Still in Pain? The Economic Suffering from the Wenchuan Earthquake in China

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Abstract

This paper studies the economic loss of the Wenchuan earthquake in 2008, one of the most destructive earthquakes in modern China. Using county-level panel data from 2003 to 2019, the event-study design presents the variation in the earthquake effect over time, as the largest economic setback takes place in 2008. However, the economic recovery in the following years drives severely affected counties to catch up with non-severely affected counties at the end of the sample period. I also find that the average effect of the Wenchuan earthquake causes a decline of 12% in GDP per capita for those severely affected counties, despite that the method tends to ignore the post-earthquake recovery. Consequently, the economic suffering from the earthquake is considered as short-term.

Keywords: economic performance; earthquake; severe counties

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1 Introduction

Natural disasters have become recurring events in human history, such as earthquakes, hurricanes, and wildfires. In recent years, understanding their consequences from different perspectives are flourishing due to their close attainment to daily life as well as the development of causal inference methods (Deschênes and Greenstone, 2007; Cavallo et al., 2011). Even though, the opinions still remain divided regrading whether a subsequent recovery will be expected after one natural disaster. Some catastrophes have led to prolonged and widespread negative economic impacts, possibly due to the large destruction of infrastructures and buildings (Krichene et al., 2021; Cavallo et al., 2013; Joseph, 2022). On the other hand, some studies argue that the destruction has been temporary and has even stimulated economic recovery after severe disasters (Strobl, 2011; Dell et al., 2012; Deryugina et al., 2018). Following this path, this study investigates the long-term pattern of a natural disaster and the mechanisms at play in this paper.

Specifically, I focus on the 2008 Wenchuan earthquake in Sichuan province, China, which presents as the most destructive disaster the country has suffered in the 21st century.[1] The Wenchuan earthquake registered a magnitude of 8.0 on the Richter scale. In the aftermath, governmental bureaus collaborated to assess the severity of damage across this area. After evaluation, counties in Sichuan are classified as severely affected counties ("severe counties" hereafter) and non-severely affected counties ("non-severe counties" hereafter) based on their exogenous exposures to the earthquake. This classification yields two balanced types of county as they are similar in various aspects during the pre-earthquake period. Thus, the main research question in this paper attempts to understand the long-term effect of the earthquake to severe counties, compared with non-severe counties.

There are at least two advantages to choosing the Wenchuan earthquake as the setting. First, although historical records show that China is earthquake-prone (He et al., 2021), significant earthquakes occur only in limited regions,[2] while the rest rarely experience earthquakes. This geographic variation provides a natural "never treated" control group,

[1] Wenchuan is the name of county where the earthquake epicentre is. See more in Background.

[2] Southwestern region (such as parts of Sichuan province) and the eastern coastal region (some parts of Guangdong province) belong to this category. See from `https://www.gov.cn/ztzl/prdz/content_635516.htm`.

which could help establish causal relations regarding earthquake effects. Second, destructive earthquakes are not frequent in Sichuan either. In the three decades before 2008, only two earthquakes occurred in the province, one in 1981 with 150 deaths and another in 2001 with 3 deaths. Both are far less deadly than the Wenchuan earthquake, which claimed nearly 90,000 lives.[3] The accidental natural disaster minimizes any anticipation effects in Sichuan and also makes the Wenchuan earthquake an exogenous shock for analysis.

I use a dynamic Difference-in-Differences (DID) method to estimate the earthquake effect on economic performance. The empirical analysis first suggests that severe and non-severe counties display pre-trends in GDP per capita, and then the largest contraction in severe counties occurs in the earthquake year of 2008. The next several years see a gradual attenuation to the effect, which implies a sign of economic recovery in severe counties. Therefore, the dynamic analysis proves that the Wenchuan earthquake only has a short-term impact on economic performance. Besides, I also use the traditional DID method to examine the average earthquake effect. After the earthquake, severe counties suffer from a 12% decline in GDP per capita relative to non-severe counties. However, it should be reminded that the average estimation does not fully describe the trajectory of the post-earthquake period.

The robustness and credibility of the main findings come from the inherent exogeneity of earthquakes, as their occurrence cannot be accurately predicted or influenced by human activity. However, a potential treat to identification still arises. For example, the official evaluation of earthquake exposure may consider endogenous factors to the economic outcome when deciding the severity status; or the designation of treatment has the risk of manipulation. If so, the estimation in the baseline specification would deviate from the real effect. To address this concern, I conduct several robustness checks, such as using alternative outcome and the treatment variable, spillover effect test, and placebo test. In general, the results from those checks could confirm the consistency of the main findings.

I explore the potential mechanisms that explain the diminishing earthquake effect and economic recovery in severe counties. First, the analysis indicates that the Wenchuan earthquake has minimal impact on the employment structure in severe counties, particularly within the rural and industrial sector. This stability in employment composition preserves

[3] See from `https://en.wikipedia.org/wiki/List_of_earthquakes_in_China`.

local labourers and facilitates future recovery once the short-term pain is over. Next, fixed-asset investment in these counties display a surge shortly after the earthquake, supporting reconstruction efforts in Sichuan at the same period. Though it eventually reverts to levels comparable to non-severe counties, this temporary investment spike still suggests that asset renovation likely plays an important role in the recovery process. Last, the earthquake leads to an immediate increase in government spending. Like fixed-asset investment, this fiscal expansion in severe counties allows for extensive reconstruction efforts to repair affected areas. Besides, this fiscal pressure proves temporary as spending levels have normalized within a few years.

My study contributes to the existing literature in several key aspects. First, it directly adds to the body of research on the Wenchuan earthquake by providing a county-level evaluation of its economic consequences and portraying the post-disaster development trajectory. Previous studies on the Wenchuan earthquake primarily focus on the individual or micro-level analyses, such as behavioural changes (Deng et al., 2015; Filipski et al., 2019; Yao et al., 2019; Yin et al., 2022), disruptions in education (Liu and Xu, 2021; Lu et al., 2023; Park et al., 2025), firm aids and exports (Bulte et al., 2018; Li et al., 2024), and government subsidy (Park and Wang, 2017). Only few studies examine this earthquake from a more "aggregate" perspective, such as the simulation of recovery through high-way transportation (Wu and Ishiro, 2024), the role of public expenditures in economic growth (Yao et al., 2021), and post-disaster technological progress (Deng et al., 2022). By comparison, my study differs from theirs in exploring the earthquake-induced economic dynamics at the county level. Exploiting exogenous variation in earthquake exposure, I demonstrate how differences in disaster severity shape long-term economic outcomes. The findings indicate that while severe counties suffered substantial economic losses in the short term, they ultimately recovered to pre-earthquake levels by the end of the study period. This evidence supports the notion that affected regions can achieve long-term economic recovery, enriching the understanding of the earthquake's overall impacts.

Second, the results contribute to the broader literature of post-disaster evaluations by offering novel empirical insights into the ambiguous relation between natural disasters and economic recovery. The evolution of causal analysis enables scholars to study the economic impacts of natural disasters with greater credibility, such as earthquakes (Barone and Mocetti, 2014; Pathak and Schündeln, 2022; Hanaoka et al., 2018), hurricanes (Boustan et al., 2012; Strobl, 2011; Gröger and Zylberberg, 2016; Mahajan and Yang, 2020), wildfires (Ho et al., 2023; Boomhower et al., 2023; Wang and Lewis, 2024), floodings (Boustan et al., 2012; Gallagher and Hartley, 2017; Kucuk and Ulubasoglu, 2024), and droughts (Jia, 2014; Fernández et al., 2023). However, the literature has not reached a census whether a post-disaster recovery is achievable. Some suggest that capital accumulation and increased labour force participation can drive recovery (Burton and Hicks, 2005; Hallegatte and Dumas, 2009; Noy, 2009; Noy and Vu, 2010), whereas other studies argue that earthquakes can deepen economic vulnerabilities, particularly in developing countries where recovery is often uncertain (Skidmore and Toya, 2002; Kahn, 2005; Barone and Mocetti, 2014; Joseph, 2022). Through the vigorous empirical investigation in this study, the findings support the recovery hypothesis at the county level after the earthquake.

Besides, the topic of this study is closely aligned with the role of external shocks in shaping long-term economic development. This strand of literature typically examines how unexpected and exogenous historical events disrupt established economic trajectories. For instance, the introduction of New World crops centuries ago led to population growth in China (Chen and Kung, 2016), Europe (Nunn and Qian, 2011), and Africa (Cherniwchan and Moreno-Cruz, 2019). Research on American military presence during wartime explores its effects on convergence of economic activities (Davis and Weinstein, 2002; Miguel and Roland, 2011; Brodeur et al., 2018). In this study, I also analyze the disruption of the Wenchuan earthquake on the pre-existing growth pattern, using non-severe counties as the convincing control group.

The remaining part of this paper is organized as follows: Section 2 introduces the historical background of the Wenchuan earthquake and government reactions afterwards and the conceptual framework describing potential paths after a natural disaster. Section 3 describes the data set for the empirical analysis that will be explained in detail in Section 4. Section 5 presents empirical evidence of the Wenchuan earthquake on economic performance along with robustness checks. Section 6 discusses some potential channels for the earthquake effect to pass on affected counties. And Section 7 concludes the study.

2 Background

2.1 The Wenchuan Earthquake and Government Response

Around 2:28 pm on May 12, 2008, a catastrophic earthquake struck in Sichuan, a southwestern province in China. This seismic event, known as the Wenchuan earthquake, proved to be one of the deadliest earthquakes in recent Chinese history.[4] China Earthquake Administrative promptly located the epicentre in Yinxiu Town, Wenchuan County, Sichuan Province (31° N, 103.4° E), registering a magnitude of 8.0 on the Richter scale.[5] Figure A1 displays the Wenchuan earthquake epicentre in China. Although the epicentre was situated in Sichuan Province, the seismic waves reverberated across a significant portion of China, leading to substantial impacts on neighbouring provinces as well.

Despite ongoing aftershocks, the then-Prime Minister promptly flew from Beijing to Sichuan and led the rescue efforts just two hours after the earthquake struck. On the same day, the Sichuan Provincial Committee of the Communist Party of China and the Sichuan Provincial Government approved the initial rescue plan and established the earthquake relief headquarters, with support pledged from other provinces sending troops and medical teams to assist. International condolences poured in, with some countries dispatching medical personnel to aid in the rescue efforts.[6]

Although the government's response to the sudden disaster was prompt, the earthquake resulted in significant losses.[7] Approximately 70,000 people lost their lives during the earthquake, with an additional 18,000 reported missing. The destruction was widespread, with around 20 million square meters of urban residential areas and approximately 7,000 school buildings reduced to rubble (Compilation Committee of the Sichuan Earthquake Relief Chronicle of the Wenchuan Earthquake, 2018). By September 2008, the central government estimated that the financial toll, such as the destruction of houses, buildings, roads, and bridges, reached 845 billion RMB ($\approx$ 122 billion USD), a similar level as Hurricane Katrina caused (Deryugina et al., 2018).[8]

[4] Before the Wenchuan earthquake, the most destructive was the Tangshang earthquake in 1976.
[5] See from `https://www.cea.gov.cn/cea/dzpd/zqsd/2815725/index.html`
[6] See from `https://www.gov.cn/jrzg/2008-05/23/content_989714.htm`.
[7] See from `http://news.bbc.co.uk/2/hi/asia-pacific/7424262.stm`.
[8] See from `http://www.npc.gov.cn/zgrdw/npc/zt/2008-09/05/content_1448390.htm`.

Following the three-week rescue operation, the focus shifted to rebuilding the destroyed areas. Over 40,000 projects were initiated, covering various sectors including housing, infrastructure, healthcare, education, and industry. The funds allocated for rehabilitation and reconstruction in Sichuan amounted to 1.7 trillion RMB ($\approx$ 245 billion USD), exceeding the provincial GDP in 2008 by 35%. From 2008 to 2010, the Ministry of Finance provided substantial subsidies to Sichuan, totalling 6.45 billion RMB ($\approx$ 1 billion USD), equivalent to 4.6% of the provincial fiscal revenues in 2008. Severe counties also received assistance from partner provinces outside of Sichuan for three years, focusing on rebuilding residential houses, public services, and infrastructure. Each partner province committed to providing support equivalent to at least 1% of their provincial fiscal revenues annually.[9] By the end of 2011, the reconstruction efforts were nearing completion, with nearly all national projects and budget investments finalized.[10]

2.2 Conceptual Framework

Understanding the long-term economic impact of earthquakes remains an area of ongoing debate among economists due to a variety of development patterns observed in real life. Here I intend to list and summarize the main theoretical claims found in the literature. For simplicity, GDP per capita serves as the primary metric for measuring economic performance or the quality of life in a given region throughout the discussion (Becker et al., 2005; Dell et al., 2012; Barone and Mocetti, 2014). Figure 1 illustrates several potential growth patterns for severe counties after the Wenchuan earthquake occurred, assuming GDP per capita (y_{base}) in a representative non-severe county grows at a constant rate of g_{base}. All scenarios depict a discrete drop in GDP per capita in the earthquake year, likely due to capital destruction and/or the loss of effective labour ($y_{after} < y_{base}$ and $g_{after} < 0 < g_{base}$). These trajectories diverge over time with distinct outcomes eventually (Hsiang and Jina, 2014). In general, three scenarios for severe counties could happen after the earthquake: "come back strong", "pain is over", and "still in pain".

The most optimistic scenario is labelled as "come back strong", which underscores that

[9] See from https://www.gov.cn/zwgk/2008-06/18/content_1019966.htm.
[10] See from https://www.gov.cn/test/2012-02/02/content_2056707.htm.

experiencing the earthquake would trigger faster development in severe counties after a short-term drop. In this scenario, the disaster acts as a catalyst, leading to a higher post-earthquake growth rate than the baseline level ($g_{after} > g_{base}$). In the end, severe counties are expected to surpass non-severe counties which are assumed to be the baseline ($y_{after} > y_{base}$). Unlike the concept of "creative destruction," where market forces or social ideologies drive the transformation, the recovery from the earthquake can be facilitated by aid from international and domestic organizations and government subsidies. These sources can provide reliable financial support for reconstruction efforts, particularly in transparent and efficient governments (Gignoux and Menéndez, 2016; Huang and Hosoe, 2017; Heger and Neumayer, 2019). Destroyed equipment is replaced by newer and more advanced ones, thereby enhancing productivity levels (Skidmore and Toya, 2002; Hallegatte and Dumas, 2009; Hornbeck and Keniston, 2017).

In the "pain is over" scenario, severe counties run into a finite period of accelerated growth after the earthquake. However, unlike the previous scenario, the development eventually converges to the baseline trend over the long term without surpassing it ($y_{after} \approx y_{base}$). This indicates that while severe counties recover from the initial shock, they do not sustain economic growth rates that outpace counterfactual development in the long run. The underlying reasons for this outcome are similar to those discussed in the "come back strong" scenario, particularly during the initial stage of recovery. Reconstruction efforts and an influx of external aid and government subsidies facilitate economic recovery. However, achieving a higher post-disaster growth rate than the baseline trend is not guaranteed, as it depends on various factors such as the effectiveness of reconstruction efforts and the inherent resilience of the severe counties. This scenario aligns with the neoclassical growth theory (Solow, 1956), which posits that economies tend to converge towards a new steady state over time due to diminishing returns on capital. In this context, although the reconstruction process helps severe counties regain their economic footing, the long-term growth rate stabilizes at the pre-disaster level, reflecting the natural tendency of economies to return to a steady state.

In the most pessimistic scenario, severe counties fail to achieve a growth rate higher than the baseline level, as evidenced by $g_{after} < g_{base}$. Moreover, the initial decline in GDP per capita persists in the long run, indicating a lack of economic recovery, as expressed by

$y_{after} < y_{base}$. In the end, the earthquake leaves a permanent scar on the development of severe counties. Barone and Mocetti (2014) have found that cities with a weaker institutional quality struggle to recover to their pre-disaster levels following earthquakes. This lack of recovery may be attributed to factors such as resource misallocation, corruption, and elite capture, which hinder effective post-disaster reconstruction efforts. Cross-country comparisons also suggest that developing countries are more susceptible to this scenario compared to developed nations (Kahn, 2005; Strobl, 2011; Loayza et al., 2012; Joseph, 2022). Effective governance typically helps avoid this scenario. At the individual level, residents of affected regions may alter their consumption behaviour by prioritizing immediate needs over long-term savings (Sawada and Shimizutani, 2008; Yao et al., 2019; Yin et al., 2022). This shift in preferences reduces the rate of capital accumulation and further contributes to the prolonged economic downturn in the aftermath of the disaster.

3 Data

I exploit different data sources in this study to conduct an empirical analysis. The primary data source focuses on the aftermath of the Wenchuan Earthquake in 2008, drawing detailed information from *The Sichuan's Relief Chronicle of the Great Wenchuan Earthquake* published 10 years after the disaster.[11] This series documents a wide range of critical aspects about the Wenchuan earthquake, including damage evaluation, disaster relief, epidemic prevention, and reconstruction.

Between June and July 2008, the Sichuan Provincial Government collaborated with the National Wenchuan Earthquake Expert Committee, the China Earthquake Administration, the National Bureau of Statistics, and other ministries from the State Council to assess the severity of damage across various counties in the affected region.[12] Then they constructed a disaster index, considering factors such as average earthquake intensity (30%), deaths and missing persons (30%), number of collapsed houses (20%), geological disaster risk (10%), and resettlement per ten thousand people (10%).[13] Counties then were categorized into

[11]The copyright belongs to the Local Chronicles Office in Sichuan province.

[12]See from `https://www.gov.cn/zwgk/2008-09/23/content_1103686.htm`.

[13]Resettlement aims to evacuate residents from potentially dangerous areas and provide a temporary

four groups based on the index: the most severe county (the index is above 0.4), severe county (between 0.15 to 0.4), less severe county (between 0.01 to 0.15), and least affected county (less than 0.01). In summary, Sichuan has 10 most severe counties and 29 severe counties out of 180.[14] Figure 2 presents their geographic locations along with the epicentre. Those severely affected counties are located around the epicentre in relatively short distances. With the data, I match the distribution of severe counties, earthquake intensity scale,[15] and earthquake-related deaths at the county level. Besides, the distribution of deaths is uneven among counties and positively related to the severity of the earthquake. According to the statistics, 97.6% of death tolls and 98.4% of missing persons were concentrated in the 10 most severe counties (Compilation Committee of the Sichuan Earthquake Relief Chronicle of the Wenchuan Earthquake, 2018). In this study, I treat most severe and severe counties together as severe counties (treatment counties) and the rest as non-severe counties (control counties).

The second source is county-level data obtained from the *Sichuan Statistical Yearbook* spanning the years 2003 to 2019. Each year, the Sichuan Bureau of Statistics takes the responsibility of carrying out household surveys in Sichuan and compiling the yearbook under the supervision of the National Bureau of Statistics. The data include indicators about GDP, population, employment, fiscal revenue and expenditure, investment, land area, and so on. Besides, the local CPI during the study period is used for adjusting monetary indicators to the 2007 price level. In this study, I choose the year 2019 as the end date for two reasons. Firstly, the data collection period ended just before the global outbreak of the coronavirus in early 2020. The growth patterns during the COVID-19 pandemic might differ significantly from those in normal circumstances due to quarantine or lockdown policies implemented in China. Secondly, given that this study aims to explore whether the earthquake had a long-term impact, the post-earthquake period of 11 years is already sufficiently long to provide meaningful evidence.

residence for families whose houses were destroyed. Usually, resettlement occurs within the same county.

[14] Outside Sichuan Province, there are 12 more severe counties in neighbouring provinces.

[15] China adopts its own standard to measure earthquake intensity, known as China Seismic Intensity Scale. This standard includes 12 scales with a higher number representing a stronger intensity. The data on the county-level earthquake intensity is obtained from the China Earthquake Administration. See from `https://www.gov.cn/wszb/zhibo262/content_1085953.htm`.

Last, I obtain each county's longitude and latitude from the National Geomatics Center of China to calculate the linear distance to the epicentre. I also match each county with the relief degree of land surface to account for altitude difference in the region from You et al. (2018).[16]

4 Identification Strategy

I use a Difference-in-Differences (DID) approach to investigate the impact of the Wenchuan earthquake on the county-level economy in Sichuan province. The earthquake effect defined in this study surfaces during the post-earthquake period through comparisons among counties with different but exogenous degrees of damage. Thus, the key assumptions here are twofold: First, severe counties do not diverge from non-severe counties in the outcome of interest before the earthquake. This is often mentioned as the parallel trend assumption. Second, the locally reported degrees of severity are orthogonal to economic outcomes of interest, which is also the conventional treatment of earthquakes as exogenous in the literature (Barone and Mocetti, 2014; Wang et al., 2017).

Table 1 presents a balance check of the statistical characteristics between severe and non-severe counties before the earthquake (2003-2007). The time frame allows for exploring any systematic differences. Columns (1) and (2) provide the mean of the variable accompanied by the standard deviation in the parenthesis. Column (3) record their mean differences conditional on the year fixed fixed, with significance levels included. In panel A, severe counties have a slight advantage in GDP per capita over non-severe counties, but their difference is insignificant. Both types of counties display similar economic sector compositions, population sizes, fiscal conditions, arable lands share, and fixed-asset investment. This implies that the classification of severe and non-severe counties yields to a treatment group and a convincing control group.

I compare their county-fixed characteristics in panel B. On average, severe counties are located approximately 114 km closer to the epicentre than non-severe counties. This proxim-

[16] Data on China's relief degree of land surface can be accessed at `https://www.geodoi.ac.cn/doi.aspx?Id=887`.

ity suggests a stronger seismic impact, consistent with the expectation that counties closer to the epicentre experience more severe destruction. The significant disparity in earthquake intensity further supports this claim. While 30% of non-severe counties experience an intensity scale of 5 or below, none of severe counties fall into this category. Among counties with an intensity scale above 5 (strong earthquake intensity), the difference in intensity is substantial, nearly 2 scales. Related to this, severe counties have a much higher earthquake-related death rate than non-severe counties.[17] For every ten thousand persons, 131 deaths are reported in severe counties, while about 0.2 deaths in non-severe counties. In the appendix, figure A2 visualizes the correlation between earthquake-related deaths and distance to the epicentre. In summary, the balance check shows that the classification in this study sufficiently captures variation in earthquake exposure while maintaining negligible per-existing economic disparities.

I present the event-study model to estimate the yearly effects following the Wenchuan earthquake. It can be expressed as follows by setting one year prior to the earthquake as the reference:

$$\begin{aligned} y_{it} = \alpha + \sum_{j=-5}^{-2} \beta_j Severe_i \times Lag_{jt} + \sum_{k=0}^{11} \beta_k Severe_i \times Lead_{kt} \\ + x'_{it}\gamma + \delta_i + \eta_t + \epsilon_{it} \end{aligned} \tag{1}$$

where y_{it} denotes the outcome of interest for county i at the year to the earthquake t; $Severe_i$ is a treatment dummy about earthquake severity which takes 1 only if county i was reported as severe by the local government; $Lag_{jt}/Lead_{kt}$ are lag/lead year dummies which is equal to 1 only if $j = t/k = t$; x'_{it} represents a set of county-level controls; δ_i and η_t absorb county- and year-level fixed effects; ϵ_{it} captures the unobservable random shocks to the outcome variable. Standard errors are clustered at the county level. In table A1, I examine the exogeneity of treatment assignment using the pre-earthquake sample. If the pre-existing economic development could predict the likelihood of being reported as a severe county, the estimation equation presented above might lead to a biased result. However, columns (1)-(3) show that GDP per capita has no significant predictive power in determining

[17] This indicator combines both reported deaths and missing persons.

treatment status. In columns (4) and (5), I further test whether other pre-existing factors, such as population or investment, may have influenced the classification, but the results again indicate no evidence of endogeneity. In the next section, I also explore an alternative treatment measure as part of robustness checks.

The random nature of earthquake exposure suggests that systematic differences between severe and non-severe counties are unlikely to exist before the disaster. The estimation model can validate this assumption if β_j (for lag dummies) are found to be insignificant. Besides, another advantage of this approach is its ability to estimate the by-year earthquake effects, providing detailed insights into the economic performance of severe counties over time. Statistically, β_k represents the relative difference in outcomes between the two types of county against their difference in 2007.

In addition, I estimate a more standard DID model, using the following equation:

$$y_{it} = \alpha + \beta Severe_i \times Post_t + x'_{it}\gamma + \delta_i + \eta_t + \epsilon_{it} \tag{2}$$

where $Post_t$ is a post-earthquake time dummy which is equal to 1 if the year is after the earthquake, and the rest of the settings remain the same. If the results from the event-study model suggest parallel trends in severe and non-severe counties before the earthquake, β measures the average causal effect of the earthquake to severe counties in the outcome of interest. Besides, it is already assumed here that severe counties should receive a homogeneous impact from the earthquake.

5 Empirical Evidence on the Earthquake Effect

The main purpose of this study is to evaluate how the Wenchuan earthquake has impacted the county-level economic performance in Sichuan province. To achieve that, I focus on the variation of GDP per capita through the years to estimate the earthquake effect. Before an in-depth exploration of regression results, I conduct a preliminary examination through the depiction of GDP per capita trends in severe and non-severe counties from 2003 to 2019, as illustrated in figure A3. Severe counties maintain their economic advantage until a discrete slump in 2008, with non-severe counties overtaking in GDP per capita. This observation aligns with the statistical description provided earlier. Despite this initial shift, the disparity in economic performance persists over the years, albeit with a gradual narrowing of the gap between them. In the final two years of the study period, severe counties begin to close the economic divide and even surpass non-severe counties in 2019. This trend could be indicative of the "pain is over" or "come back strong" scenario outlined in the conceptual framework, suggesting a period of economic recovery.

In the subsequent paragraphs, I report and interpret the empirical evidence of the earthquake effect first. Next, I adapt several robustness checks to test the consistency of my main finding.

5.1 Dynamic Earthquake Effect

In this section, I provide the empirical evidence of dynamic earthquake effects. The results are obtained by estimating the event-study design outlined in Eq. (1). The specification integrates the two-way fixed effects (county and year) to absorb variations at the county and year levels, while the standard errors are clustered at the county level. An advantage of this approach is to show the evolution of the earthquake effect from a longer frame. The outcome of interest has been modified as the natural log of GDP per capita (adjusted at the 2007 price level). Since the 1-year lag estimate is omitted due to multicollinearity, the rest can be interpreted as the difference in the outcome between severe and non-severe counties relative to the level in the year just before the earthquake.

Figure 3 illustrates the estimated earthquake effects on GDP per capita, along with their 95% confidence intervals. The baseline specification does not include any controls. Before the earthquake, the estimates are all insignificant, implying no systematic pre-existing differences. This supports the parallel trends assumption in the DID strategy in Eq. (2) where the trend of non-severe counties can severe as a counterfactual case for the trend of severe counties in the absence of the earthquake. More importantly, the figure reveals a significant negative economic impact on severe counties. The effects vary over time. In 2008 (period 0 on the horizontal axis), GDP per capita in severe counties contracts by approximately 20% relative to non-severe counties, marking the largest decline in the post-earthquake period. Over the next five years (periods 1 to 5), the economic setback persists with declines of around 10%, but the power of effect gradually diminishes. By 2016 (period 8), severe counties catch up with non-severe counties in the outcome. The estimates become statistically insignificant and remain until the end of the study period.

The economic performance over 11 years after the earthquake suggests that the earthquake effect on severe counties has been predominantly short-term in nature, despite the initial suffering in GDP per capita. Seven years after the earthquake, the economic recovery in severe counties brings them back to the counterfactual level where no earthquake had happened. Over a longer time frame, the recovery enables severe counties to stay at a similar level as non-severe counties. In the Appendix, table A2 provides the detailed estimates in each year. A threat to the identification arises from two additional earthquakes of 7.0-Richter scale that struck Sichuan in 2013 and in 2017.[18] Despite their lower intensity and more localized damage, I control for their potential confounding effects by adding two interaction terms between the distance to their epicentres and the post-earthquake dummies, denoted as $Distance_{2013} \times Post_{2013,t}$ and $Distance_{2017} \times Post_{2017,t}$. The specification in column (2) reports similar estimates to column (1), with one notable difference: the estimate in period 9 becomes significantly negative. This suggests that the 2013 Lushan earthquake has minimal impact, while the 2017 Jiuzhaigou earthquake contributes to an additional economic decline. To further assess the robustness of the baseline findings, I introduce different types of controls. Column (3) accounts for the influence of pre-earthquake economic structure by including the shares of agricultural and industrial sectors in 2007, interacted with the post-earthquake dummy. Column (4) controls for geographic characteristics by adding the interaction between county altitude differences and the post-earthquake dummy. Finally, column (5) considers population density in 2007 interacted with the post-earthquake dummy to capture potential demographic effects. Across all specifications, the estimates in the pre- and post-earthquake periods are not sensitive to the inclusion of controls.

[18]The earthquake in 2013 is referred as the Lushan earthquake, while the one in 2017 is the Jiuzhaigou earthquake.

5.2 Average Earthquake Effect

The analysis of dynamic earthquake effects above supports the key assumption of a standard DID model. Table 2 provides the regression results from estimating Eq. (2). Columns (1)-(5) use the full sample (2003-2019) to capture any longer-term effect that might be revealed over an extended period. The significantly negative estimates are stable and not sensitive to the types of controls. I then restrict the sample before 2017 in columns (6) and before 2013 in column (7) to reveal the short-term earthquake effect which will be compared with the estimate in column (1). Besides, it also excludes potential influences from the 2013 and 2017 earthquakes. The estimated magnitude diminishes when using a sample with a longer post-earthquake period. This suggests that the economic impact of the earthquake becomes less pronounced over time and also indicates a recovery phase, which aligns well with the event-study results. The decline is primarily concentrated in the initial years following the earthquake. To further test this claim, I select the sample from 2003 to 2007 and 2015 to 2019 and re-estimate the same regression equation in column (8). The estimate now loses significance, indicating that the difference in the outcome during the last 5 years are similar as the pre-earthquake level. In other words, severe counties have recovered economically after a short-term disruption.

If taken the specification in column (2) as the baseline to interpret, severe counties loss approximately 12% of GDP per capita after the earthquake. By a back-of-envelope calculation, it translates to a substantial loss of 2,486 RMB (approximately \$324) per person in severe counties compared to non-severe counties, considering its mean value in non-severe counties to be 20,717 RMB. One should be cautious when interpreting the earthquake effect from the DID model. The empirical results do not imply that non-severe counties are immune to any possible drop in GDP per capita. Instead, the estimate represents the post-earthquake difference between severe and non-severe counties relative to the pre-earthquake difference. From the statistical perspective, the earthquake effect is the average treatment effect to the treated (ATT). The decline in GDP per capita should be regarded as an average effect only in severe counties, rather than all counties in Sichuan province.

Last, it should be reminded that only checking the average effect of the Wenchuan earthquake does not provide the whole picture of development pattern. The empirical evidence in this section shows the earthquake effect varies across years. The estimated 12% reduction in GDP per capita merely represents an average across the entire post-earthquake period. Although this recovery is obscured by focusing solely on the average effect, it becomes evident when the magnitude of the impact diminishes over a longer time frame.

5.3 Robustness Checks

The previous analysis suggests the Wenchuan earthquake has brought the short-term economic pain to severe counties. I introduce a series of robustness checks to assess the consistency of the main findings in this part, which is crucial to confirming the causal claims of this study.

5.3.1 Heterogeneity Test

This section discusses whether the earthquake has heterogeneous effects on GDP per capita across different economic sectors. Using the same settings in Eq. (1), figure A4 plots the event-study analysis for the agricultural, industrial, and tertiary sectors. From panel (a), severe counties have higher agricultural GDP per capita before the earthquake, relative to non-severe counties. Although this pre-existing difference violates the strict parallel trends assumption in a DID model, the sharp drop into negative territory in the earthquake year may still reflect the disruptive effect of the disaster.[19] In contrast, severe and non-severe counties have similar trends in the industrial and tertiary sectors, as are shown in panels (b) and (c). Both of them confirm the causal interpretation of the significant declines observed in these sectors. Beyond the immediate impact, the figure also reveals sectoral differences in the recovery trajectories. In both the agricultural and industrial sectors, the economic gap between severe and non-severe counties gradually diminishes and becomes statistically insignificant several years later. Different from them, the tertiary sector shows a persistent gap that remains negligible until the end of the study period, suggesting that service-based industries in severe counties have yet to fully rebound. In summary, the heterogeneity

[19] The magnitude of the decline is not precisely estimated.

analysis suggests that while severe counties experience economic recovery in the agricultural and industrial sectors, they continue to lag in the tertiary sector.

5.3.2 Alternative Outcome

The outcome of interest in the baseline specification is GDP per capita, which captures aggregate production. However, this indicator may not fully reflect changes in social welfare (Jorgenson, 2018). While production and consumption are typically cyclical in an equilibrium economy, natural disasters can disrupt this relationship. Following a disaster, private consumption stagnates due to household asset losses, even as factories resume production after a certain period (Nakamura et al., 2013; Gignoux and Menéndez, 2016; Yin et al., 2022). This argument suggests that the recovery of GDP per capita alone may not provide strong evidence on the recovery of demand. Therefore, I use total retail sales of consumer goods as a measure of private consumption in this check. This indicator captures the monetary value of physical goods and services sold to individuals and social groups through financial transactions but also measures consumer demand and willingness to spend within the economy.

Similar to the previous settings in Eq. (1), figure A5 depicts dynamic earthquake effects on retail sales per capita (in the natural log form). Before the earthquake, the standardized difference in consumption between severe and non-severe counties are insignificant. After the earthquake, retail sales in severe counties sharply decline and remain significantly lower for the next three years. However, from 2010 to 2013 (periods 2 to 5) and again in 2019 (period 11), the differences become insignificant again. In the Appendix table A3, I present the estimates of the average effect on retail sales of consumer goods and confirm the same finding. Overall, this analysis reinforces the economic recovery of severe counties from the demand side.

5.3.3 Alternative Treatment

In the next robustness check, I first use the variation in county-level earthquake intensity scales to estimate the earthquake effect on the economic outcome. This approach offers two key advantages over the binary treatment in the baseline analysis. First, it allows for a finer assessment of heterogeneous effects among severe counties, based on intensity scales. Second, it largely mitigates the concern about human intervention, thus better reflecting the true severity at the county level.

Table 3 presents the estimates from this robustness check, following the same specifications as Eq. (2). The interaction term between the intensity scale and the post-earthquake dummy serves as the primary explanatory variable in columns (1)-(3).[20] The significantly negative estimates align with the main findings, as counties receive stronger earthquake intensity would suffer greater economic losses. Besides, the specification with a shorter post-earthquake period reveals a stronger decline in GDP per capita, which indicates the case of economic recovery over time.

I also replace the treatment dummy with the linear distance to the epicentre (in the natural log form) and document the estimates in columns (4)-(6) of Table 3. In columns (7)-(9), I modify the treatment dummy into another binary variable ("Far From Earthquake") which equals 1 if a county is located beyond the 50th percentile of the distance distribution. Those significantly positive estimates support the expectation that counties farther from the epicentre receive less impacts from the earthquake. Again, comparing the full-sample specification with those using a shorter post-earthquake period reveals evidence of economic recovery.

5.3.4 Spillover Effect

The classification of severe and non-severe counties in this study has provided robust estimations. Ideally, only severe counties are subject to the earthquake effect, which satisfies the Stable Unit Treatment Value Assumption (SUTVA). However, the assumption may be violated if spillover effects extend to non-severe counties. To assess the presence of spillover effects, I test whether non-severe counties bordering severe counties also experience the post-earthquake change in the outcome. I define neighbour counties as non-severe counties that share a direct border with severe counties and introduce an interaction term between the neighbour dummy and post-earthquake dummy ($Neighbour_i \times Post_t$) in Eq. (1) and Eq. (2). This term captures potential spillover effect from severe counties to adjacent non-severe

[20] In this measure, counties with an earthquake intensity scale of 5 or below serve as the reference group.

counties. Figure A6 displays the revised event-study analysis of GDP per capita, which barely differs from the baseline result in figure 3. Spillover effects, even if existed, do not pose a threat to the identification strategy.

Table A4 presents the two types of evidence on negligible spillover effects. Columns (1)-(3) document the estimates of the revised average earthquake effect, suggesting that the results are consistent with the main findings. Besides, spillover effects are marginally significantly only in a longer time frame. In columns (4)-(6), I exclude those non-severe counties bordered with severe counties, and the estimates remain largely unchanged too.

5.3.5 Migration

I investigate whether the Wenchuan earthquake induces migration in severe counties. A cross-country study by Mahajan and Yang (2020) suggests that households in disaster-stricken areas may relocate in search of better opportunities. It is plausible that the migration of wealthier families might worsen the economic decline in their home counties, as they typically represent higher productivity. Such migration could bias the baseline estimation of the earthquake effect. Figure A8 illustrates county population levels and growth trends from 2003 to 2019, and the data show little evidence of a large-scale demographic shift following the earthquake. Figure A7 further presents the dynamic effects on county population. The gap in population does not widened between severe and non-severe counties. In table A5, columns (1)(3) report the average earthquake effect on population, while columns (4)(6) incorporate the control for potential spillover effects. The insignificant estimates across these specifications indicate that mass migration does not occur in response to the natural disaster in Sichuan province.[21]

The unique design of the Hukou (registered residence) system in China increases the cost of migrating to another area. It is probably the reason for the lack of migration following disasters (Whalley and Zhang, 2007; Bao et al., 2011). Residents without a local Hukou often face barriers to accessing social resources such as healthcare and education available to the locals (Zhang et al., 2020; Vendryes, 2011). While changing one's Hukou status is not

[21]It should be noted that the resettlement right after the earthquake only represents temporary relocation of residence, usually within the same county. Thus, local resettlement should not counted as inter-county migration.

excessively challenging across Sichuan province, the processing time can still impede migration efforts. I acknowledge that some families still choose to migrate between counties after the earthquake, but their impact on the transfer of wealth and the overall economy may have been limited. In the Appendix A.3, I present a theoretical model which implies that limited mobility can improve post-earthquake economic recovery by preventing skilled workers from moving around. In the section, I further analyze this problem from the perspective of county employment.

5.3.6 Placebo Test

In this section, I conduct the placebo test to reinforce the main results. First, I randomly assign the treatment of being a severe county and repeat the regression in Eq. (2) 1,000 times to plot the distribution of the estimates. With 39 severe counties out of 180 in total, each county has a 22% probability of receiving the treatment. In the appendix, figure A9 illustrates the distribution of the simulated estimates from the 1,000 regression results and its kernel density. The vertical dashed line represents the average earthquake effect as a comparison. From the figure, the majority of simulations deviate from the actual effect, ruling out the spurious earthquake effect. This placebo test indicates that the decline in GDP per capita in the post-earthquake period should be attributed to the exposure of the earthquake severity.

Then, I explore hypothetical scenarios in which the earthquake is assumed to have occurred at different times, specifically testing whether severe counties display signs of economic decline in the pre-earthquake period. To do this, I interact hypothetical post-earthquake dummies with the severe county status, assuming the earthquake occurred in 2004, 2005, and 2006. Maintaining the same settings as in Eq. (2), Table A6 presents the estimates from this falsification test with the pre-earthquake sample. In summary, the estimates are much smaller in magnitude and consistently insignificant across all columns.

The direct explanation is that the timing of the earthquake is crucial for understanding its economic impact, as evidenced by the result. The specifications rule out the possibility that severe counties already diverge from non-severe counties prior to the disaster. This result also strengthens the identification by implying a non-existent pre-trend difference.

6 Discussion: Mechanisms of Economic Recovery

I investigate the mechanisms that severe counties manage to recover after short-term pain in this section. The supply side of an economy typically comprises three fundamental elements: technology, labour, and capital. While technology is less likely to undergo discrete changes from a natural disaster, the other two components are more likely to be influenced temporary shocks. Meanwhile, the presence of local governments are hard to ignore in the process of recovery. Thus, I focus on the following aspects: employment structure, fixed-asset investment, and fiscal expenditures.

6.1 Employment Structure

It is possible that the earthquake exerts minimal influence on employment level in severe counties, which promotes the economic recovery in later periods. Given this, I examine whether the Wenchuan earthquake alters the labour market in severe counties. Likewise, the analysis takes the specification outlined in Eq. (1) with the outcome of interest now being the number of employees in rural, industrial, and tertiary sectors.

Figure 4 presents these yearly estimates along with their corresponding 95% confidence intervals. To ensure comparability, the coefficients in the event-study plots are standardized to the year just before the earthquake. Severe and non-severe counties have similar employment structures measured by the number of employees before the earthquake. Right after the earthquake, severe counties experience a temporary decline in industrial and tertiary employment, while no significant impact exists in the rural labour market. In the following years, the gap of employment levels disappears in both the rural and industrial sectors, indicating that these sectors recover relatively quickly from the initial shock. However, the tertiary sector in severe counties displays more volatility. Tertiary employment experiences significant relative declines in 2014 (period 6) and again in 2019 (period 11). This pattern aligns with previous heterogeneous findings in figure A4 that the tertiary sector remains the slowest to recover from the earthquakes economic impact.

This section prompts a thoughtful exploration into the economic setback and subsequent recovery through an analysis of the number of employees. Resilience in employment may help explain the economic recovery in the baseline findings. Another implication here is that the stability of local labour market over the years could also rule out a large-scale migration from severe counties, further validating the causal claim made in this study. Aside from this, it is equally important to distinguish between the extensive and intensive margins of labour market outcomes. In the Appendix A.4, I attempt to provide an analysis on the earthquake effect at the individual level to shed light on the intensive margin of labour market outcomes. These findings highlight the importance of examining both the extensive and intensive margins of labour market outcomes to gain a more comprehensive understanding of the economic impact. Nonetheless, I remain open to further exploration to capture the effect on labour market thoroughly.

6.2 Fixed-Asset Investment

Investment in fixed assets represents the spending on the reconstruction of infrastructure and the rebuilding of homes in affected regions, as well as the renovation of existing assets, which becomes the top priority after the disaster. As those efforts aim to restore life normalcy and improve production efficiency (Deng et al., 2022), the recovery years observed years later might emerge through this channel.

I apply Eq. (1) with fixed-asset investment per capita as the outcome of interest and derive the yearly estimates. Figure 5 illustrates that severe and non-severe counties display similar levels of fixed-asset investment prior to the earthquake. However, severe counties experience a substantial increase in fixed-asset investment after that, particularly from 2009 to 2011, coinciding with the period of large-scale government-led reconstruction. By 2012, as reconstruction efforts reach completion, fixed-asset investment in severe counties begins returning to levels comparable to those of non-severe counties. Given that investment often functions as a lagging economic indicator, this temporary surge likely contributes to economic recovery in subsequent years. This pattern reflects a short-term response to the earthquake, aimed at supporting immediate economic stabilization and recovery.

A question arises as to whether the surge in investment observed in severe counties between 2009 and 2011 results from a crowding-out effect on non-severe counties. This could be this case if reconstruction efforts divert resources away from non-severe counties.

Figure A10 illustrates trends in fixed-asset investment per capita, which does not support this hypothesis. Investment levels in non-severe counties show no sudden disruptions during the post-earthquake period. This observation reinforces the interpretation that the positive estimates identified in the event-study design are driven purely by reconstruction in response to the earthquake, rather than resource reallocation at the expense of non-severe counties.

6.3 Fiscal Conditions

Another aspect of the investigation focuses on the role of county governments which are responsible for leading post-earthquake reconstruction efforts. Following the Wenchuan earthquake, these governments received substantial fiscal transfers from the provincial or central government to finance recovery initiatives (Barone and Mocetti, 2014; Park and Wang, 2017). Consequently, an expansion in fiscal capacity is expected to be reflected in increased of fiscal expenditures, which serve as proxy for the scale of government operations (Zhu et al., 2021; Masi et al., 2024).

Using the same approach in Eq. (1), figure 6 illustrates the differences in fiscal expenditures per capita between severe and non-severe counties. Prior to the earthquake, both display parallel trends in the fiscal outcome. However, the sharp surge of expenditures in severe counties is observed in the earthquake year of 2008. From 2008 to 2010, they spend drastically more than non-severe counties, likely due to affluent subsidies from various sources, as discussed in the Background section. However, the surge in spending proves to be temporary. Beginning in 2011, severe counties return to expenditure levels similar to those of their non-severe counterparts. This suggests that the temporary fiscal stimulus play a role in facilitating economic recovery.

The substantial increase in fiscal expenditures does not "crowd-out" intergovernmental transfers to non-severe counties in the same jurisdiction. By presenting trends in fiscal expenditures per capita from 2003 to 2019, figure A11 shows that fiscal expenditures per capita in non-severe counties stably grow during the key reconstruction period (2009-2012), with no notable disruptions or declines. This suggests that the fiscal support received by severe counties comes from upper-level governments and does not influence resource allocations to non-severe counties.

The temporary effect on fiscal conditions is also depicted by the evolution of fiscal dependency in figure A12, measured as the ratio of fiscal revenue to expenditure. The pattern closely mirrors that of GDP per capita, as fiscal dependency in severe counties deteriorates significantly in the three years following the earthquake. This decline reflects increased budget deficits and heightened fiscal pressures because of the large expansion in fiscal expenditures. In subsequent years, fiscal dependency in severe counties financially returns to the pre-earthquake level.

7 Conclusion

The Wenchuan earthquake in 2008 has brought tremendous damage to the affected residents and local economic activities. After the earthquake, experts assessed earthquake severity and then classified counties in Sichuan province as severe and non-severe. There are no significant pre-existing differences between them under this classification, which provides a good opportunity to explore the impact of natural disasters on development trajectory.

The analytical framework employs a Difference-in-Differences approach to evaluate the earthquake effect. The results from the event-study design suggest that the largest economic contraction occurs in the earthquake year of 2008: GDP per capita in severe counties decreases by about 20% relative to that in non-severe counties. The negative effect persists but diminishes over years. In 2016, severe counties catch up with non-severe counties in GDP per capita for the first time, suggesting the recovery from the Wenchuan earthquake in the former. Therefore, this empirical analysis claims that the impact of the Wenchuan earthquake turns out to be short-lived.

Furthermore, I also investigate the potential mechanisms to explain the main findings, which are stable employment structure and temporary surge in fixed-asset investment and fiscal expenditures. First, the earthquake does not alter the employment structure nor lead to an increase in the unemployment population across sectors, which lays a foundation for the later economic recovery. Then, the surge in fixed-asset investment in severe counties plays a significant role in stimulating economic recovery during the post-earthquake period. With a lagging effect, more investment contributes to the restoration of economic activity and growth in affected regions. Next, an analysis of fiscal expenditures indicates that severe counties spend considerably more than non-severe counties during the first three years after the earthquake. The increase in government operations may help explain local recovery years later. Back to the research question: are severe counties "still in pain"? And the answer should be "no".

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Tables

Table 1: Balance Check Before the Wenchuan Earthquake

	(1) Non-Severe Counties	(2) Severe Counties	(3) Conditional Difference
Panel A: County-Year Variables			
GDP per capita (RMB)	9741.463	10474.182	-738.274
	(8002.782)	(6577.866)	(1202.732)
Agricultural Share	0.282	0.277	0.005
	(0.143)	(0.137)	(0.025)
Industrial Share	0.380	0.388	-0.009
	(0.156)	(0.155)	(0.027)
Population (10k persons)	46.177	42.756	3.424
	(35.323)	(31.491)	(5.833)
Rural Population Share	0.776	0.804	-0.028
	(0.352)	(0.591)	(0.028)
Fiscal Expenditures per capita (RMB)	1444.965	1446.344	-2.759
	(1183.621)	(1011.651)	(174.993)
Fiscal Revenues per capita (RMB)	308.262	379.255	-71.284
	(377.571)	(444.976)	(73.273)
Arable Lands Share	0.165	0.149	0.017
	(0.129)	(0.130)	(0.024)
Fixed-Asset Investment per capita (RMB)	5127.692	6328.576	-1205.664
	(5533.922)	(6079.327)	(962.240)
Panel B: County-Fixed Characteristics			
Minority County	0.305	0.205	0.100
	(0.462)	(0.409)	(0.082)
Altitude Difference	1.980	2.395	-0.416
	(1.915)	(1.817)	(0.343)
Distance to Epicentre (km)	274.358	159.871	114.486***
	(117.427)	(90.042)	(20.289)
Share of Earthquake Intensity Scale <= 5	0.305	0.00	0.305***
	(0.462)	(0.00)	(0.074)
Strong Earthquake Intensity	6.327	8.103	-1.777***
	(0.715)	(1.619)	(0.199)
Death Rate (/10k persons)	0.225	131.125	-130.870***
	(1.162)	(411.176)	(34.496)

Note: This table documents the balance check between severe and non-severe counties in Sichuan province before the Wenchuan earthquake in 2008. All monetary indicators have been adjusted at the 2007 price. Each cell reports the variable's mean and standard deviation in the parenthesis. The third column calculates the mean difference conditional on the year (except those county-fixed variables in panel B), while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

Table 2: Average Earthquake Effect on GDP per capita

Dependent Variable: ln(GDP per capita)	Full Sample: 2003-2019					2003-2016	2003-2012	2003-2007 and 2015-2019
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severe × Post	-0.1144***	-0.1247***	-0.1270***	-0.1155***	-0.1244***	-0.1339***	-0.1590***	-0.0709
	(0.0415)	(0.0409)	(0.0349)	(0.0339)	(0.0342)	(0.0408)	(0.0396)	(0.0448)
Distance Control		✓	✓	✓	✓			
Structure Control			✓	✓	✓			
Geographic Control				✓	✓			
Density Control					✓			
County FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	3042	3042	3042	3042	3042	2507	1798	1788

Note: An observation is an individual county at one year in the sample spanning from 2003 to 2019. The outcome of interest is GDP per capita (adjusted at the 2007 price) in its natural log form. Coefficients are estimated in Eq. (2) at the county level. The full sample is used in columns (1) and (5), while the 2003-2016 sample in columns (6) and the 2003-2012 sample in (7). In column (8), only the pre-earthquake sample and the 2015-2019 sample are used. Distance control has the interaction term between the distance to their epicentres in the 2013 and 2017 earthquakes and their respective post-earthquake dummies; structure control includes the share of agricultural and industrial sectors in county GDP in 2007 both interacted with the post dummy ; geographic control considers county altitude difference interacted with the post dummy; density control represents county density in 2007 interacted with the post dummy. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

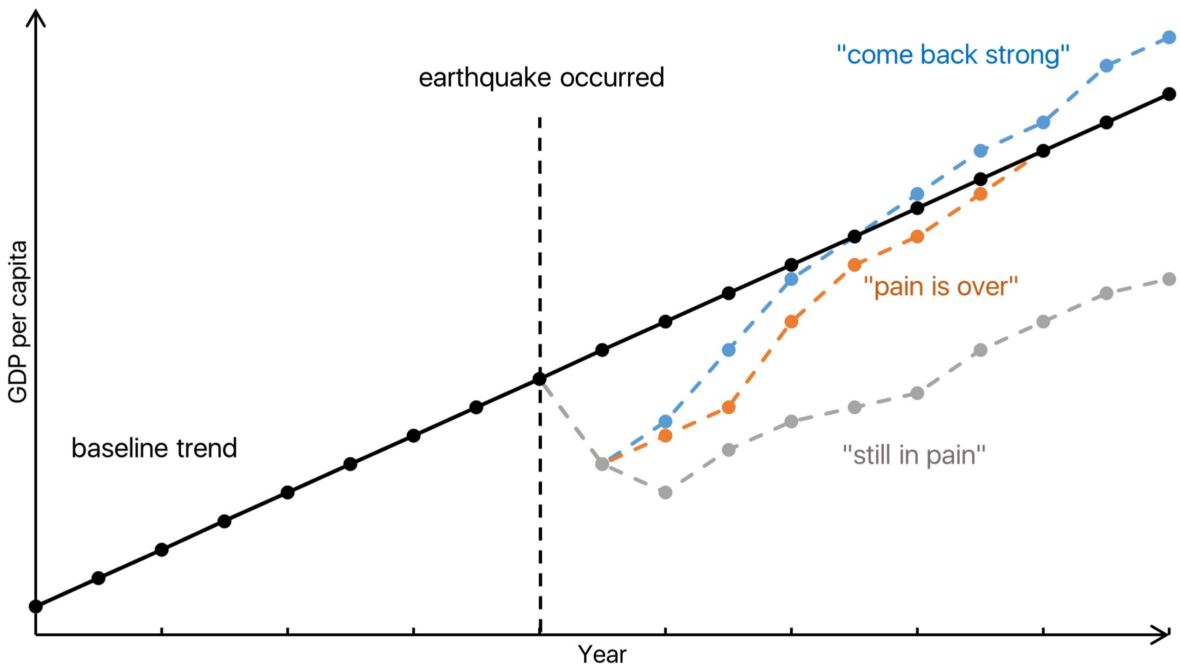
Table 3: Alternative Treatment

Dependent Variable: ln(GDP per capita)	Intensity			Distance					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Earthquake Intensity Scale × Post	-0.0527***	-0.0594***	-0.0680***						
	(0.011)	(0.011)	(0.010)						
Distance to Epicentre × Post				0.1209***	0.1347***	0.1501***			
				(0.022)	(0.022)	(0.020)			
Far From Earthquake × Post							0.0976***	0.1087***	0.1224***
							(0.032)	(0.031)	(0.029)
Sample Period	Full	<2017	<2013	Full	<2017	<2013	Full	<2017	<2013
County FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	3049	2511	1798	3049	2511	1798	3049	2511	1798

Note: An observation is an individual county at one year in the sample spanning from 2003 to 2019. The outcome of interest is GDP per capita (adjusted at the 2007 price) in its natural log form. Coefficients are estimated in Eq. (2) at the county level. Columns (1)-(3) record the estimates if using the earthquake intensity scale, instead of the treatment dummy. Similarly, the treatment dummy is replaced by the natural log of the distance to the epicentre in columns (4)-(6). Another distance-related binary dummy in columns (7)-(9) is equal to 1 if a county is located beyond the 50th percentile of the distance distribution. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

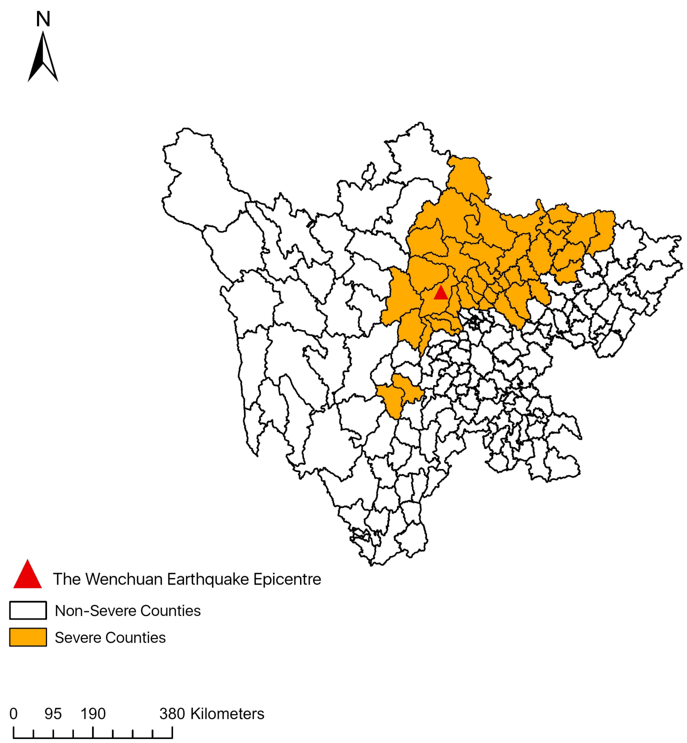
Figures

Figure 1: Possible Growth Patterns After Earthquake



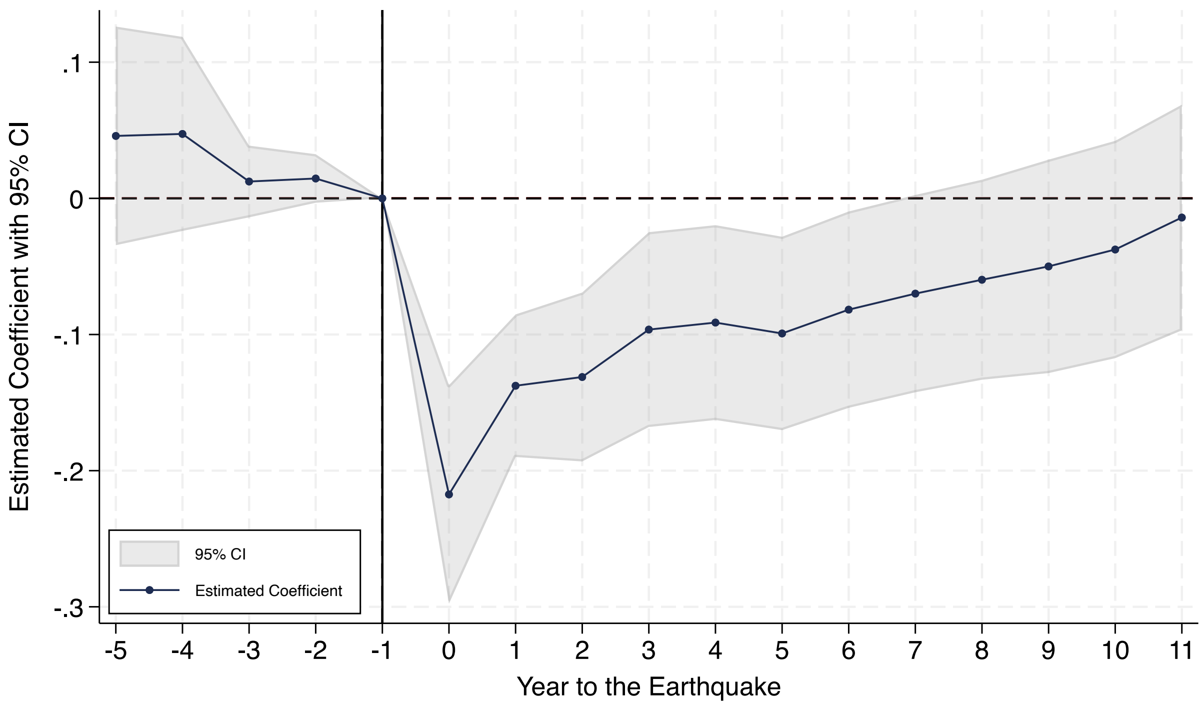
Note: Hsiang and Jina (2014) originally proposed the four hypotheses about growth patterns after a disaster. I redrew and modified the figure to fit into the background of this study.

Figure 2: Counties in Sichuan Classified by Severity



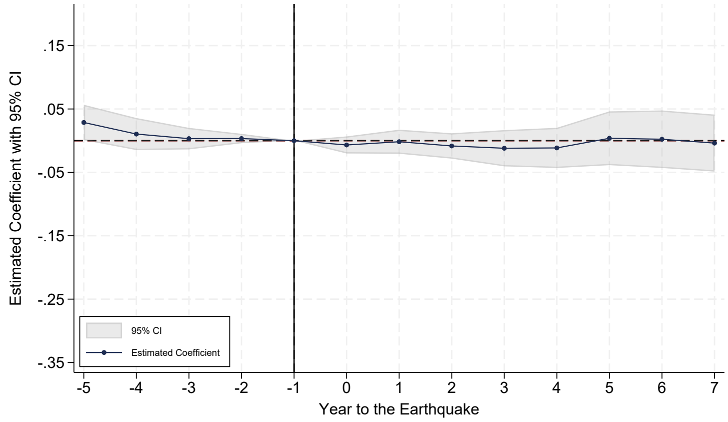
Note: In the map of Sichuan province, those in orange are severe counties.

Figure 3: Event-Study Analysis of GDP per capita

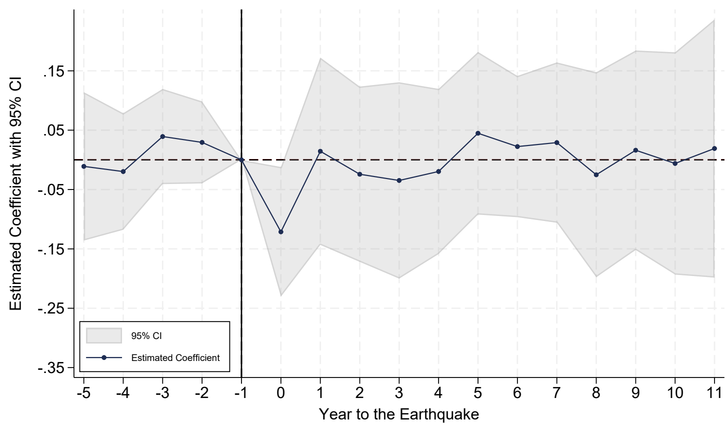


Note: The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure from the event-study regression in Eq. (1). The outcome of interest is GDP per capita in the natural log form. The vertical dashed line indicates the reference year in 2007, one year before the earthquake. Standard errors are clustered at the county level.

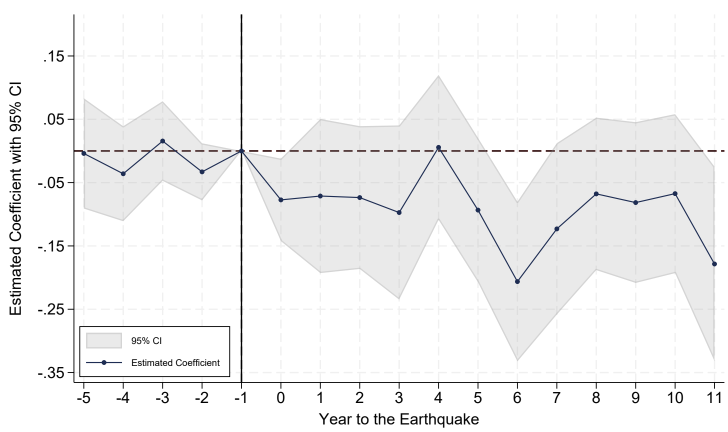
Figure 4: Effect on Employees by Sector



(a) The Outcome is ln(Rural Employees)



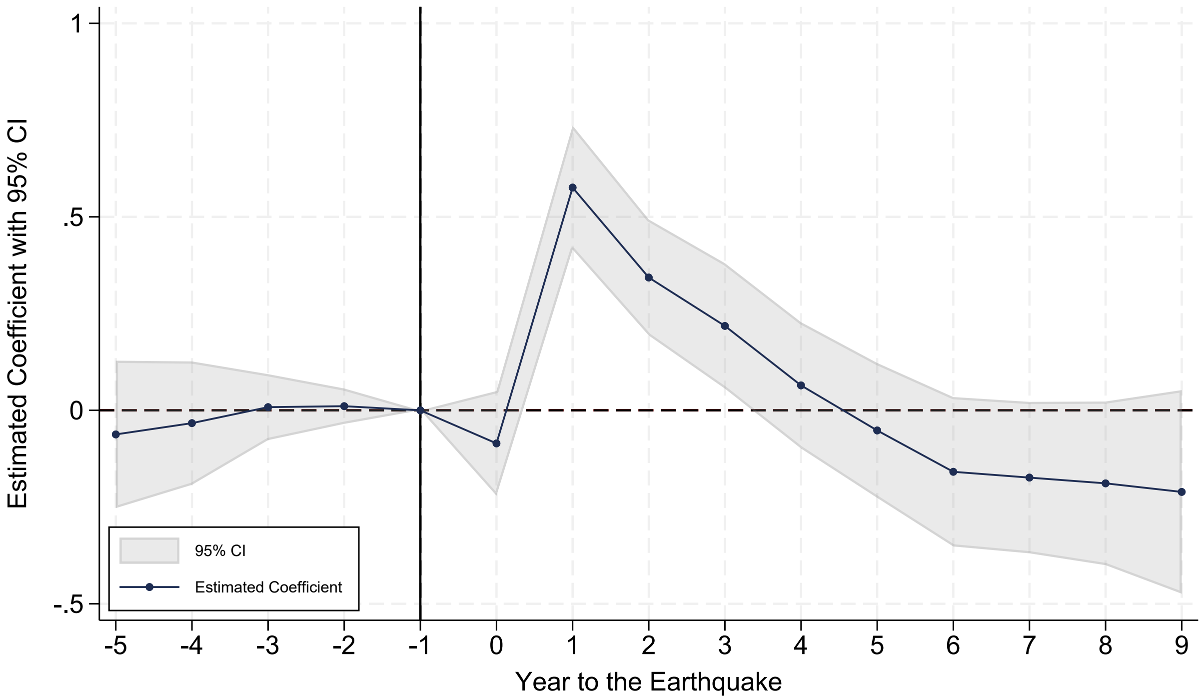
(b) The Outcome is ln(Industrial Employees)



(c) The Outcome is ln(Tertiary Employees)

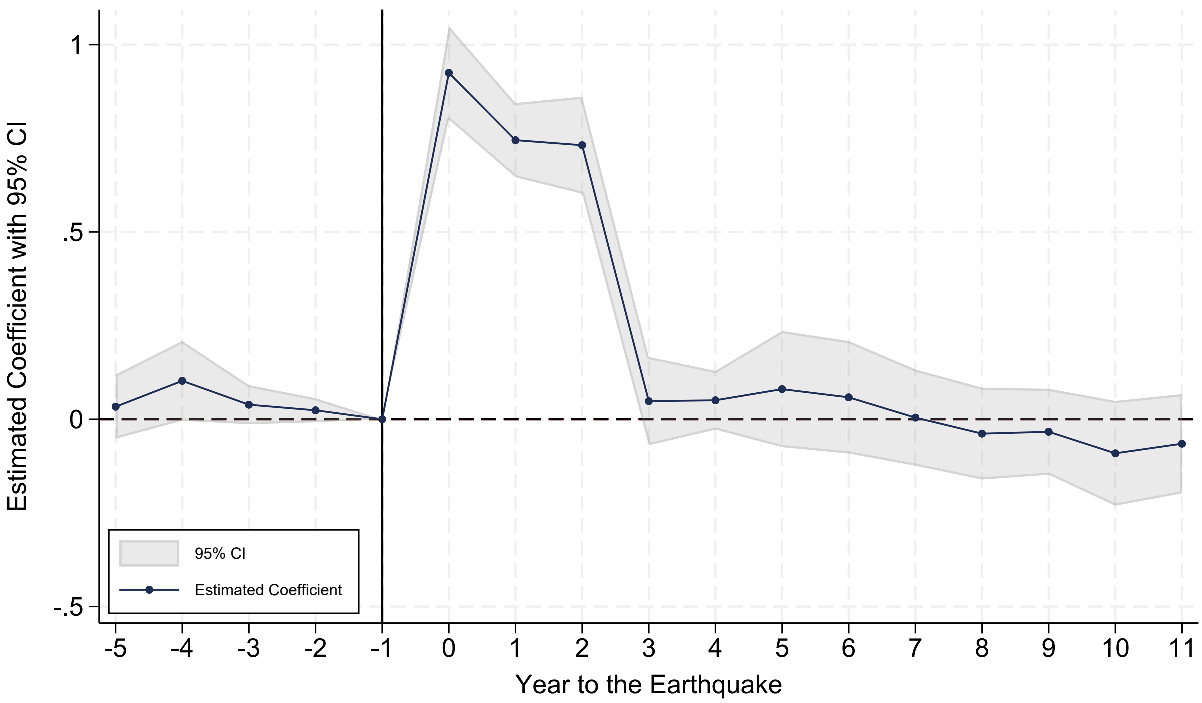
Note: The event-study regression is the same as proposed in Eq. (1), but the outcomes of interest are the natural log of rural, industrial, and tertiary employees. The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure. The vertical dashed line indicates the reference year in 2007, one year before the earthquake, and the standard errors are clustered at the county level.

Figure 5: Effect on Fixed-Asset Investment



Note: The event-study regression is the same as proposed in Eq. (1), but the outcome of interest is the natural log of fixed-asset investment per capita. The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure. The vertical dashed line indicates the reference year in 2007, one year before the earthquake, and the standard errors are clustered at the county level.

Figure 6: Effect on Fiscal Expenditure per capita



Note: The event-study regression is the same as proposed in Eq. (1), but the outcome of interest is the natural log of fiscal expenditures per capita. The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure. The vertical dashed line indicates the reference year in 2007, one year before the earthquake, and the standard errors are clustered at the county level.

A Appendix

A.1 Tables

Table A1: Exogeneity Test of Treatment

Dependent Variable: Being a Severe County					
	Time Frame: 2003-2007				
	(1)	(2)	(3)	(4)	(5)
ln(GDP per capita)	0.0551	0.0606	-0.0107		
	(0.0446)	(0.0490)	(0.0425)		
ln(Population)				0.0100	
				(0.0320)	
ln(Fixed-Asset Investment per capita)					0.0407
					(0.0312)
Prefecture FE			✓	✓	✓
Year FE		✓	✓	✓	✓
Observations	898	898	898	898	898

Note: This table tests whether the pre-earthquake (2003-2007) county-level characters could influence being reported as a severe county after the earthquake. The key regressor of interest is GDP per capita from columns (1) to (3), population in column (4), and fixed-asset per capita in column (5).The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

Table A2: Event-Study Estimates of GDP per capita

Dependent Variable: ln(GDP per capita)	(1)	(2)	(3)	(4)	(5)
5-Year Lag	0.046	0.046	0.047	0.047	0.047
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
4-Year Lag	0.047	0.047	0.047	0.047	0.047
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
3-Year Lag	0.012	0.012	0.012	0.012	0.012
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
2-Year Lag	0.015	0.015	0.015	0.015	0.015
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
0-Year Lead	-0.217***	-0.217***	-0.216***	-0.205***	-0.214***
	(0.041)	(0.041)	(0.039)	(0.036)	(0.035)
1-Year Lead	-0.138***	-0.138***	-0.136***	-0.126***	-0.134***
	(0.027)	(0.027)	(0.027)	(0.026)	(0.025)
2-Year Lead	-0.131***	-0.131***	-0.130***	-0.119***	-0.128***
	(0.031)	(0.031)	(0.028)	(0.027)	(0.027)
3-Year Lead	-0.096***	-0.096***	-0.095***	-0.084***	-0.093***
	(0.036)	(0.036)	(0.031)	(0.030)	(0.030)
4-Year Lead	-0.091**	-0.091**	-0.090***	-0.079***	-0.088***
	(0.036)	(0.036)	(0.032)	(0.030)	(0.031)
5-Year Lead	-0.099***	-0.096***	-0.095***	-0.084**	-0.093***
	(0.036)	(0.036)	(0.034)	(0.033)	(0.033)
6-Year Lead	-0.082**	-0.078**	-0.077**	-0.067**	-0.076**
	(0.037)	(0.037)	(0.034)	(0.034)	(0.034)
7-Year Lead	-0.070*	-0.066*	-0.065*	-0.055	-0.064*
	(0.037)	(0.037)	(0.035)	(0.034)	(0.035)
8-Year Lead	-0.060	-0.056	-0.055	-0.045	-0.054
	(0.037)	(0.038)	(0.036)	(0.035)	(0.035)
9-Year Lead	-0.050	-0.084**	-0.100***	-0.082**	-0.090**
	(0.040)	(0.040)	(0.038)	(0.036)	(0.036)
10-Year Lead	-0.038	-0.071*	-0.087**	-0.069*	-0.078**
	(0.040)	(0.040)	(0.038)	(0.036)	(0.036)
11-Year Lead	-0.014	-0.048	-0.065*	-0.048	-0.056
	(0.042)	(0.040)	(0.039)	(0.037)	(0.037)
Distance Control		✓	✓	✓	✓
Structure Control			✓	✓	✓
Geographic Control				✓	✓
Density Control					✓
County FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Observations	3049	3049	3049	3049	3049

Note: Coefficients are estimated in Eq. (1) at the county level, while the outcome of interest is the GDP per capita (adjusted at the 2007 price and natural log form). Distance control has the interaction term between the two interaction terms between the distance to their epicentres in the 2013 and 2017 earthquakes and their respective post-earthquake dummies; structure control includes the share of agricultural and industrial sectors in county GDP in 2007 both interacted with the post dummy ; geographic control considers county altitude difference interacted with the post dummy; density control represents county density in 2007 interacted with the post dummy. The county and year-fixed effects are included in all columns. The reference year is 2007, one year before the Wenchuan earthquake. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

Table A3: Alternative Outcome of Interest

Dependent Variable: ln(Retail Sales of Consumer Goods)	Full Sample: 2003-2019	2003-2016	2003-2012
	(1)	(2)	(3)
Severe × Post	-0.1010**	-0.0984**	-0.1104**
	(0.0436)	(0.0424)	(0.0434)
County FE	✓	✓	✓
Year FE	✓	✓	✓
Observations	3048	2510	1797

Note: The outcome of interest is retails sales of consumer goods (adjusted at the 2007 price) in its natural log form. The full sample is used in columns (1) and (2), while the sample after 2017 is excluded in column (3) and after 2013 is excluded in column (4). The controls are distance control, structure control, geographic control, and density control. The county and year-fixed effects are included in all columns. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

Table A4: Test of Spillover Effects

Dependent Variable: ln(GDP per capita)	Full Sample			Exclude Neighbour Counties		
	(1)	(2)	(3)	(4)	(5)	(6)
Severe × Post	-0.1296***	-0.1493***	-0.1709***	-0.1295***	-0.1492***	-0.1709***
	(0.043)	(0.042)	(0.041)	(0.043)	(0.042)	(0.041)
Neighbour × Post	-0.0664*	-0.0686*	-0.0541			
	(0.038)	(0.037)	(0.034)			
Sample Period	Full	<2017	<2013	Full	<2017	<2013
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	3049	2511	1798	2522	2077	1488

Note: The outcome of interest is GDP per capita (adjusted at the 2007 price) in its natural log form. Columns (1)-(3) add an interaction term between the neighbour dummy and post-earthquake dummy. Columns (4)-(6) exclude those neighbour counties (non-severe counties bordered with severe counties). The county and year-fixed effects are included in all columns. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

Table A5: Test of Migration Induced by the Earthquake

Dependent Variable: Population	(1)	(2)	(3)	(4)	(5)	(6)
Severe × Post	-0.8894	-0.8403	-0.8283	-0.6011	-0.5760	-0.6271
	(1.393)	(1.280)	(1.070)	(1.452)	(1.334)	(1.131)
Neighbour × Post				1.3073	1.1986	0.9136
				(2.146)	(1.899)	(1.394)
Sample Period	Full	<2017	<2013	Full	<2017	<2013
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	3049	2511	1798	3049	2511	1798

Note: The outcome of interest is county-level population. Columns (4)-(5) add an interaction term between the neighbour dummy and post-earthquake dummy. The county and year-fixed effects are included in all columns. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

Table A6: Falsification Test of Baseline Results

Dependent Variable: ln(GDP per capita)	If the Earthquake in 2004	If the Earthquake in 2005	If the Earthquake in 2006
	(1)	(2)	(3)
Severe × $Post_{2004}$	-0.028		
	(0.029)		
Severe × $Post_{2005}$		-0.038	
		(0.035)	
Severe × $Post_{2006}$			-0.028
			(0.026)
County FE	✓	✓	✓
Year FE	✓	✓	✓
Observations	898	898	898

Note: The outcome of interest is GDP per capita (adjusted at the 2007 price) in its natural log form. Coefficients are estimated in Eq. (2) at the county level. I only keep the pre-earthquake sample and then assume the earthquake was in 2004, 2005, and 2006, represented in columns (1), (2), and (3) respectively. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

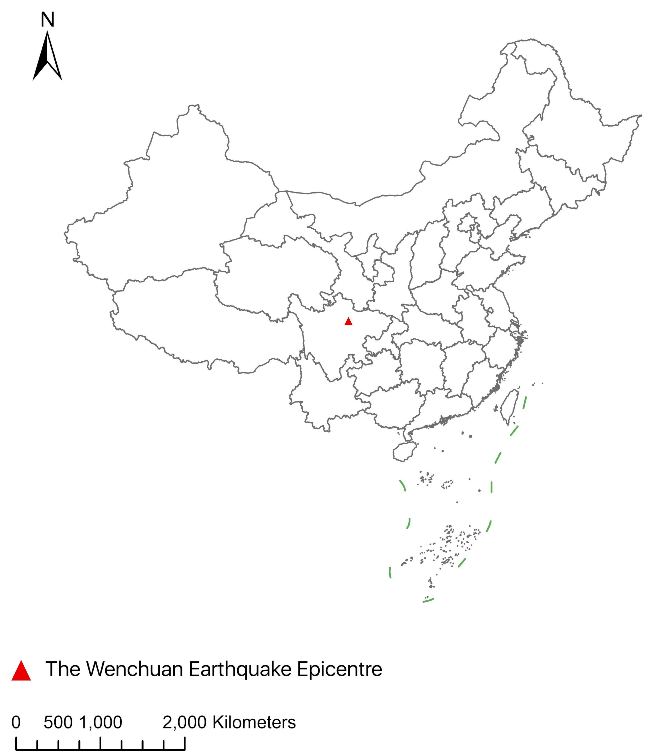
Table A7: Effect on Labour Market Outcomes

	Labour Force Participation = 1	Employment = 1	Weekly Working Hours	Weekly Wage
	(1)	(2)	(3)	(4)
Panel A: Rural Labour Market				
Severe × Post	0.005	-0.008	0.093**	0.031
	(0.013)	(0.011)	(0.038)	(0.056)
Observations	2510	1175	2433	2419
Panel B: Urban Labour Market				
Severe × Post	0.021	0.009	-0.009	-0.002
	(0.016)	(0.012)	(0.040)	(0.063)
Observations	1694	1653	1597	1603
Personal Controls	✓	✓	✓	✓
Occupation-Year Fixed Effects			✓	✓
Year Fixed Effects	✓	✓		
County Fixed Effects	✓	✓	✓	✓

Note: I construct individual-level panel data using two waves of the China Household Income Project (CHIP) surveys, conducted in 2008 and 2009. The labour market outcome in columns (1), (2), and (3) are labour force participation, employment status, and weekly working hours. The personal controls include gender, age, marriage status, number of children, education level, health status, Hukou type, and working experience. I also account for the occupation-year fixed effects and county fixed effects. The standard errors are clustered at the county level and reported in parentheses, while *, **, and *** denote significance levels at 10%, 5%, and 1% respectively.

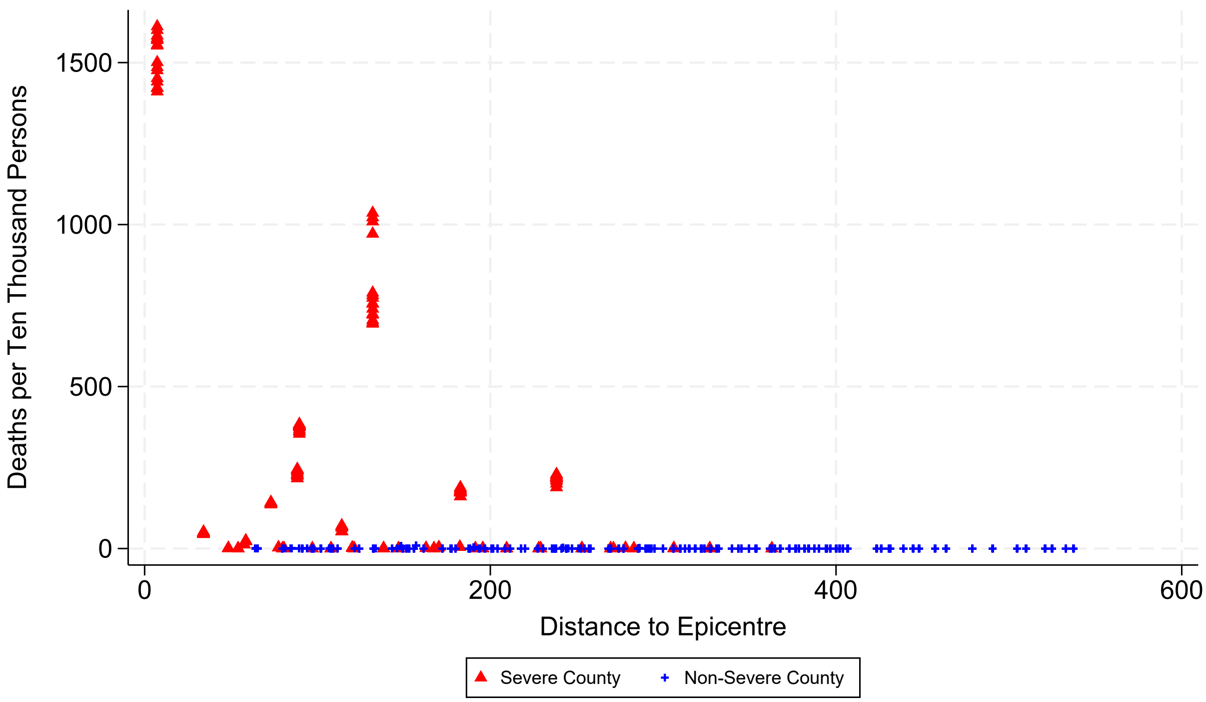
A.2 Figures

Figure A1: The Location of The Wenchuan Earthquake Epicentre



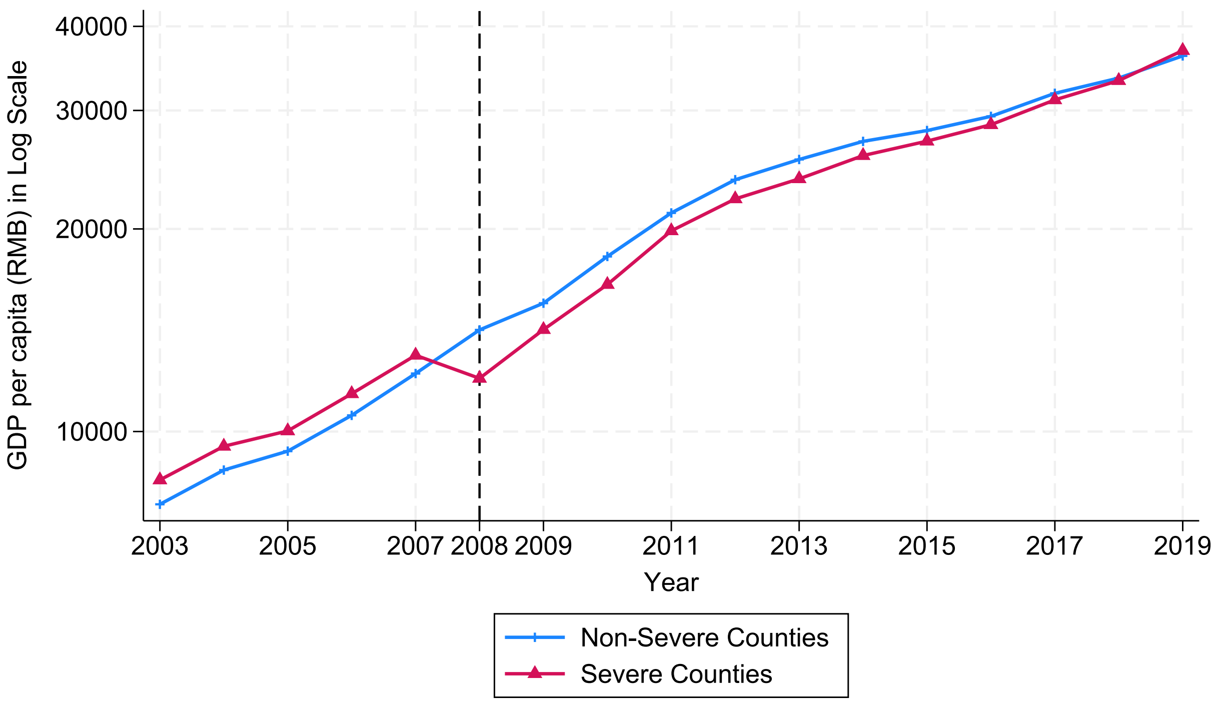
Note: This map shows the location of the Wenchuan earthquake epicentre in China, and the black lines plot the provincial boundaries.

Figure A2: Earthquake-Related Death Rate and Distance to Epicentre



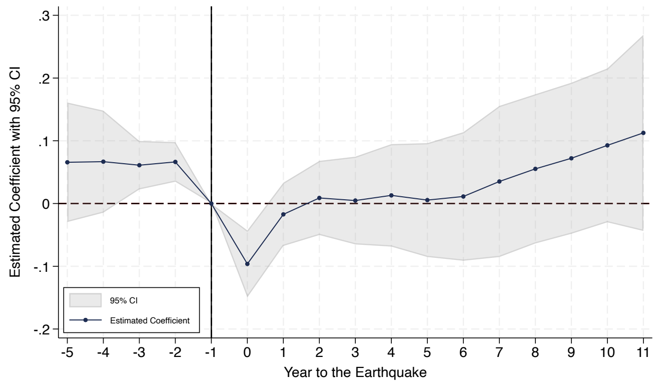
Note: The scatter plot depicts the correlation between the earthquake-related deaths and the distance to the earthquake epicentre at the county level. The triangle marker represents severe counties, while the plus marker is used for non-severe counties.

Figure A3: Trends of GDP per capita From 2003 to 2019

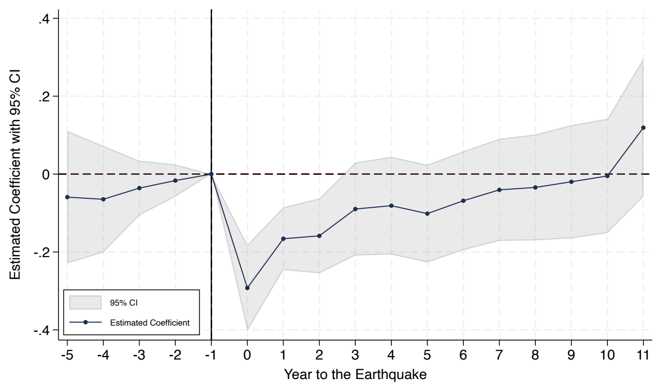


Note: This figure plots the trends of GDP per capita in severe and non-severe counties. The vertical axis represents GDP per capita in the log scale, adjusted at the 2007 price, while the horizontal axis represents the years, from 2003 to 2019.

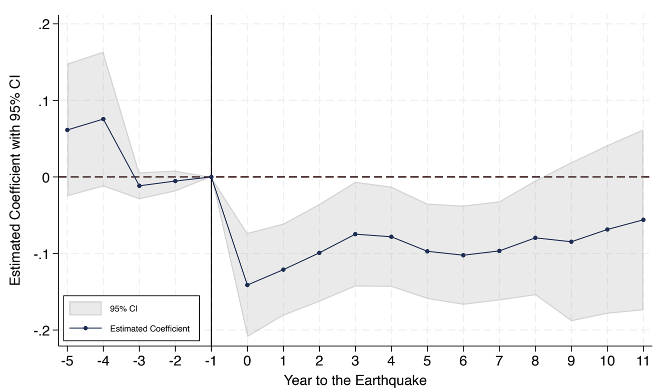
Figure A4: Sectoral Event-Study Analysis



(a) The Outcome is ln(GDP per capita in Agricultural Sector)



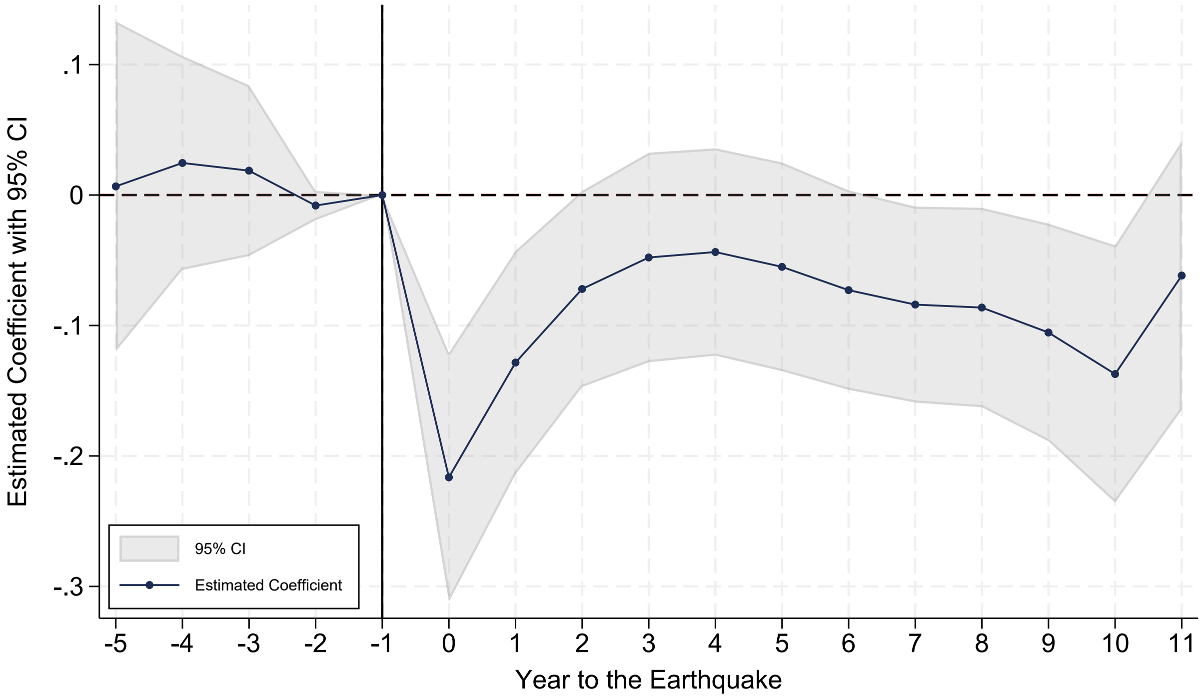
(b) The Outcome is ln(GDP per capita in Industrial Sector)



(c) The Outcome is ln(GDP per capita in Tertiary Sector)

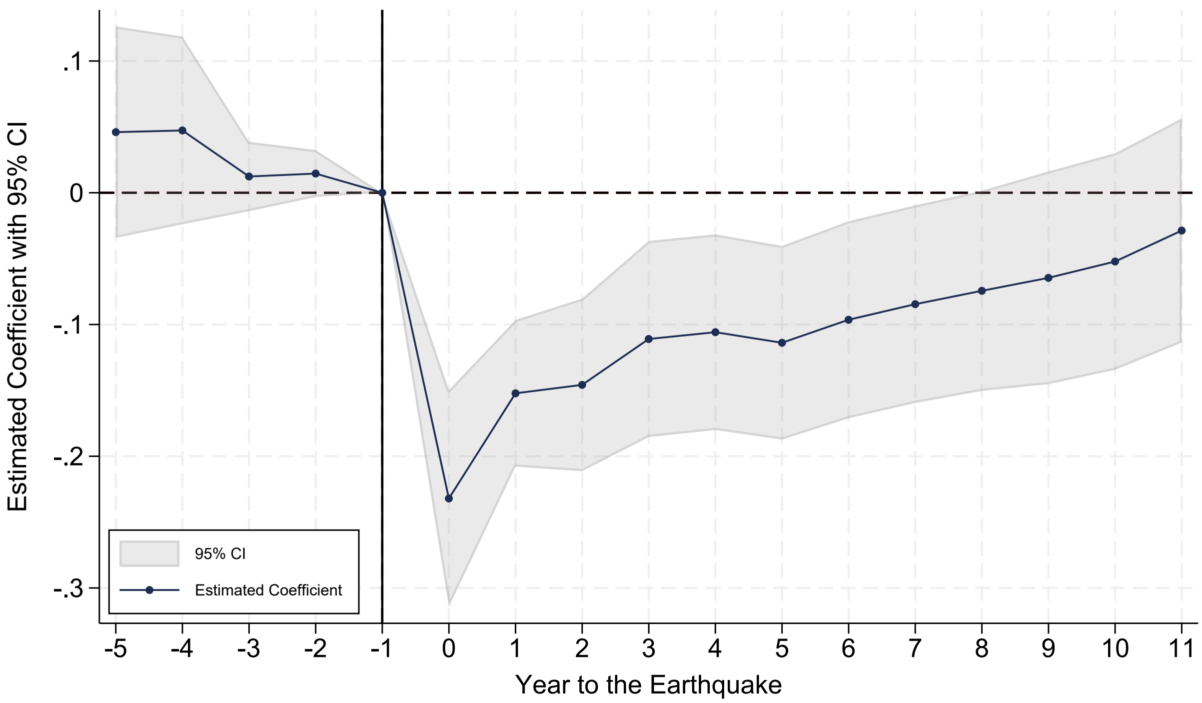
Note: The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure from the event-study regression in Eq. (1). Each subfigure represents a sectoral GDP per capita in the natural log form. The vertical dashed line indicates the reference year in 2007, one year before the earthquake. Standard errors are clustered at the county level.

Figure A5: Effect on Total Retail Sales of Consumer Goods



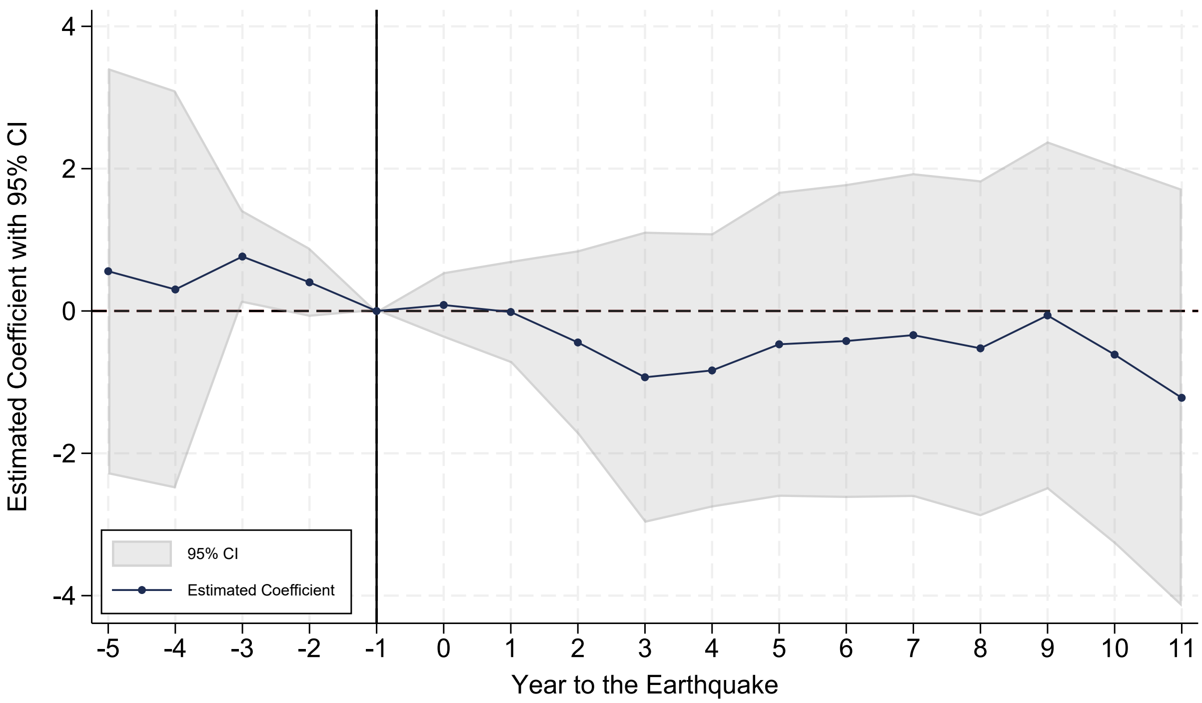
Note: The event-study regression is the same as proposed in Eq. (1), but the outcome of interest is the natural log of total retail sales of consumer goods per capita. The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure. The vertical dashed line indicates the reference year in 2007, one year before the earthquake, and the standard errors are clustered at the county level.

Figure A6: Event-Study Analysis with Potential Spillover Effects



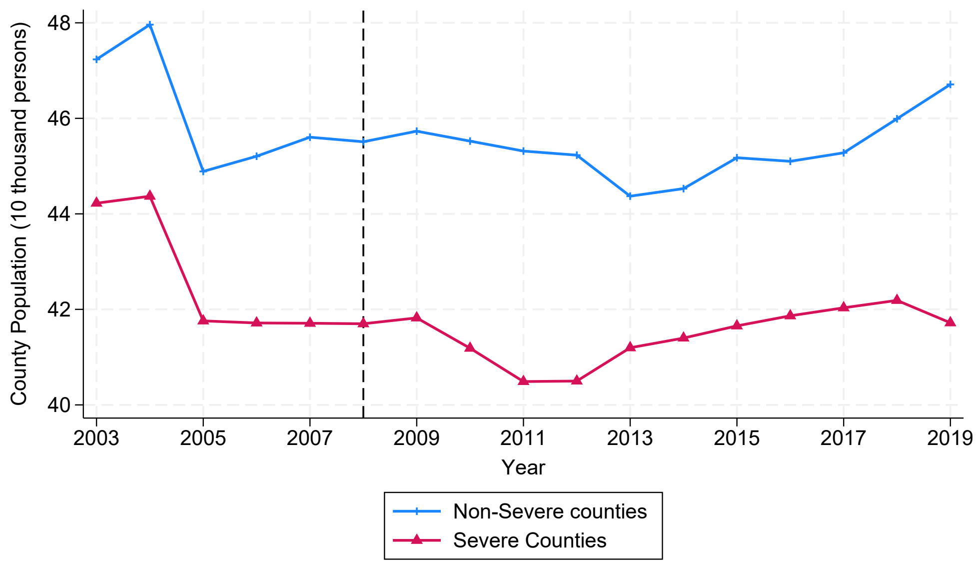
Note: The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure from the event-study regression in Eq. (1), considering potential spillover effects. The outcome of interest is GDP per capita in the natural log form. The vertical dashed line indicates the reference year in 2007, one year before the earthquake. Standard errors are clustered at the county level.

Figure A7: Effect on County Population

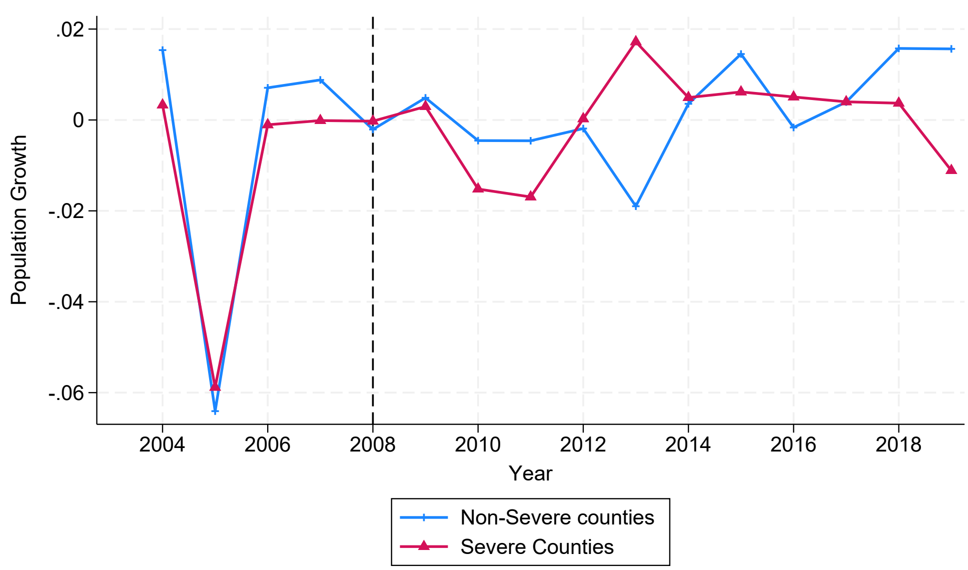


Note: The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure from the event-study regression in Eq. (1). The outcome of interest county population. The vertical dashed line indicates the reference year in 2007, one year before the earthquake. Standard errors are clustered at the county level.

Figure A8: Population Change from 2003 to 2019



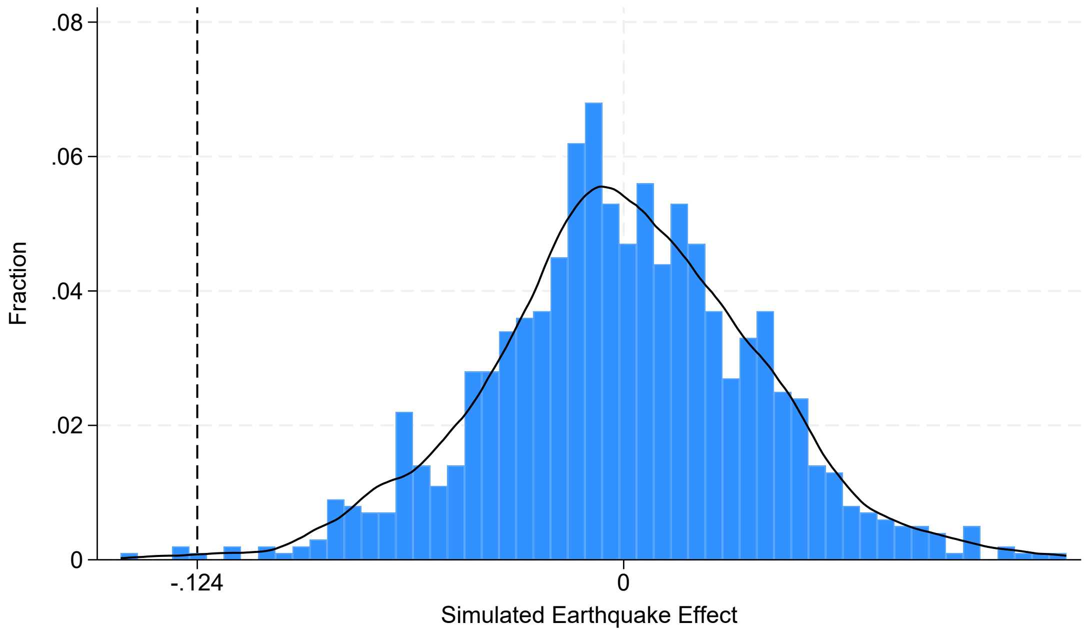
(a) Trends in Population



(b) Trends in Population Growth

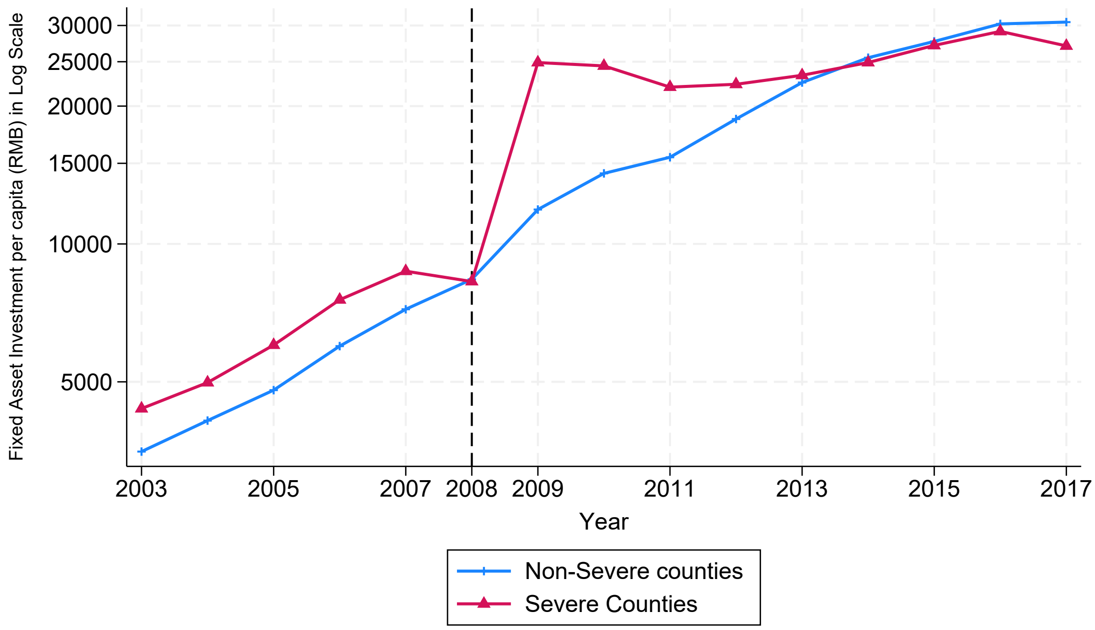
Note: This figure plots the trends of county population and population growth in severe and non-severe counties. The vertical axis is a unit of ten thousand persons, while the horizontal axis represents time frame from 2003 to 2019.

Figure A9: Distribution of the Simulated Effect



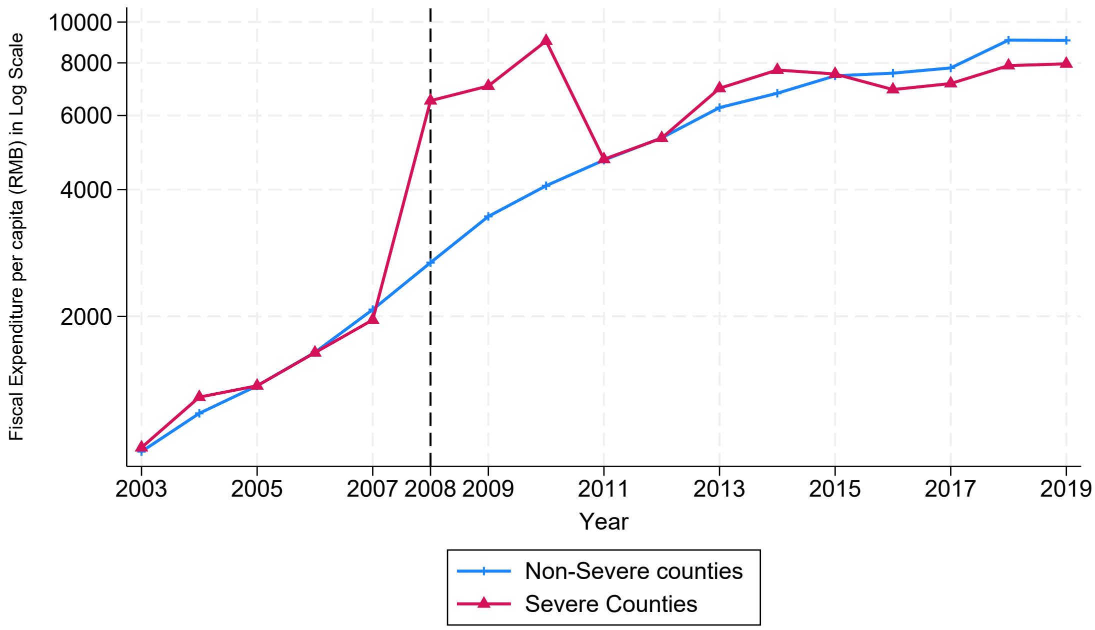
Note: I re-ran the regression in Eq. (2) 1,000 times, randomly assigning the treatment dummy variable based on the percentage of severe counties. The estimates were plotted as a distribution, each represented as a fraction. The vertical line on the plot denotes the earthquake effect observed in the baseline outcomes.

Figure A10: Trends of Fixed-Asset Investment per capita



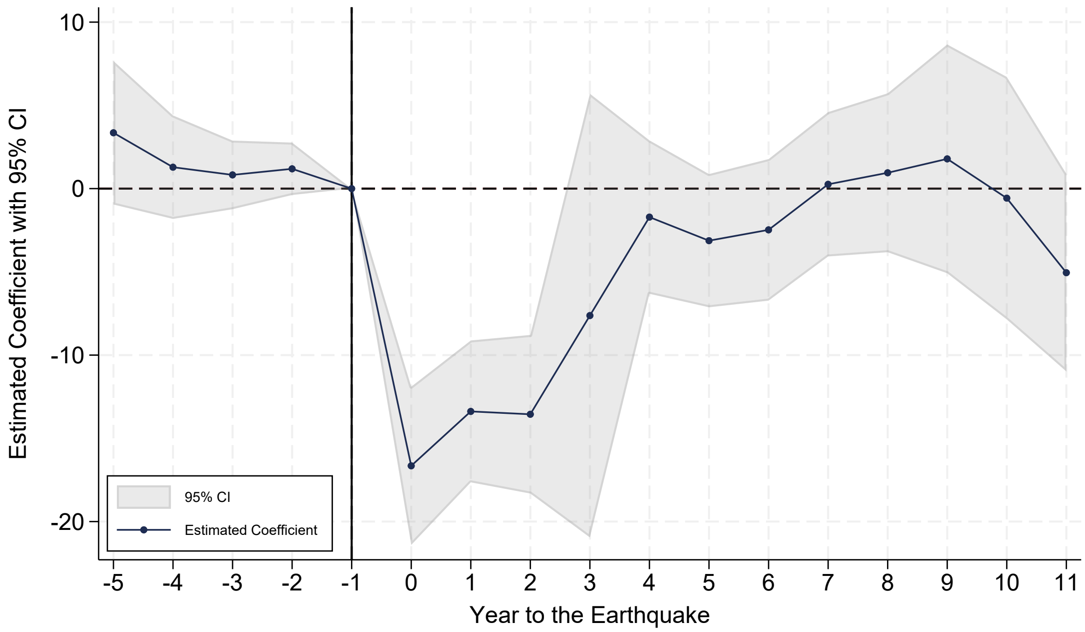
Note: This figure plots the trends of fixed-asset investment per capita in severe counties and non-severe counties. The vertical axis represents fixed-asset investment per capita in the log scale, adjusted at the 2007 price, while the horizontal axis represents the time frame from 2003 to 2017.

Figure A11: Trends of Fiscal Expenditure per capita



Note: This figure plots the trends of fiscal expenditure per capita in severe counties and non-severe counties. The vertical axis represents fiscal expenditure per capita in the log scale, adjusted at the 2007 price, while the horizontal axis represents the time frame from 2003 to 2019.

Figure A12: Effect on Fiscal Dependency



Note: The event-study regression is the same as proposed in Eq. (1), but the outcome of interest is the fiscal dependency, fiscal revenue over fiscal expenditure. The estimated coefficients in each year with their 95% confidence intervals are plotted in this figure. The vertical dashed line indicates the reference year in 2007, one year before the earthquake, and the standard errors are clustered at the county level.

A.3 The Wenchuan Earthquake Migration Model

The Hukou system in China imposes restrictions on internal migration, preventing residents from relocating to other regions and accessing public benefits without certain administrative procedures. In the context of this study, a key implication of this system is that it increases the likelihood that skilled workers remain in affected areas, thereby mitigating the potential loss of human capital and productivity that could arise under conditions of unrestricted labour mobility. This paper presents a theoretical framework to illustrate how limited mobility, enforced by the Hukou system, may have facilitated economic recovery and development in severe counties.

I consider a representative severe county in a two-period model ($t = 0, 1$) where the earthquake strikes in $t = 0$. The production function uses the standard Cobb-Douglas form:

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha},\ \alpha \in (0, 1) \tag{1}$$

where Y_t represents output, A is the constant level of technology, K_t is the capital stock, and L_t is the labour force at time t. And the per worker production is:

$$y_t = \frac{Y_t}{L_t} = A\left(\frac{K_t}{L_t}\right)^{\alpha} = Az_t^{\alpha} \tag{2}$$

where $z_t = \frac{K_t}{L_t}$ is the capital-labour ratio. From this expression, per worker production is positively correlated with the capital-labour ratio. The depreciation rate of capita is δ, and the saving rate in the county is s, both parameters being exogenous and between 0 and 1. In a typical scenario without shocks, capital accumulation follows:

$$K_{t+1} = sY_t + (1-\delta)K_t = sAK_t^{\alpha} L_t^{1-\alpha} + (1-\delta)K_t \tag{3}$$

Suppose each period a constant share ($M \in$ (0,1)) of the labour force chooses to migrate, reflecting the strictness of the Hukou system. Migration is lower with Hukou enforcement than without, i.e., $M^{no\ hukou} > M^{hukou}$. Besides, I assume the natural birth rate is zero. When the earthquake strikes in period 0, a fraction γ of the initial capital stock is destroyed, but the death toll among the labour force is negligible. However, migration occurs as residents respond to the current Hukou system constraints, leading to a reduction in skilled workers, which in turn reduces productivity. For simplicity, the post-earthquake productivity level is modelled as $(1 - M)A$.

The next step is to analyze how the strictness of the Hukou system influences the per worker production through the capital-labour ratio. Firstly, when the earthquake strikes at period 0, the capital and labour become $(1-\gamma)K_0$ and $(1-M)L_0$, respectively, with productivity reduced to $(1-M)A$. The capital-labour ratio in period 1 is:

$$\begin{aligned} z_1 = \frac{K_1}{L_1} = \frac{sY_0 + (1-\delta)(1-\gamma)K_0}{L_1} &= \frac{s(1-M)AK_0^{\alpha}[L_0(1-M)]^{1-\alpha} + (1-\delta)(1-\gamma)K_0}{L_0(1-M)} \\ &= sAz_0^{\alpha}(1-M)^{1-\alpha} + (1-\delta)(1-\gamma)z_0(1-M)^{-1} \end{aligned} \tag{4}$$

In this equation, the key parameter of interest is the migration rate M. Taking the derivative of z_1 with respect to M, I obtain:

$$\frac{dz_1}{dM} = -sAz_0^{\alpha}(1-M)^{-\alpha} + (1-\delta)(1-\gamma)z_0(1-M)^{-2} \tag{5}$$

The sign of this derivative depends on the relative sizes of the terms. Specifically, if:

$$M < 1 - \left[\frac{(1-\delta)(1-\gamma)}{sA(1-\alpha)}\right]^{\frac{1-\alpha}{2-\alpha}} = M_{critical} \tag{6}$$

where $\left[\frac{(1-\delta)(1-\gamma)}{sA(1-\alpha)}\right]^{\frac{1-\alpha}{2-\alpha}}$ is assumed to be between 0 and 1, then the first-order derivative of z_1 with respect to M is negative.

The enforcement of the Hukou system restricts labour migration, keeping M lower than $M_{critical}$. Then:

$$\frac{dy_1}{dM} = \frac{dy_1}{dz_1} \cdot \frac{dz_1}{dM} < 0 \tag{7}$$

This implies that limited mobility can improve post-earthquake economic conditions by preserving skilled workers and preventing a substantial reduction in productivity. Intuitively, fewer skilled workers migrating helps maintain the local technology level, supporting faster recovery and growth.

A.4 Individual Labour Market Outcomes

I construct an individual-level panel dataset using the longitudinal survey on Rural Urban Migration in China (RUMiC). The (RUMiC) survey was initiated as a collaborative effort between the Australian National University, the University of Queensland, the Beijing Normal University, and the Institute of Labor Economics (IZA), to better understand the socioeconomic and demographic impacts of rural-to-urban migration in China. To be more specific, its questionnaires have covered many critical aspects of quality of life, such as household demographic characteristics, health conditions, social networks, and household finance (Akgüç et al., 2014).

I use two waves of the RUMiC survey conducted in 2008 and 2009, which provides a unique opportunity to capture the short-term impacts of the Wenchuan earthquake, as it occurred between the two survey periods. For this analysis, I only focus on answers from adults (aged 18 and older) residing in Sichuan province and match their residence with the severity status at the county level. The empirical specification is expressed as:

$$y_{ict} = \alpha + \beta Severe_c \times Post_t + x'_{ict}\gamma + \delta_c + \eta_t + \epsilon_{ict}$$

where y_{ict} represents labour market outcomes for individual i in county c in year t. Specifically, those outcomes include labour force participation, employment status, weekly working hours, and weekly wage.[22] $Severe_c$ is a severity indicator that is equal to 1 if the county is classified as severely affected by the earthquake; $Post_t$ a time indictor that is equal to 1 if the year is after the earthquake; x'_{ict} includes a set of individual characteristics, such gender, age, marriage status, number of children, education level, minority, health status, Hukou type, and work experience; δ_c and η_t control the county and year fixed effects; ϵ_{ict} measures unobservable random shocks. Standard errors are clustered at the household level in this analysis.

Table A7 present the estimates in the previous specification. The dependent variables in columns (1) and (2) reflect the extensive margin of labour market outcomes, while those in columns (3) and (4) analyze the earthquake effect on the intensive margin. In the final two columns, the specification incorporates occupation-year fixed effects instead of year fixed effects alone. This adjustment captures for potential influences of occupation type on the intensive margin. Overall, the Wenchuan earthquake does not significantly affect either the extensive or intensive margins of labour in the short term. Respondents in severe counties, whether in rural or urban areas, do not experience changes in labour force participation,

[22] Weekly wages have been adjusted to 2007 price levels and transformed into their natural log form, as have weekly working hours.

employment status, or wage levels due to the earthquake. The only exception is among rural residents in severe counties, whose weekly working hours increase by approximately 9% following the earthquake.