al. (2013), Klomp (2016), Loayza et al. (2012)). Specifically, easing monetary policy when domestic supply is constrained by disaster-induced damage can risk exacerbating inflation. The optimal policy response is a subject of debate: while Keen and Pakko (2011) suggests that the ideal response to natural disasters to increase short-term nominal interest rates in the U.S., White (1997) argues that, given the temporary and localized nature of disaster-induced inflation, monetary policy should lean towards expansion to foster growth.

Typically, the short-term policy interest rate decreases in the year following an earthquake as authorities prioritize economic recovery over price stability (Klomp (2020)). However, in economies with fixed exchange rates, central banks are more inclined to hike interest rates post-disaster to stabilize the currency. Furthermore, Klomp and Sseruyange (2021) observes that post-earthquake inflation rates are generally lower when monetary policy is enacted by a more independent central bank, though this approach may lead to a larger estimated output gap following the disaster.

3.3 Disaster preparedness

Ex-ante measures aimed at assessing the risk of natural disasters and mitigating their impacts can significantly reduce the adverse effects of earthquakes. For example, countries frequently exposed to cyclones tend to experience less economic disruption from such events due to their higher investment in protective infrastructure (Hsiang and Jina (2014)).

These preventative measures encompass zoning and building codes, flood defenses, early warning systems, evacuation planning, and emergency response strategies. Catastrophe modeling, which provides detailed insights into the direct economic impacts of disasters, such as casualties and property damage, can inform evacuation policies, building standards, and flood protection infrastructure design. For instance, flood risk assessments from these models have informed optimal flood protection standards at the country level and influenced building code policies in urban areas, including New York City (Kind (2014), Aerts et al. (2014)). Businesses and households can also adopt proactive measures to mitigate disaster impacts, such as employing

disaster-resilient construction techniques, maintaining adequate inventories of essential production inputs, and developing a broad network of suppliers (Botzen et al. (2019)).

The next section builds on recent literature and applies the synthetic control methodology to provide estimates of the impact of major earthquakes on economic activity. A similar approach was used by Cavallo et al. (2013) to study the effects of natural disasters more generally, Yun and Kim (2022) to look at the impact of Hurricane Katrina in 2005 and Chupilkin and Koczan (2022) to study the economic effects of armed conflict. Complementing these studies, we extend the analysis to other macroeconomic variables, in particular in terms of fiscal impact (the effect of earthquakes and subsequent reconstruction efforts on government expenditure and government debt as a share of GDP) as well as exports and imports.

4 Data and estimation strategy

4.1 Data

The analysis uses data from the NCEI/WDS Global Significant Earthquake Database, focusing on major earthquakes with a magnitude of at least 6 and fatalities constituting at least 0.001 percent of the affected population. The sample encompasses earthquakes in various countries, including Chile, Colombia, Haiti, India, Indonesia, Italy, and Japan, as detailed in Table 1.

To ensure a comprehensive analysis with broad country coverage and diverse variables, we collected data from various sources. GDP per capita data was obtained from the Maddison Project Database, offering insights into long-term economic growth trends. This is supplemented by GDP and government expenditure data from the Penn World Tables, which have been adjusted for purchasing power parity to enable accurate international comparisons. Information on government debt is sourced from the International Monetary Fund’s (IMF) Global Debt Database, which provides extensive historical debt data across various countries. Furthermore, trade data, including exports and imports, are drawn from the IMF’s World Economic Outlook Database. The time frame for our analysis extends from the 1820s to 2016, providing a broad historical perspective.

By incorporating data from a variety of countries, we extend our analysis beyond specific case studies to uncover broader macroeconomic effects of significant earthquakes. This analysis covers a range of economic indicators, including GDP, government expenditures, changes in trade balances, and levels of national debt.

Table 1: Earthquakes of magnitude 6 and above with fatalities of 0.001% of the population or more

Country	Year	Country	Year	Country	Year
Afghanistan	1956	Afghanistan	1982	Afghanistan	1991
Algeria	1980	Algeria	2003	Argentina	1920
Argentina	1944	Bolivia	1998	Chile	1833
Chile	1868	Chile	1877	Chile	1906
Chile	1922	Chile	1939	Chile	1985
Chile	2010	China	2008	Colombia	1923
Colombia	1950	Colombia	1979	Ecuador	1906
Ecuador	1942	Ecuador	1949	Ecuador	1987
El Salvador	1951	El Salvador	1965	El Salvador	2001
Greece	1894	Greece	1932	Greece	1953
Greece	1999	Guatemala	1976	Guatemala	2001
Guinea	1983	Haiti	2010	India	1905
India	1934	India	1993	India	2001
Indonesia	1899	Indonesia	1917	Indonesia	1976
Indonesia	2006	Iran	1990	Iran	1997
Italy	1857	Italy	1915	Italy	1930
Japan	1995	Japan	2011	Mexico	1920
Mexico	1932	Mexico	1973	Mexico	1985
Morocco	2004	New Zealand	1931	New Zealand	2011
Nicaragua	1972	Pakistan	1974	Peru	1913
Peru	1940	Peru	1969	Peru	2007
Philippines	1955	Philippines	1976	Philippines	1990
Romania	1940	Romania	1977	Russia	1995
Spain	1884	Tanzania	1966	Türkiye	1983
Türkiye	1992	Türkiye	1999	Uganda	1966
Venezuela	1894	Venezuela	1950	Venezuela	1967
Yemen	1982				

Source: NCEI/WDS Global Significant Earthquake Database.

Note: The list above includes all earthquakes of at least magnitude 6 and fatalities of 0.001 per cent of the population in the sample where GDP per capita is available for the year of the earthquake, 5 years before and 5 years after. Samples for other variables are smaller: 41 for investment and government spending, 31 for government debt and 22 for exports and imports.

4.2 Estimation strategy: synthetic control method

This subsection presents an overview of the synthetic control method, which was originally proposed by Abadie and Gardeazabal (2003) to estimate the economic effects of terrorist conflict in the Basque Country, and extended in Abadie et al. (2010) to examine the effects of aggregate interventions affecting a relatively small number of economies (or other units of analysis).

The synthetic control method seeks to create a credible counterfactual for an economy without a specific "treatment", such as an earthquake, in this instance. It assumes that no single economy may provide a good comparison and uses a weighted average of various comparator economies selected based on predefined criteria. The contribution of each comparison unit to the counterfactual of interest are explicit, with weights ranging between zero and one (Abadie et al. (2015)). The resulting approach is well suited for cases where the examined series are not too volatile (Abadie (2021)).

Synthetic controls offer advantages relative to comparative case studies, cross-sectional analyses, and time-series analyses. While case studies can draw counterfactuals, synthetic control methods

Table 2: Summary Statistics for the year of the earthquake

Variable	Mean	Median	Std. dev.	Max	Min	Observations
<i>Growth variables, per cent</i>						
Real GDP per capita	1.81	2.17	4.76	12.50	-16.67	79
Export growth	1.79	2.38	8.86	20.70	-15.79	22
Import growth	8.65	7.04	12.61	42.18	-9.46	23
<i>Share of GDP variables, per cent</i>						
Investment	25.36	23.61	5.99	42.43	17.71	23
Government spending	26.78	25.74	9.54	46.55	12.64	17
Government debt	62.83	50.65	50.95	216.98	10.36	31

Note: This table presents summary statistics for the final balanced panel used in the analysis.

formalize the comparison unit selection through a data-driven procedure (Abadie (2021)). In addition, synthetic controls inherently adjust for year fixed effects by comparing economies impacted by specific incidents, such as earthquakes, with those that are not, within the same time frame. Conversely, time series analyses may be affected by other shocks influencing the outcome of interest and by the arbitrary selection of pre-trends.

In our analysis, we investigate the impact of earthquakes on various economic indicators—GDP, GDP per capita, government spending, government debt as a percentage of GDP, and trade balances (exports and imports)—in affected countries. We compare these outcomes against a synthetic comparator: a counterfactual trajectory derived from similar economies that did not experience earthquakes during the relevant period. This approach allows us to estimate the changes that would be expected in the absence of such events.

To construct a synthetic control country, we use a combination of countries that did not experience earthquakes. This synthetic country mirrors the key economic characteristics of the earthquake-affected country prior to the event, including GDP per capita at purchasing power parity (PPP), population, population density, and the pre-earthquake growth rate of the variable of interest. We then compare the economic trajectory of this “counterfactual” country—without an earthquake—to the actual post-earthquake economic developments of the affected country

More formally, we observe $j = 1, \dots, J + 1$ aggregate units (in this case countries), for $t = 1, \dots, T$ periods. The first unit ($j = 1$) experiences an earthquake (the ‘treatment’) at time $t = T_0 + 1$ with $T_0 + 1 \leq T$. Countries used to construct a synthetic control do not experience an earthquake (no ‘treatment’). We aim to estimate the effect of the earthquake (and implicitly that of any subsequent reconstruction) on GDP and other macroeconomic variables during the year of the earthquake and subsequent years, $T_0 + 1, \dots, T$.

The effects of the earthquake are examined using a model of potential outcomes. Y_{jt}^N denotes the potential outcome observed for unit $j \in \{1, \dots, J + 1\}$ and time $t = 1, \dots, T$ in the absence of an earthquake. Y_{1t}^I denotes the potential outcome observed for the country with the earthquake (the ‘treated’ unit) at time $t = T_0 + 1, \dots, T$ under the ‘intervention’ (earthquake). $T_0 + 1$ refers to the year of the earthquake, T to the fifth year after. For each unit and time period, Y_{jt} is the observed outcome. Therefore, observed outcomes for untreated units, $j = 2, \dots, J + 1$, are equal to Y_{jt}^N . For the treated unit, the observed outcome is equal to Y_{1t}^N for $t = 1, \dots, T_0$ and equal to

Y_{1t}^I for $t = T_0 + 1, \dots, T$. The object of interest is the treatment effect on the treated unit, that is the impact of the earthquake on the country experiencing the earthquake, $\tau_t = Y_{1t}^I - Y_{1t}^N$ for $t = T_0 + 1, \dots, T$. A synthetic control estimator of Y_{1t}^N is a weighted average of the outcomes of the ‘donor pool’ of J untreated units (economies without earthquakes), $\hat{Y}_{1t}^N = \sum_{j=2}^{J+1} W_j Y_{jt}$ where W_2, \dots, W_{J+1} are non-negative and sum to one. These weights represent the contribution of each untreated observation to the estimate of the counterfactual of interest, \hat{Y}_{1t}^N .

The goal of the synthetic control is to approximate the trajectory that would have been observed for Y_{1t} and $t > T_0$ in the absence of the earthquake. The set of weights are thus selected in a way that the resulting synthetic control closely resembles the treated unit before the intervention along the values of the predictor (Abadie (2021)).

A synthetic control estimator of $\hat{\tau}_t$ is equal to the difference between the outcome values for the treated units (countries experiencing earthquakes) and the outcome values for the synthetic control (see Equation 1).

$$\hat{\tau}_t = Y_{1t} - \sum_{j=2}^{J+1} W_j Y_{jt} \quad (1)$$

Synthetic controls come with certain limitations that must be acknowledged upfront (for a comprehensive review of the methodology, see Abadie (2021)). Firstly, the effectiveness of synthetic controls hinges on the premise that the constructed control unit accurately mirrors the counterfactual scenario; failure to meet this condition can result in skewed estimates. Additionally, the method’s feasibility is limited by the need for appropriate donor units to construct the synthetic control, which can be particularly challenging in contexts involving rare events. The choice of predictor variables and the determination of their weights may also lead to issues with sensitivity and the risk of overfitting. Moreover, synthetic controls necessitate extensive pre-treatment data, which may restrict their use for analyzing recent events. Unlike traditional methods, synthetic controls do not yield confidence intervals or the statistical measures commonly employed in hypothesis testing. Lastly, although synthetic controls aim to adjust for unobserved heterogeneity, they cannot fully eliminate the influence of unmeasured confounding factors.

Nevertheless, these limitations do not significantly impact our research objectives for several reasons. Given our focus on general macroeconomic trends post-earthquake, the donor pool is sufficiently large to accommodate all events in our study. Our predictor variables only include fundamental factors such as GDP per capita, population, population density alongside growth of the variable of interest which prevents the matching process from being driven by idiosyncratic factors. Finally, after aggregating the results we observe that the pre-earthquake GDP per capita index of the treated group deviates from the control group by less than one percentage point, indicating parallel trends.

The Synthetic Control Methodology (SCM) is better suited for our research goals than the Difference-in-Differences (DID) approach for several reasons. First, SCM is more apt in constructing a control group for countries affected by earthquakes than DID. Using all countries as a control group in the DID model is likely to violate the parallel trends assumptions, while

SCM constructs the closest counterfactual possible. Second, SCM is more adapt in showing the over-time effects of earthquakes while DID requires a clear before and after distinction. Finally, the main strength of SCM is its clear interpretability which we think it especially important for the policy-relevant topic such as economic consequences of earthquakes. SCM does not provide a simple coefficient but shows a clear path of the average affected country illustration both immediate and medium-term effects.

4.3 Impact of earthquakes: economic growth and investment

In this subsection, we discuss the findings from 79 large earthquakes in 33 countries. Using the synthetic control method previously detailed, we assess the economic performance of the affected countries against that of similar economies that did not experience such natural disasters.

In the year following an earthquake, GDP per capita is, on average, 0.2 percentage points lower in earthquake-affected economies compared to similar economies without such events. However, this difference is short-lived and not statistically significant, as shown in Figure 1, top left panel. The impact on GDP itself is even smaller and statistically insignificant. These findings align with previous research on the broader effects of natural disasters (Cavallo et al. (2013)), suggesting that reconstruction efforts may mitigate some economic disruptions caused by earthquakes. Notably, investment rates are observed to rise by approximately 2 percentage points of GDP after an earthquake, moving from an average of 20 to 22 percent (1, top right panel). This increase persists over time and statistically significant at the 10 percent level.

4.4 Impact of earthquakes: fiscal accounts

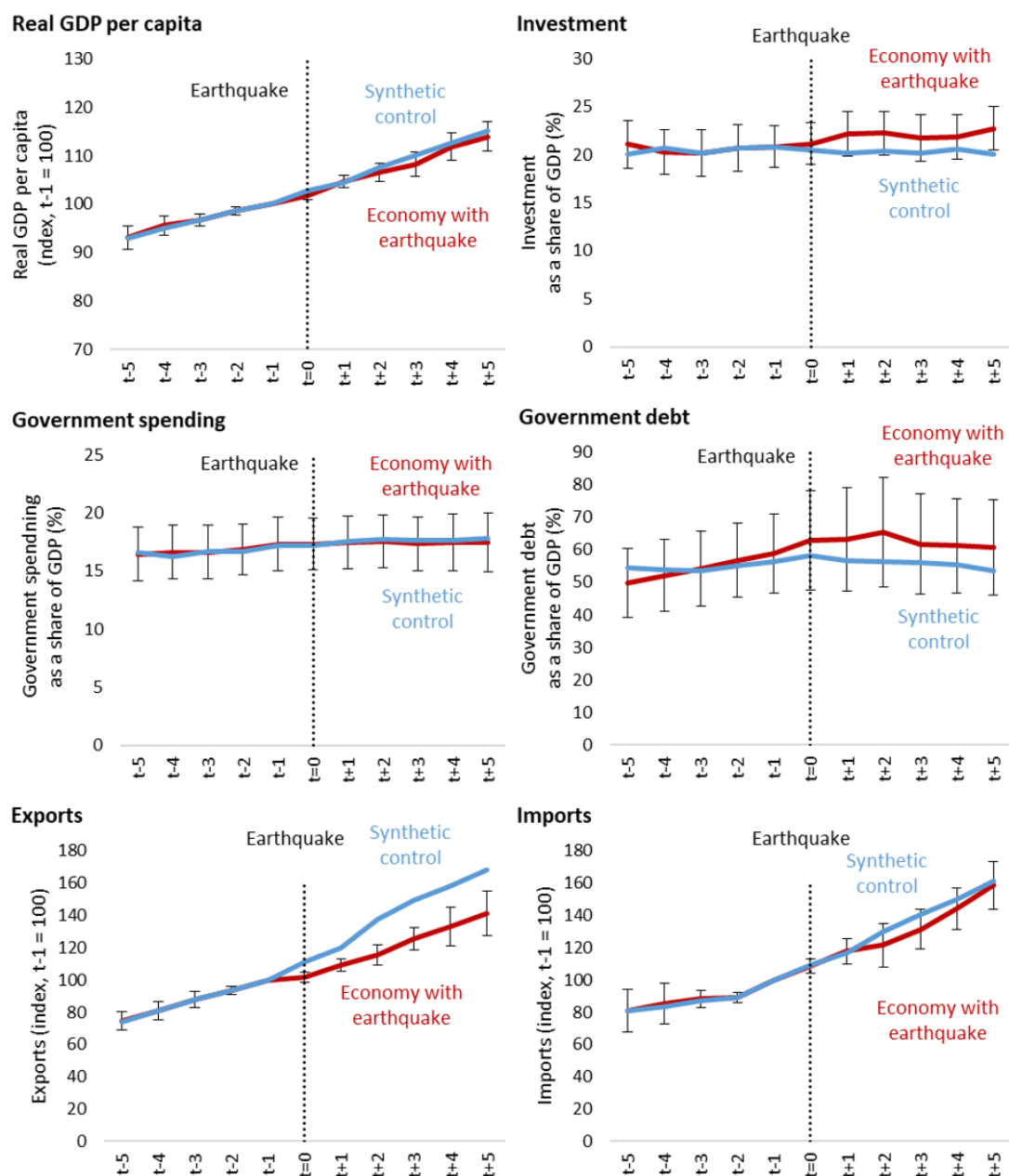
Fiscal policy often follows a counter-cyclical approach, where government spending as a percentage of GDP generally stays constant, even in the face of declining revenue. This situation results in higher government debt-to-GDP ratios. For instance, after the 2011 earthquake in Japan, which led to an estimated 0.9 percent decrease in real GDP, government expenditures increased by 1.2 percentage points of GDP, and the debt-to-GDP ratio grew by 16 percentage points (Smith (2012)).

However, our estimates suggest that these patterns do not hold universally. The large standard errors in our small sample underscore the wide variation in individual country experiences. Many countries, constrained by limited fiscal capacity, may depend heavily on external aid for financing reconstruction efforts. In some cases, debt levels in economies actually fall in the years after earthquakes. Consequently, the estimated effects between countries affected by earthquakes and their synthetic controls are not statistically significant (Figure 1, middle panel).

4.5 Impact of earthquakes: international trade

As discussed earlier, earthquakes can significantly impact trade connections. Loss of life (impacting firms' human capital), destruction of physical capital of exporters, and damage to public infrastructure such as roads, bridges, railways, telecommunications networks, and the electricity system can adversely affect exports by disrupting supply chains and reducing production capacity. For example, after the 1987 earthquake in Ecuador, exports declined by

Figure 1: Estimates of the economic impact of earthquakes



Source: IMF Global Debt Database, IMF World Economic Outlook Database, Maddison Tables, Penn World Tables and authors' calculations.

Note: For all figures, synthetic control denotes a counterfactual growth path based on the evolution of the variable of interest in a weighted average of economies that were similar to the economy experiencing the earthquake in terms of GDP per capita, population, population density and growth of the variable of interest. 90 per cent confidence intervals shown.

16 percent, following an average growth of 6 percent in the five years before the earthquake. Similarly, after the 2011 earthquake, Japan's exports dropped by 0.1 percent, compared to an average growth of more than 4 percent in the preceding five years.

Our synthetic control analysis suggests that these patterns are generally applicable. Specifically, exports from countries affected by earthquakes are estimated to be around 16 percent lower than

those of their synthetic counterparts five years post-earthquake. These effects are significant, persistent, and statistically significant, even with a small sample size (Figure 1, bottom panel). The impact of earthquakes on imports is less clear-cut: while disruptions to domestic production and reductions in disposable income might decrease import demand, reconstruction efforts could increase the demand for imported construction materials and machinery. The synthetic control analysis supports the existence of these mixed effects. The average estimates for imports are relatively minor, not statistically significant, and short-lived, likely due to considerable variation in the import intensity of reconstruction activities across different earthquake events (Figure 1, bottom panel)

5 Case studies: insights across development levels

5.1 Case selection

This section evaluates the effectiveness of policy measures in response to earthquakes by reviewing and contrasting the economic policies, disaster relief initiatives, and rebuilding strategies implemented after three major earthquakes: the 1999 earthquake in Türkiye, the 2010 earthquake in Haiti, and the 2011 earthquake in Japan. The 1999 Marmara earthquake in Türkiye, with a magnitude of 7.6, led to approximately 17,000 deaths and substantial economic losses, mainly from damage to infrastructure and housing. The earthquake in Haiti in 2010, which was of a similar magnitude of 7.0, caused over 200,000 deaths and severely affected Haiti’s GDP due to the devastation of parts of its capital city. The 2011 earthquake in Japan, a potent event of magnitude 9.0, resulted in about 15,000 deaths and substantial damage to crucial industries.

These examples illustrate how countries at varying stages of development confront distinct challenges in disaster response. Türkiye, as a middle-income country, possesses a developed industrial sector and state capabilities but faces typical challenges of a middle-income country, such as bureaucratic obstacles and issues with policy implementation. Haiti, representing low-income nations, suffered amplified effects of the disaster due to a significant shortfall in state capacity. Japan, despite being a high-income country with advanced institutions, also faced difficulties in disaster management and introduced reforms to improve future responses.

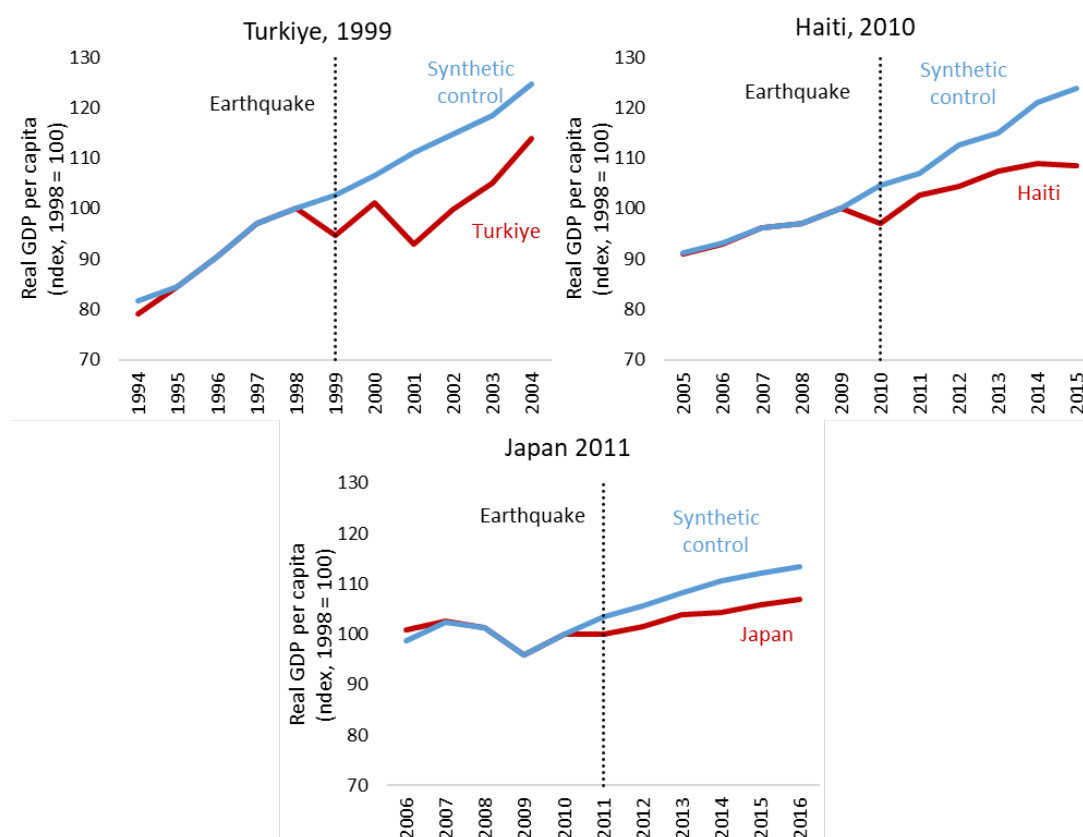
5.2 Synthetic control estimates

We initially offer synthetic control estimates of real GDP per capita for each of the three instances. Following that, we delve into the policies implemented by these countries after the earthquakes and evaluate their effectiveness based on evidence from multiple studies.

Figure 2 displays the results, showing that all three earthquakes had a significant negative impact on the real income of the affected countries. In Türkiye, real GDP per capita in 1999 was 7.8 percent lower than it might have been without the earthquake. In Haiti, the figure was 7.2 percent lower, and in Japan, it was 3.5 percent lower. Reconstruction efforts in the year following the earthquake narrowed the gap to 5 percent in Türkiye and 3.9 percent in Haiti, while in Japan, the gap slightly widened to 3.8 percent. However, the gap further expanded for all three countries afterward, though for different reasons. In Türkiye, the widening was likely

due to the financial crisis of 2001; in Haiti, it was due to unsuccessful reconstruction efforts and declining state capacity; and in Japan, it was attributed to prolonged economic stagnation.

Figure 2: Real GDP per capita



Source: Maddison Tables and authors' calculations.

5.3 Policy measures in response to earthquakes

Policy responses are outlined in Table 3, highlighting five key insights. First, immediate economic support and emergency response are crucial to assist affected populations and businesses, preventing further deterioration. Second, the scope of response is limited by pre-disaster fiscal conditions and the country's socioeconomic status, necessitating context-specific expectations. Third, while international aid can relieve immediate post-disaster pressures, effective reconstruction should be led by local governments, supported but not dominated by foreign entities. Fourth, it's important to prevent temporary emergency measures from becoming entrenched and persisting beyond their intended short-term duration. Finally, disaster relief and reconstruction efforts demand coordinated action among all stakeholders, including those unfamiliar with working together, with a central agency ensuring clear communication and efficient management of resources.

Table 3: Policy Responses to Earthquakes in Türkiye 1999, Haiti 2010, and Japan 2011

Policy	Türkiye 1999	Haiti 2010	Japan 2011	Effectiveness (General Notes)
Macroeconomics				
Fiscal Policy	Fiscal stimulus through government spending on reconstruction of housing and infrastructure. Introduction of the earthquake tax to fund reconstruction.	Limited fiscal response due to budget constraints. Large reliance on international aid.	Large-scale stimulus for reconstruction of infrastructure funded by bonds and loans; cuts in other expenditures; budgetary surplus from previous year	Fiscal stimuli are crucial for post-disaster but must be fiscally sustainable. High debt levels pre-earthquake can constrain policy options
Monetary Policy	Limited interest rate cuts	Monetary easing was limited in order to restrain inflationary risks	Aggressive monetary easing through asset purchase expansion and liquidity provision	Monetary policy can provide necessary liquidity and encourage investment, but effectiveness depends on the pre-disaster macroeconomic environment
Exchange Rate Policy	Moved to the currency board arrangement in end of 1999.	Limited exchange rate volatility due to a build up of international reserves	Intervention in currency markets to weaken the yen and boost export competitiveness	Flexible exchange rate regimes may absorb shocks better, but interventions might be needed to prevent harmful volatility
Economic Support	Deferral of all tax payments and subsidised credit through state banks for affected businesses and individuals.	Cash-for-work programs in debris removal, road repair, and construction of temporary shelters.	Tax exemptions and reductions in affected areas	Direct support to affected population and businesses is often needed as a primary measure.
Emergency Relief				
Emergency Response	Quick military deployment.	Slow and uncoordinated response.	Rapid deployment of Self-Defense Forces.	Military involvement is generally effective for immediate response but requires good coordination with civilian efforts
Relief Coordination	Establishment of crisis center.	Heavy reliance on international aid agencies.	Creation of a centralized disaster management agency.	Centralized coordination improves efficiency but must be adaptable to local needs
Housing	Temporary housing followed by permanent solutions.	Prolonged use of temporary shelters more than a year after the earthquake.	Rapid provision of prefabricated housing.	Temporary housing is critical but must be paired with a clear and timely transition to permanent housing to avoid long-term displacement issues
Health Services	Field hospitals and mental health services.	Deployment of field hospitals by NGOs.	Resilient health care system pre-disaster.	Pre-disaster healthcare resilience and post-disaster health services are crucial for long-term recovery
Public Order and Safety	Use of military to prevent looting.	Increase in looting, violence, and sexual crime. UN peacekeepers to maintain order.	Low crime rates; focus on safety inspections.	Maintaining public order is easier in societies with higher pre-disaster social capital but requires international support in others
Reconstruction				
Infrastructure Rebuilding	Government-led reconstruction with some private sector involvement	Outsourced to international NGOs; slow reconstruction.	Extensive use of public-private partnerships in infrastructure and housing	Government-private partnerships can expedite rebuilding but need proper oversight to ensure equitable and efficient reconstruction
International Utilization	Selective acceptance of international aid.	Heavy reliance on and mismanagement of aid.	Selective acceptance of international aid.	Effectiveness of international aid varies; proper management and alignment with local priorities are essential
Structural Reforms	Mandate for earthquake insurance, reforms in housing codes and disaster management policies.	Efforts to decentralize and strengthen governance were slow.	Switching from nuclear power to fossil fuel power, reforms to nuclear safety standards.	Structural reforms are essential for long-term resilience but may face implementation challenges due to political and social constraints

Source: Authors.

Note: The list above is based on the authors' analysis of the news reports, UN news and OECD and World Bank (2019), Bank for International Settlements (2011), Bibbee et al. (2000), Best and Burke (2019)

5.4 Economic measures

The fiscal response is crucial in the aftermath of an earthquake, encompassing two main aspects: spending and financing the expenditures. It's vital for the government to accurately identify the areas most in need of fiscal stimulus to maximize the benefits of reconstruction, alongside establishing sustainable funding methods for this spending. For instance, in Türkiye, the 1999 earthquake led to the introduction of an earthquake tax to fund reconstruction efforts. In Japan, the fiscal stimulus in 2011 was financed through a combination of bond issuance, direct loans, reallocating funds from other government expenses, and utilizing the budgetary surplus from the 2010 budget. Haiti's experience in 2010 highlighted the importance of pre-disaster economic sustainability. Constrained by significant budgetary limitations and limited fiscal capacity, Haiti was unable to implement the necessary fiscal stimulus, heavily depending on international aid instead.

Moreover, fiscal stimulus can be supported by an active monetary policy. After the 2011 earthquake, the Bank of Japan embarked on aggressive monetary easing and liquidity provision, which helped stabilize the financial system.

A country's finances might also suffer from exchange rate volatility due to internal and external pressures. In Japan in 2011, the anticipation that Japanese insurance companies would need to convert US dollars to yen led to the yen's sharp appreciation against the dollar, necessitating an intervention by the Bank of Japan to stabilize the exchange rate Bank for International Settlements (2011).

Finally, direct economic support to earthquake victims is imperative. Both individuals and businesses affected by the disaster often find themselves in vulnerable positions, and government support is crucial for sustaining their livelihoods. Common measures, such as tax deferrals and exemptions, have been implemented in Türkiye in 1999 and Japan in 2011. In Haiti, where direct support was essential, the UN launched cash-for-work programs to provide short-term employment opportunities in debris removal, road repair, and the construction of temporary shelters, helping to mitigate the disaster's effects.

5.5 Emergency relief

The first action required from the government is a rapid emergency response, as the scale of destruction from earthquakes often surpasses the capabilities of standard emergency services. A successful strategy, as seen in Türkiye in 1999, involves leveraging military personnel for immediate tasks such as search and rescue and medical aid, as well as for medium-term needs like establishing temporary shelters and providing transportation. Japan, in 2011, similarly utilized its defense forces, including for the Fukushima nuclear crisis management. After Haiti's 2010 earthquake, the shortfall in local forces necessitated the deployment of foreign military units, including the US military and UN peacekeeping forces. However, involving multiple forces from various countries can complicate coordination and delay the response.

The coordination challenge underscores the importance of a centralized disaster management agency. Japan's response to the 2011 earthquake exemplifies effective coordination, facilitated by its pre-existing disaster management agency, through the establishment of a crisis center. This

existing infrastructure enabled Japan to swiftly and effectively coordinate the efforts of various actors in disaster response, which is particularly crucial for organizing international agencies that often have overlapping mandates and unclear communication hierarchies.

One of the primary issues created by the earthquake is destruction of housing. Provision of temporary shelters is the most common direct response to alleviate the problem in the short-term. However, the key issue is providing more stable housing in the medium-term. Japan has offered the exemplary response to the 2011 earthquake by establishing pre-fabricated housing and moving affected families from temporary shelters sometimes as early as one month after the earthquake. The pre-fabricated housing was also considered a temporary solution prior to finding a long-term home for the affected family. Türkiye has also responded to the 1999 earthquake by building new housing with a specific mandate to make newly built homes earthquake resistant. While the program was successful, it faced issues with delays and quality. Haiti's response to housing is the main cautionary tale. As the government did not have enough resources and state capacity to quickly build new homes for the affected population. As a result, some families remained in temporary shelters for several years after the earthquake.

Health services are also fundamental for an efficient disaster response. The primary issue is that hospitals in the affected areas are often destroyed or can sustain only limited response due to damage to important infrastructure. Available hospitals including hospitals in the neighbouring areas are often rapidly overwhelmed with the victims from the disaster. The damage and overwhelming of healthcare facilities has been an issue in all three of the studied cases. Due to generally higher level of development and protocols for disaster response, Japan has been the most successful in addressing the challenge by setting up temporary clinics and providing emergency healthcare response in the affected areas. Türkiye's medical system has been overwhelmed by the earthquake and required substantial support from international medical teams. In Haiti the destruction of major health facilities and the generally less developed state of healthcare resulted in direct consequences of the earthquake transforming into further health crises such as outbreak of cholera.

The final issue critical for emergency relief is preserving order and safety. Natural disasters often lead to increase in crime such as violence, sexual crime, and looting. Enforcing public safety in the affected areas is key for the success of overall emergency response. One option is to extend the military involvement to policing. This measure has been implemented in Türkiye in 1999 which resulted in no significant disruptions to public order. In Haiti the situation has rapidly unravelled reflecting limited state capacity and destruction of existing policing structures. The earthquake resulted in the public order crisis including widespread looting, crime, and sexual violence including in the temporary shelters.

5.6 Reconstruction

Reconstruction is a critical medium- to long-term response to earthquakes, focusing primarily on infrastructure rebuilding. Governments often seize the opportunity during reconstruction to implement stricter building codes, a strategy explicitly adopted by Türkiye following the 1999 earthquake. Financing the reconstruction is another vital aspect, with Japan's use of extensive public-private partnerships (PPPs) for major infrastructure projects like the Sendai Airport,

energy grid, and housing construction being a notable success. However, pre-existing policy challenges can hinder reconstruction efforts, as seen in Haiti’s slow rebuilding process after the 2010 earthquake, partly due to unclear land ownership issues.

International aid can significantly contribute to reconstruction funds and efforts. However, Haiti’s experience demonstrates that such aid can also create long-term complications. In Haiti, aid was funneled directly through international organizations rather than the government, rendering the reconstruction efforts less efficient (Schuller (2012)). This approach led to several problems: the lack of coordination among agencies resulted in the absence of a comprehensive reconstruction plan; international organizations often prioritized short-term relief, which aligned with their mandates, over long-term reconstruction; and the heavy reliance on foreign aid sidelined the government, contributing to a further decline in state capacity.

Finally, reconstruction often necessitates structural reforms. The case studies of all three countries highlight implemented reforms in disaster management and response. These reforms included the establishment of a new disaster management agency in Türkiye, the creation of a reconstruction commission in Haiti, and the revision of disaster response plans in Japan. Furthermore, each country has sought to enact reforms in building codes and urban planning. While Türkiye and Japan saw success in these reforms, implementation in Haiti has fallen short. Additionally, specific areas affected by the earthquake prompted targeted structural reforms: Japan significantly revised its nuclear energy regulations, and Haiti initiated a plan to decentralize its economy, moving focus away from Port-au-Prince, which was severely impacted by the earthquake.

6 Conclusion

We provide an overview of the economic effects of earthquakes, building on newly analysed evidence from 79 major earthquakes. The analysis points to a small impact on GDP, and a large variance in outcomes across economies, as initial conditions and policy response largely determine the extent to which the boost from reconstruction activities can offset the effect of the disruption to production. The impact on fiscal accounts can be large, though experiences also vary widely across economies. External trade balances, on the other hand, tend to weaken significantly, with substantially lower exports and an ambiguous impact on imports. This highlights the importance of international assistance that can help offset the adverse impact of the earthquake on external accounts (as well as the fiscal position in cases where fiscal space is more limited).

In conclusion, the evidence emphasizes the critical need for immediate financial support and emergency responses to assist affected communities and businesses, thus preventing further setbacks. It shows that the scale of response is shaped by the financial health of a country before the disaster struck. Additionally, the role of international aid is undeniably crucial mitigating the immediate impacts of a disaster, yet it’s essential that reconstruction efforts are primarily led by local governments to ensure aid supports rather than overshadows their efforts. Importantly, measures taken in response to a disaster must be carefully managed to avoid becoming long-term solutions beyond their initial emergency purpose. Finally, successful disaster relief and rebuilding demand cohesive and well-coordinated collaboration across various stakeholders, even those not

typically accustomed to working together, under the guidance of a central authority to ensure clear communication and effective resource management.

References

- Abadie, Alberto (2021) ‘Using synthetic controls: Feasibility, data requirements, and methodological aspects.’ *Journal of Economic Literature* 59(2), 391–425
- Abadie, Alberto, Alexis Diamond, and Jens Hainmueller (2010) ‘Synthetic control methods for comparative case studies: Estimating the effect of California’s tobacco control program.’ *Journal of the American Statistical Association* 105(490), 493–505
- (2015) ‘Comparative politics and the synthetic control method.’ *American Journal of Political Science* 59(2), 495–510
- Abadie, Alberto, and Javier Gardeazabal (2003) ‘The economic costs of conflict: A case study of the basque country.’ *American Economic Review* 93(1), 113–132
- Aerts, Jeroen C. J. H., W. J. Wouter Botzen, Kerry Emanuel, Ning Lin, Hans de Moel, and Erwann O. Michel-Kerjan (2014) ‘Evaluating flood resilience strategies for coastal megacities.’ *Science* 344(6183), 473–475
- Aguirre, Pablo, Kenzo Asahi, Diego Diaz-Rioseco, Ignacio Riveros, and Rodrigo O. Vald’es (2023) ‘Medium-run local economic effects of a major earthquake.’ *Journal of Economic Geography* 23(2), 277–297
- Andrabi, Tahir, and Jishnu Das (2017) ‘In aid we trust: Hearts and minds and the Pakistan earthquake of 2005.’ *The Review of Economics and Statistics* 99(3), 371–386
- Bank for International Settlements (2011) ‘International banking and financial market developments.’ BIS Quarterly Review, Bank for International Settlements, June
- Barone, Guglielmo, and Sauro Mocetti (2014) ‘Natural disasters, growth and institutions: A tale of two earthquakes.’ *Journal of Urban Economics* 84, 52–66
- Beine, Michel, Gary Charness, Anaud Dupuy, and Majlinda Joxhe (2020) ‘Shaking things up: On the stability of risk and time preferences.’ Technical Report
- Belloc, Marianna, Francesco Drago, and Roberto Galbiati (2016) ‘Earthquakes, Religion, and Transition to Self-Government in Italian Cities.’ *The Quarterly Journal of Economics* 131(4), 1875–1926
- Best, Rohan, and Paul J. Burke (2019) ‘Macroeconomic impacts of the 2010 earthquake in haiti.’ *Empirical Economics* 56, 1647–1681
- Bibbee, Alexandra, Rauf Gönenç, Scott Jacobs, Josef Konvitz, and Robert Price (2000) ‘Economic effects of the 1999 Turkish earthquakes: An interim report.’ OECD Economics Department Working Paper 247
- Botzen, W., Olivier Deschenes, and Mark Sanders (2019) ‘The economic impacts of natural disasters: A review of models and empirical studies.’ *Review of Environmental Economics and Policy* 13, 167–188

- Brancati, Dawn (2007) ‘Political aftershocks: The impact of earthquakes on intrastate conflict.’ *Journal of Conflict Resolution* 51(5), 715–743
- Cao, Yiming (2023) ‘Institutional weakness and societal vulnerability: Evidence from the Sichuan earthquake.’ Conference Paper, National Bureau of Economic Research
- Carlin, Ryan E., Gregory J. Love, and Elizabeth J. Zechmeister (2014) ‘Trust shaken: Earthquake damage, state capacity, and interpersonal trust in comparative perspective.’ *Comparative Politics* 46(4), 419–437
- Caruso, Germán, and Sebastian Miller (2015) ‘Long run effects and intergenerational transmission of natural disasters: A case study on the 1970 Ancash earthquake.’ *Journal of Development Economics* 117, 134–150
- Carvalho, Vasco M, Makoto Nirei, Yukiko U Saito, and Alireza Tahbaz-Salehi (2020) ‘Supply Chain Disruptions: Evidence from the Great East Japan Earthquake.’ *The Quarterly Journal of Economics* 136(2), 1255–1321
- Cavallo, Eduardo, Sebastian Galiani, Ilan Noy, and Juan Pantano (2013) ‘Catastrophic natural disasters and economic growth.’ *The Review of Economics and Statistics* 95(5), 1549–1561
- Cerqua, Augusto, Chiara Ferrante, and Marco Letta (2023) ‘Electoral earthquake: Local shocks and authoritarian voting.’ *European Economic Review*
- Chang, Dongfeng, Qiannan Liu, Wanlin Liu, and Peng Zhang (2023) ‘The intergenerational transmission of risk preference: Evidence from parental earthquake experiences.’ Working Paper, Social Sciences Research Network
- Chen, Kevin Z., and Claire Hsu (2016) ‘Summary and looking ahead.’ In *Earthquake lessons from China: Coping and rebuilding strategies*, ed. Kevin Z. Chen, Qiang Zhang, and Claire Hsu IFPRI book chapters (International Food Policy Research Institute (IFPRI)) chapter 6, pp. 115–120
- Chupilkin, Maxim, and Zsoka Koczan (2022) ‘The economic consequences of war: Estimates using synthetic controls.’ Working Paper 271, European Bank for Reconstruction and Development
- Cipollone, Piero, and Alfonso Rosolia (2007) ‘Social interactions in high school: Lessons from an earthquake.’ *American Economic Review* 97(3), 948–965
- Crespo Cuaresma, Jes’us, Jaroslava Hlouskova, and Michael Obersteiner (2008) ‘Natural disasters as creative destruction? Evidence from developing countries.’ *Economic Inquiry* 46(2), 214–226
- DuPont, William, and Ilan Noy (2015) ‘What happened to Kobe? A reassessment of the impact of the 1995 earthquake in Japan.’ *Economic Development and Cultural Change*
- Eldemerdash, Nadia, and Steven Landis (2023) ‘The divergent effects of remittance transfers for post-disaster states.’ *Economics of Disasters and Climate Change* 7, 1–19

- Escaleras, Monica, Nejat Anbarci, and Charles A. Register (2007) ‘Public sector corruption and major earthquakes: A potentially deadly interaction.’ *Public Choice* 132(1/2), 209–230
- Fabian, Marius, Christian Lessmann, and Tim Sofke (2019) ‘Natural disasters and regional development – the case of earthquakes.’ *Environment and Development Economics* 24, 1–27
- Felbermayr, Gabriel, and Jasmin Gröschl (2014) ‘Naturally negative: The growth effects of natural disasters.’ *Journal of Development Economics* 111, 92–106. Special Issue: Imbalances in Economic Development
- Fomby, Thomas, Yuki Ikeda, and Norman V. Loayza (2013) ‘The growth aftermath of natural disasters.’ *Journal of Applied Econometrics* 28(3), 412–434
- Freund, Caroline, Aaditya Mattoo, Alen Mulabdic, and Michele Ruta (2022) ‘Natural disasters and the reshaping of global value chains.’ *IMF Economic Review* 70(3), 590–623
- Fujiki, Hiroshi, and Cheng Hsiao (2015) ‘Disentangling the effects of multiple treatments—Measuring the net economic impact of the 1995 great Hanshin-Awaji earthquake.’ *Journal of Econometrics* 186(1), 66–73
- Gao, Ming, Yu-Jane Liu, and Yushui Shi (2020) ‘Do people feel less at risk? Evidence from disaster experience.’ *Journal of Financial Economics* 138(3), 866–888
- Gignoux, Jérémie, and Marta Menéndez (2016) ‘Benefit in the wake of disaster: Long-run effects of earthquakes on welfare in rural indonesia.’ *Journal of Development Economics* 118, 26–44
- Green, Penny (2005) ‘Disaster by Design: Corruption, Construction and Catastrophe.’ *The British Journal of Criminology* 45(4), 528–546
- Hanaoka, Chie, Hitoshi Shigeoka, and Yasutora Watanabe (2018) ‘Do risk preferences change? Evidence from the Great East Japan Earthquake.’ *American Economic Journal: Applied Economics* 10(2), 298–330
- Heinen, Andréas, Jeetendra Khadan, and Eric Strobl (2023) ‘The price impact of extreme weather in developing countries.’ *The Economic Journal* p. Forthcoming
- Hoeppe, Peter (2016) ‘Trends in weather related disasters – Consequences for insurers and society.’ *Weather and Climate Extremes* 11, 70–79
- Horwich, George (2000) ‘Economic lessons of the Kobe earthquake.’ *Economic Development and Cultural Change* 48(3), 521–542
- Hsiang, Solomon M., and Amir S. Jina (2014) ‘The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones.’ NBER Working Papers 20352, National Bureau of Economic Research, Inc, July
- Huang, Lulu, Qiannan Liu, and Yugang Tang (2024) ‘Long-term economic impact of disasters: Evidence from multiple earthquakes in China.’ *World Development*

- IMF (2016) ‘Analyzing and managing fiscal risks: Best practices.’ Policy Paper, International Monetary Fund
- Inoue, Hiroyasu, and Yasuyuki Todo (2019) ‘Firm-level propagation of shocks through supply-chain networks.’ *Nature Sustainability* 2, 1–7
- Joseph, Iverson-Love (2022) ‘The effect of natural disaster on economic growth: Evidence from a major earthquake in Haiti.’ *World Development* 159, 106053
- Keen, Benjamin D., and Michael R. Pakko (2011) ‘Monetary policy and natural disasters in a DSGE model.’ *Southern Economic Journal* 77(4), 973–990
- Kind, J.M. (2014) ‘Economically efficient flood protection standards for the Netherlands.’ *Journal of Flood Risk Management* 7(2), 103–117
- Klomp, Jeroen (2016) ‘Economic development and natural disasters: A satellite data analysis.’ *Global Environmental Change* 36, 67–88
- (2020) ‘Do natural disasters affect monetary policy? A quasi-experiment of earthquakes.’ *Journal of Macroeconomics* 64, 103164
- Klomp, Jeroen, and John Sseruyange (2021) ‘Earthquakes and economic outcomes: Does central bank independence matter?’ *Open Economies Review* 32(2), 335–359
- Leeson, Peter T., and Russell S. Sobel (2008) ‘Weathering corruption.’ *The Journal of Law Economics* 51(4), 667–681
- Loayza, Norman V., Eduardo Olaberría, Jamele Rigolini, and Luc Christiaensen (2012) ‘Natural disasters and growth: Going beyond the averages.’ *World Development* 40(7), 1317–1336
- Masiero, Giuliano, and Michael Santarossa (2021) ‘Natural disasters and electoral outcomes.’ *European Journal of Political Economy* 67, 101983
- Nguyen, Cuong N., and Ilan Noy (2020) ‘Measuring the impact of insurance on urban earthquake recovery using nightlights.’ *Journal of Economic Geography* 20(3), 857–877
- OECD and World Bank (2019) ‘Fiscal resilience to natural disasters: Lessons from country experiences.’ Technical Report, OECD
- Parker, Miles (2018) ‘The impact of disasters on inflation.’ *Economics of Disasters and Climate Change* 2, 1–28
- Pathak, Prakash, and Matthias Schündeln (2022) ‘Social hierarchies and the allocation of development aid: Evidence from the 2015 earthquake in Nepal.’ *Journal of Public Economics*
- Paudel, Jayash, and Hanbyul Ryu (2018) ‘Natural disasters and human capital: The case of Nepal’s earthquake.’ *World Development* 111, 1–12
- Pereira, Alvaro S. (2009) ‘The opportunity of a disaster: The economic impact of the 1755 Lisbon earthquake.’ *The Journal of Economic History* 69(2), 466–499

- Porcelli, Francesco, and Riccardo Trezzi (2019) ‘The impact of earthquakes on economic activity: Evidence from Italy.’ *Empirical Economics* 56(4), 1167–1206
- Rahman, Muhammad, Nejat Anbarci, Prasad Bhattacharya, and Mehmet Ulubasoglu (2016) ‘The shocking origins of political transitions: Evidence from earthquakes: The shocking origins of political transitions.’ *Southern Economic Journal*
- Reinhardt, Robert (2022) ‘Shaking up foreign finance: FDI in a post-disaster world.’ Documents de travail du Centre d’Economie de la Sorbonne 22024, Université Panthéon-Sorbonne (Paris 1), Centre d’Economie de la Sorbonne, December
- Schuller, Mark (2012) *Killing with kindness: Haiti, international aid, and NGOs* (Rutgers University Press)
- Skidmore, Mark, and Hideki Toya (2002) ‘Do natural disasters promote long-run growth?’ *Economic Inquiry* 40(4), 664–687
- Smith, S.A. (2012) ‘Beyond quake, Japan’s political aftershocks.’ Expert brief 8 March, Council of Foreign Relations
- Tian, Xinping, Jinqian Gong, and Zhe Zhai (2022) ‘Natural disasters and human capital accumulation: Evidence from the 1976 Tangshan earthquake.’ *Economics of Education Review* 90, 102304
- Torche, Florencia (2018) ‘Prenatal exposure to an acute stressor and children’s cognitive outcomes.’ *Demography* 55, 1611–1639
- White, Bruce (1997) ‘Preparing for natural disasters - where does the Reserve Bank fit in?’ *Reserve Bank of New Zealand Bulletin*
- Xiao, Yu (2011) ‘Local economic impacts of natural disasters.’ *Journal of Regional Science* 51(4), 804–820
- Yuan, Hongmin, Yanmin Ouyang, and Yuxiang Li (2024) ‘Local earthquakes and households’ risk-taking: Evidence from the China household finance survey.’ *Journal of Asian Economics* 91, 101648
- Yun, Seong D., and Ayoung Kim (2022) ‘Economic impact of natural disasters: A myth or mismeasurement?’ *Applied Economics Letters* 29(10), 861–866