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Do Natural Disasters Influence Long-Term Savings?: Assessing the Impact of the 2008 Sichuan Earthquake on Household Saving Rates Using Synthetic Control

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By employing the synthetic control method, the authors examine the short- and long-term effects of the 2008 Sichuan earthquake on saving behaviour. The results indicate that, in the short run, the earthquake caused drastic declines in household saving rates—from 24 per cent to seven per cent and from 23 per cent to 21 per cent for rural and urban populations, respectively. However, household saving rates recovered to the baseline shortly after the shock, and the outcome exactly matches the counterfactual counterparts in the following period. The estimates imply that, at the aggregate level, the earthquake has had no discernible long-run impact on the saving propensity of the affected population.

INTRODUCTION

The economic impact of natural disasters has attracted considerable attention in the past decade. The ongoing debate centres on how and whether natural catastrophes affect economic growth, as a consensus has not yet been reached. Economic theories predict that the growth effects of natural events can be distinct in directions (positive, negative and neutral) and magnitudes, both in the short and long terms.[1] On the other

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[1] For instance, in traditional neoclassical models, natural disasters cause only capital losses; thus technological progress remains intact. Accordingly, the shock spurts short-term growth but has neutral long-term effects (in the steady state). On the other hand, endogenous growth theories generally contend that destruction will lead to a permanent growth slowdown, resulting in a deviation from the equilibrium growth path (which could translate into a sluggish growth and even a poverty trap). Furthermore, the "creative destruction" and "build back better" hypotheses suggest that destruction could boost replacement, construction and innovation, thereby fostering greater growth and probably a better economic potential in the event aftermath. See Philippe Aghion and Peter Howitt, *A Model of Growth through Creative Destruction*, National Bureau of Economic Research Working Paper 3223 (1990); and Ricardo J. Caballero and Mohamad L. Hammour, *The Cleansing Effect of Recessions*, National Bureau of Economic Research Working Paper 3922 (1991).

hand, empirical research has highlighted diverse insights as well. Early studies have established a positive correlationship between economic growth and the frequency and magnitude of moderate disasters,[2] while recent studies discover that natural catastrophes lead to negative economic consequences in the short term, especially for underdeveloped countries.[3] There is also ample evidence indicating the mixed growth impact of natural disasters, for which the overall outcome would depend on the features of disasters (type, intensity and spatial extent), geographical conditions and national characteristics.[4]

Research on disaster impact has long been focused on the growth effect, but the characterisation of aggregate growth barely provides complete answers. A further examination may be worthwhile into the mechanisms and channels through which the growth effect is formed. In this study, the authors attempt to identify the disaster impact on household savings—a critical and decisive determinant of economic growth. This analytical angle applies suitably to the case of the 2008 Sichuan earthquake, as China's economic development is largely driven by the capital-intensive investment pattern fuelled by its extraordinarily high household saving rates.

Saving behaviour is a central topic in economics. It is commonly believed that people tend to be conservative and save more in the wake of natural disasters, or that victims might become self-indulgent and consume more instead of saving (also due to the "charity hazard"). In this study, in order to extend the empirical knowledge of saving behaviour, the authors employ the synthetic control method[5] to estimate the short- and long-term effects of the 2008 Sichuan earthquake on household savings. According to the results, the earthquake caused substantial declines in Sichuan's household saving rates—from 24 per cent to seven per cent for the rural population and from 23 per cent to 21 per cent for the urban population—as the manifestation of direct economic losses from the disaster. However, both the rural and urban saving

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[2] Jose-Miguel Albala-Bertrand, "Political Economy of Large Natural Disasters: With Special Reference to Developing Countries", *OUP (Oxford University Press) Catalogue* (1993); Richard S.J. Tol, "Economic Analysis of Natural Disasters", *Climate, Change and Risk* (1999): 308–27; Mark Skidmore and Hideki Toya, "Do Natural Disasters Promote Long-run Growth?", *Economic Inquiry* 40, no. 4 (2002): 664–87.

[3] Jacob Vigdor, "The Economic Aftermath of Hurricane Katrina", *Journal of Economic Perspectives* 22, no. 4 (2008): 135–54; Ilan Noy, "The Macroeconomic Consequences of Disasters", *Journal of Development Economics* 88, no. 2 (2009): 221–31; Makena Coffman and Ilan Noy, "Hurricane Iniki: Measuring the Long-term Economic Impact of a Natural Disaster Using Synthetic Control", *Environment and Development Economics* 17, no. 2 (2012): 187–205; Eric Strobl, "The Economic Growth Impact of Natural Disasters in Developing Countries: Evidence from Hurricane Strikes in the Central American and Caribbean Regions", *Journal of Development Economics* 97, no. 1 (2012): 130–41.

[4] Hideki Toya and Mark Skidmore, "Economic Development and the Impacts of Natural Disasters", *Economics Letters* 94, no. 1 (2007): 20–5; Norman V. Loayza et al., "Natural Disasters and Growth: Going Beyond the Averages", *World Development* 40, no. 7 (2012): 1317–36; Ilan Noy and Tam Bang Vu, "The Economics of Natural Disasters in a Developing Country: The Case of Vietnam", *Journal of Asian Economics* 21, no. 4 (2010): 345–54; Eduardo Cavallo, Sebastian Galiani, Ilan Noy and Juan Pantano, "Catastrophic Natural Disasters and Economic Growth", *Review of Economics and Statistics* 95, no. 5 (2013): 1549–61.

[5] Alberto Abadie and Javier Gardeazabal, "The Economic Costs of Conflict: A Case Study of the Basque Country", *American Economic Review* 93, no. 1 (2003): 113–32.

rates had rebounded to the "counterfactual" levels shortly after the slump. Accordingly, the earthquake resulted in short-term adverse effects but exerted no perceivable long-term effect on saving propensity. This finding is confirmed by a "placebo test" and a series of robustness checks employing alternative predictors.

The structure of this study is as follows. The second section reviews the related literature and summarises the mechanisms of disaster impact. The third section presents a brief overview of the 2008 Sichuan earthquake and introduces the empirical strategy, data source and variable definition. The fourth section presents the estimates, placebo test and robustness checks. The concluding section discusses the remarks and implications.

NATURAL DISASTERS AND SAVING BEHAVIOUR

Disaster impact on saving behaviour has been rarely examined over the last century. As a notable exception, Japan—a disaster-prone country—has presented valuable early studies and data sources in disaster research. In a literature survey, Horioka argues that the high frequency and severe damages of natural events in Japan have contributed to its high savings persistence in the post-war period.[6] Overall, Skidmore's work is the first empirical attempt in English-speaking academic circles to look into the relationship between disasters and savings accumulation.[7] Employing a cross-country estimation based on a sample of 14 developed nations, the analysis finds a positive correlation between disaster loss and household saving rate, consistent with the precautionary savings hypothesis. A subsequent study by Skidmore and Toya reveals a growth impact of climatic disasters on national capital accumulation.[8] In a similar vein, Leiter et al. estimate that firms that were flood victims in Europe tend to achieve high growths in asset accumulation.[9]

On the other hand, recent empirical studies have derived diverse conclusions. Dercon deduces that rainfall shock events had significantly stimulated the consumption of rural residents in Ethiopia.[10] Sawada and Shimizutani investigate how local residents insured themselves against the 1995 Kobe earthquake.[11] Their analysis indicates that

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[6] Charles Yuji Horioka, "Why is Japan's Household Saving Rate so High? A Literature Survey", *Journal of the Japanese and International Economies* 4, no. 1 (1990): 49–92.

[7] Mark Skidmore, "Risk, Natural Disasters, and Household Savings in a Life Cycle Model", *Japan and the World Economy* 13, no. 1 (2001): 15–34.

[8] Skidmore and Toya, "Do Natural Disasters Promote Long-run Growth?", *Economic Inquiry* 40, no. 4 (2002): 664–87.

[9] Andrea M. Leiter, Harald Oberhofer and Paul A. Raschky, "Creative Disasters? Flooding Effects on Capital, Labour and Productivity Within European Firms", *Environmental and Resource Economics* 43, no. 3 (2009): 333–50.

[10] Stefan Dercon, "Growth and Shocks: Evidence from Rural Ethiopia", *Journal of Development Economics* 74, no. 2 (2004): 309–29.

[11] Yasuyuki Sawada and Satoshi Shimizutani, "How Do People Cope With Natural Disasters? Evidence from the Great Hanshin–Awaji (Kobe) Earthquake in 1995", *Journal of Money, Credit and Banking* 40, no. 2–3 (2008): 463–88.

homeowners had dis-saved significantly and borrowed extensively after the shock, implying the ineffectiveness of the formal and informal insurance systems. Gignoux and Menéndez find that individuals who had experienced short-term economic losses from the Indonesian earthquakes recovered in the medium run and even exhibited welfare gains (consumption growth) in the long run.[12] Berlemann et al. study the effect of the 2002 European floods on saving behaviour.[13] They conclude that the flood turned out to have depressed victims' saving motives, mostly due to the generous government compensation. Their findings lend support to the much-debated hypotheses known as "Samaritan's dilemma" and "charity hazard". In a study related to the current one, Filipski et al. investigate the impact of the 2008 Sichuan earthquake on consumer behaviour.[14] They find that households that lived closer to the epicentre tended to save less, spend more on alcohol and cigarettes, and pursue more leisure activities after the shock.

Previous literature has provided diverse findings concerning the short-term disaster impact on saving behaviour, yet the direction and magnitude of the long-term effect remain ambiguous. Overall, disaster impact is a multidimensional issue that is hard to quantify, since the destructive nature of disasters not only generates economic losses but also alters individuals' behaviour and expectations. Theoretically, saving propensity tends to increase with risk aversion (the attitude towards risk) and decrease with time preference (the strategy to "discount" future outcomes). In behavioural economics, there is ample evidence suggesting that individuals respond to natural disasters by becoming more risk-averse towards uncertainty.[15] However, some researchers support the contrary view, that disaster victims tend to become risk tolerant and reckless, gamble more and spend more on consumer goods.[16] In the context of time preference,

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[12] Jérémie Gignoux and Marta Menéndez, "Benefit in the Wake of Disaster: Long-Run Effects of Earthquakes on Welfare in Rural Indonesia", *Journal of Development Economics* 118 (2016): 26–44.

[13] Michael Berlemann, Max Friedrich Steinhardt and Jascha Tutt, "Do Natural Disasters Stimulate Individual Saving? Evidence from a Natural Experiment in a Highly Developed Country", CESifo Working Paper No. 5344 (2015).

[14] Mateusz J. Filipski et al., "Living Like There's No Tomorrow: Saving and Spending Following the Sichuan Earthquake", IFPRI Discussion Paper no. 1461, 2015.

[15] Marrit van den Berg, Ricardo Fort and Kees Burger, *Natural Hazards and Risk Aversion: Experimental Evidence from Latin America*, no. 1005-2016-79151, Paper given at the International Association of Agricultural Economists Conference, August 16–22, 2009, Beijing (2009); Lisa Cameron and Manisha Shah, "Risk-taking Behavior in the Wake of Natural Disasters", *Journal of Human Resources* 50, no. 2 (2015): 484–515; Alessandra Cassar, Andrew Healy and Carl Von Kessler, "Trust, Risk, and Time Preferences after a Natural Disaster: Experimental Evidence from Thailand", *World Development* 94 (2017): 90–105.

[16] Catherine C. Eckel, Mahmoud A. El-Gamal and Rick K. Wilson, "Risk Loving after the Storm: A Bayesian-Network Study of Hurricane Katrina Evacuees", *Journal of Economic Behavior & Organization* 69, no. 2 (2009): 110–24; Li Jin-Zhen et al., "Are People Always More Risk Averse after Disasters? Surveys after a Heavy Snow-hit and a Major Earthquake in China in 2008", *Applied Cognitive Psychology* 25, no. 1 (2011): 104–11; Lionel Page, David A. Savage and Benno Torgler, "Variation in Risk Seeking Behaviour Following Large Losses: A Natural Experiment", *European Economic Review* 71 (2014): 121–31; and Filipski et al., "Living Like There's No Tomorrow".

Callen argues that consumers become less impatient after catastrophic events,[17] whereas Cassar et al. advocate the opposite.[18] Beyond economics, post-traumatic stress disorder has been extensively studied in medical fields and the current consensus is that extreme shocks generally depress saving motives. The mechanisms and channels of disasters' saving impacts are summarised as follows.

First, natural disasters cause direct physical destruction; households exposed to natural events are confronted with the increases in expenditures (e.g. home, contents and medical services) and the risk of unemployment and negative income shocks.[19] Overall, individuals tend to earn less and spend more after the event. In the short run, the "volume effect" of natural disasters (e.g. destruction and income loss) generally leads to higher consumption and lower savings at both the household and aggregate levels.

Second, natural events influence the preference and expectations of individuals, which in turn induce the reallocation of time resources.[20] Exogenous shocks may bring about two kinds of uncertainties. The first concerns the uncertainty concerning future earnings. Saving is regarded as a tool to smooth lifetime consumption. To fend off potential property damage, unemployment and income loss, individuals living in disaster-prone regions react to the corresponding uncertainty by saving and other methods of self-insurance. The second concerns the uncertainty concerning life expectancy. In the context of extreme natural catastrophes, rational agents may anticipate an increase in mortality and a decrease in life expectancy. Individuals would therefore update the evaluation of the future by adjusting their time preference. All these changes in turn shape the consumption and saving patterns.[21] In this sense, in the long run, extreme events are likely to stimulate consumption expansion rather than savings accumulation. In summary, the effects of risk perception offset each other: one promotes saving propensity in preparation for potential economic losses, and the other reduces saving propensity in response to the perceived reduction in life expectancy. It remains unclear how these net effects would balance out.

Third, after-event saving behaviour relies crucially on objective factors. For instance, disaster consequences are often less severe in nations with extensive insurance coverage, better institutions, greater openness and better economic status.[22] In the

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[17] Michael Callen, "Catastrophes and Time Preference: Evidence from the Indian Ocean Earthquake", *Journal of Economic Behavior & Organization* 118 (2015): 199–214.

[18] Alexandra Cassar, Andrew Healy and Carl Von Kessler, "Trust, Risk, and Time Preferences after a Natural Disaster: Experimental Evidence from Thailand", *World Development* 94, no. C (2017): 90–105.

[19] Jacob L. Vigdor, "The Katrina Effect: Was There a Bright Side to the Evacuation of Greater New Orleans?", *The BE Journal of Economic Analysis & Policy* 7, no. 1 (2007): 1–40.

[20] Catherine C. Eckel, Mahmoud A. El-Gamal and Rick K. Wilson. "Risk Loving after the Storm: A Bayesian-Network Study of Hurricane Katrina Evacuees", *Journal of Economic Behavior & Organization* 69, no. 2 (2009): 110–24; Cassar, Healy and Von Kessler, "Trust, Risk, and Time Preferences after a Natural Disaster".

[21] As a typical example, Kinugasa and Mason theoretically and empirically study the effect of changing mortality on national saving rates. See Tomoko Kinugasa and Andrew Mason, "Why Countries Become Wealthy: The Effects of Adult Longevity on Saving", *World Development* 35, no. 1 (2007): 1–23.

[22] Howard Kunreuther, "Mitigating Disaster Losses through Insurance", *Journal of Risk and Uncertainty* 12, no. 2–3 (1996): 171–87; Toya and Skidmore, "Economic Development and the Impacts of Natural Disasters".

wake of natural disasters, external elements—such as government compensation, disaster relief, adaptation policies, external aid, private donations, and income transfers—are highly influential on saving behaviour.[23] However, private insurance generally does a poor job facing severe natural events, even in advanced economies with high take-up rates.[24] These external factors have undoubtedly significantly relieved the direct disaster consequences but will to a certain extent contaminate the statistical inference derived from empirical assessments.

Theoretical models and previous findings could take us only so far. To sum up, while natural disasters generally have negative impacts on savings in the short run, the long-term impact remains unclear due to the interaction of different mechanisms. There is an urgent need to extend the empirical knowledge of the overall disaster impact on saving behaviour. In the current study, the authors pay careful attention to the validity of empirical strategies and focus on assessing the extent and direction of long-term disaster impacts.

BACKGROUND, EMPIRICAL STRATEGY AND DATA

The 2008 Sichuan Earthquake

On 12 May 2008, an earthquake measuring 8.0 on the Richter scale hit China's Sichuan province. The earthquake was recorded as one of the deadliest natural disasters in human history, resulting in 69,268 deaths, 17,923 persons listed as missing, 374,643 injured, five million homeless and 46 million people affected. The direct economic loss was estimated at US$120 billion, of which damage to housing, non-residential property and infrastructure accounted for 27.4 per cent, 20.4 per cent and 21.9 per cent, respectively. Sichuan province suffered the most severe impact from the earthquake, accounting for 99.5 per cent of the overall human toll and 91.3 per cent of the total economic losses from the catastrophe (compared to the 5.8 per cent and 2.8 per cent economic losses incurred in Gansu province and Shaanxi province, respectively).[25] Figure 1 highlights the geographic features of the earthquake. The earthquake was felt even by people living 2,000 kilometres away from the epicentre. Between 12 May and

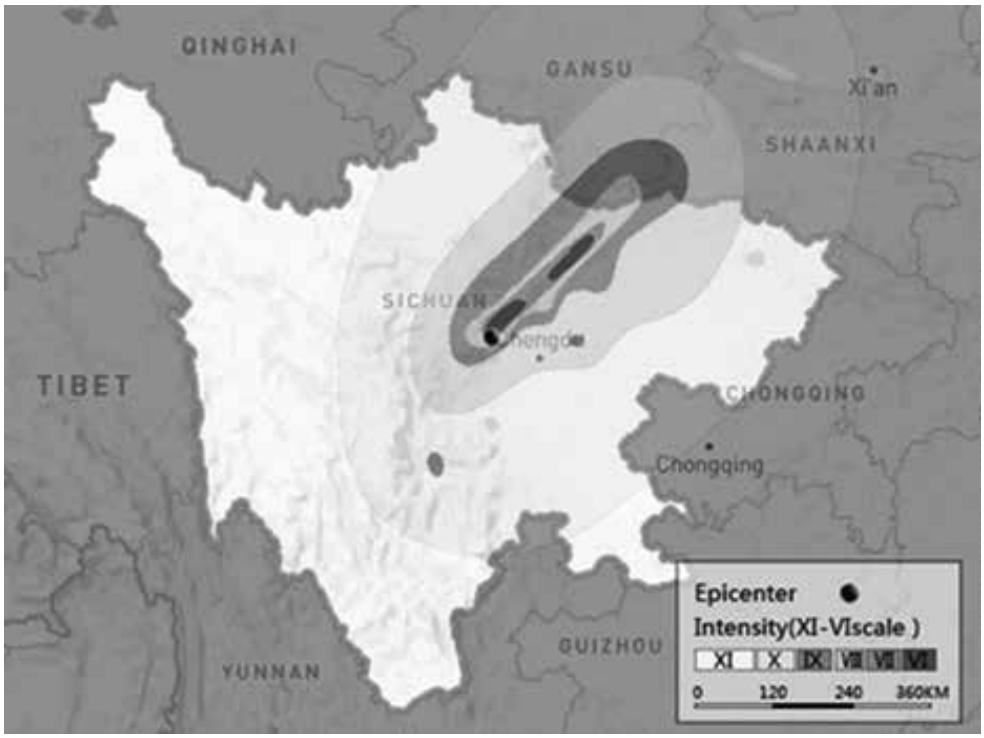
[23] Paul A. Raschky and Hannelore Weck-Hannemann, "Charity Hazard—A Real Hazard to Natural Disaster Insurance?", *Environmental Hazards* 7, no. 4 (2007): 321–9; Cavallo, Galiani, Noy and Pantano, "Catastrophic Natural Disasters and Economic Growth"; Berlemann, Steinhardt and Tutt, "Do Natural Disasters Stimulate Individual Saving?"; and Gignoux and Menéndez, "Benefit in the Wake of Disaster".

[24] See the work of Skidmore for a comprehensive survey of the insufficiency of private insurance against extreme catastrophic events. See works of Sawada and Shimizutani, and Horwich for the performance of Japanese self-insurance mechanisms in coping with the 1995 Kobe earthquake; Skidmore, "Risk, Natural Disasters, and Household Savings in a Life Cycle Model"; Sawada and Shimizutami, "How Do People Cope With Natural Disasters? Evidence from the Great Hanshin–Awaji (Kobe) Earthquake in 1995"; and George Horwich, "Economic Lessons of the Kobe Earthquake", *Economic Development and Cultural Change* 48, no. 3 (2000): 521–42.

[25] The statistics were directly taken from the publications of the National Bureau of Statistics and the National Disaster Reduction and Management Council of China.

23 June, the main shock was followed by hundreds of aftershocks, five of which reached the surface wave magnitude of MS 6.0. In April 2013, another severe earthquake of 7.0 on the Richter scale—also believed one of the aftershocks of the 2008 main shock—took place in Ya'an city in western Sichuan.

Figure 1. The 2008 Sichuan Earthquake



Source: The National Disaster Reduction and Management Council of China.

Empirical Strategy

Utilising the earthquake as a natural experiment, the authors pursue a comparative event study to assess the disaster impact on household savings. Existing research on the subject tends to be limited in several aspects. First, most studies are oriented only to the assessment of short-run effects.[26] Second, conventional regression approaches pivot critically on the model-dependent extrapolation, which provides a weak safeguard against erroneous statistical inference and could jeopardise the transparency and

[26] As documented earlier in this section, natural disasters generally lead to higher household expenditures, unemployment and income fluctuations in the short run. Accordingly, the short-term effect is most likely to be identified as negative. Negative short-run disaster impact is an unfruitful inference, as the short-panel estimations and micro-based analyses have discovered so far. However, evidence on the medium- and long-term impacts remains vague and inconclusive.

authenticity of the estimates.[27] Third, most research does not adequately address the endogeneity concern that can lead to model misspecifications.[28] Fourth, in comparative case studies based on panel data, it is crucial to control for time trends and heterogeneity.[29] Inferential techniques like the conventional difference-in-difference (DID) framework may generate biased estimates due to the lack of control for the unobserved factors. This is evidently the challenge of studying the dynamics of Chinese household saving behaviour.[30]

This study contributes to the literature by employing the methodological innovation formalised in the 2003, 2010 and 2015 works of Abadie et al., the synthetic control method, which is immune to the aforementioned limitations. The core concept of the synthetic control method is to construct a comparable counterfactual scenario to demonstrate the outcome trajectory that the affected group would have experienced in the absence of the specific event. The synthetic control method does not rely on statistical extrapolation; instead, it produces a reasonable "donor pool" in a data-driven manner through incorporating control groups that comprised of unaffected units. The comparability between the treated and control groups, supported by the visible similarities between the groups, helps to achieve more accurate estimates of the disaster impact. Accordingly, the causal effect can be derived from the comparison between the actual observation and its counterfactual counterpart.

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[27] Cavallo, Galiani, Noy and Pantano, "Catastrophic Natural Disasters and Economic Growth"; Alberto Abadie, Alexis Diamond and Jens Hainmueller, "Comparative Politics and the Synthetic Control Method", *American Journal of Political Science* 59, no. 2 (2015): 495–510.

[28] On the one hand, it is apparent that economic indicators (such as disaster losses and fatalities that are correlated with economic characteristics) cannot serve as a proper proxy for disaster occurrence. On the other hand, incorporating disaster occurrence and frequency would not satisfy the endogeneity considerations as well. Due to the inclusion criteria of databases, disaster occurrences in advanced economies are often under-reported; see Carolyn Kousky, "Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters", *Energy Economics* 46 (2014): 576–92. Accordingly, to utilise natural disasters as controlled experiments, the most harmless choice seems to be one that employs particular instrument variables (e.g. a time dummy variable and physical indexes).

[29] The 2010 and 2015 works of Abadie et al. have proven that when the length of pre-intervention periods is sufficient, the synthetic control method controls for the unobserved effects and mitigates the heterogeneity problem; see Alberto Abadie, Alexis Diamond and Jens Hainmueller, "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program", *Journal of the American Statistical Association* 105, no. 490 (2010): 493–505; Abadie, Diamond and Hainmueller, "Comparative Politics and the Synthetic Control Method". The rationale is simple: only units that resemble both the observed and unobserved characteristics over sizeable periods are able to precisely produce the "counterfactual" estimates.

[30] Chinese household saving rates vary over time and across space. Official statistics indicate that the average saving rate of rural households has been declining from 45 per cent to 18 per cent, whereas the urban counterpart has been rising from 18 per cent to 30 per cent in the past 20 years (see Table 1). To control for the time trends, the synthetic control method allows the unobserved effects to vary over time, rather than holding them constant in time as fixed effects.

The following briefly illustrates the theoretical underpinnings of the synthetic control method. Assume that there is a number of *J+1* districts, and the first district *(j=1)* is exposed to a specific event, whereas the others are not. The first district *(j=1)* is the "treated unit", and the remaining *J* districts serve as the potential "donor pool". Let $S_{i,t}$ be the recorded value of the outcome variable, or simply name it as saving rate. The earthquake occurred in 2008; thus, the pre-intervention period covers from the initial (first) year to 2007, i.e. *k* years in total.

Let $A_{1,t} = S_{1,t} - CS_{1,t}$ be the causal effect of the earthquake on saving rate, where $S_{1,t}$ denotes the observed saving rate in district 1 (Sichuan province) at time *t*, and $CS_{1,t}$ is the predicted counterfactual saving rate in district 1 at time *t*. As the work of Abadie et al.[31] put it, "*a combination of comparison units often does a better job of reproducing the characteristics of the treated unit than any single comparison unit alone or an equally weighted combination of several control units*". The strategy is to make explicit the contribution of each comparison unit to the counterfactual outcome, with proper weights that sum to unity.[32] This setting enables researchers to focus more on the similarity between the treated and control groups, which helps to cautiously select comparison units in order to reduce the subjective bias.

The synthetic control method considers a vector *J* x 1, and each particular vector represents a potential synthetic control (i.e. a specific weighted average of control units). In general, the optimal vector W is chosen to minimise $||X_1 - X_{other}W||_v = \sqrt{(X_1 - X_{other}W)\ V(X_1 - X_{other}W)}$,[33] where X_1 is the *k* x 1 vector of the observed pre-intervention characteristics of the treated unit (in this study, these factors can be saving rate and saving determinants) over *k* years. X_{other} is a *k* x *j* matrix of the same variables in the comparison units (*j* units in total). The method gauges whether the characteristics of the treated unit are efficiently matched by those of the synthetic controls. In other words, the method employs a systematic algorithm, similar to the conventional least-squares estimation, to derive the optimal weights by which the comparison units best resemble the treated one.

It should be noted that there are two matrices to be solved: the algorithm-derived weights W and the *K* x *K* positive semidefinite matrix V (which is meant to sketch the relative importance of each predictor[34]). The choice of V influences the mean-square error of the estimators, but the estimated results are generally robust to different

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[31] Abadie, Diamond and Hainmueller, "Comparative Politics and the Synthetic Control Method".

[32] That is, $w_2 + w_3 + \ldots + w_{j+1} = 1$, with $0 \leq w_j \leq 1$ (j = 2, 3, …, j +1).

[33] The process is designed to minimise the Euclidean distance between the pre-event values of the treated unit and those of its synthetic version. The equation can also be written as $\Sigma_{k=1}^{k}\ v_k(X_{1,k} - X_{other,k}W)^2$, where $X_{1,k}$ is the recorded value of the *k*-th variable for the treated unit; $X_{other,k}$ is the recorded values of the *k*-th variable for the comparison units. In this regard, $X_{other,k}W$ is the predicted value of *k*-th variable for the treated unit, as the weighted average of the variables in the control units.

[34] The intuition is that variables with larger explanatory power can be assigned larger weights.

approaches for choosing V.[35] A common practice is to select the optimal matrix among all positive and diagonal matrices to minimise the mean-square error of the synthetic control estimators over the pre-intervention period. Once the matrix is obtained, the vector becomes derivable. Accordingly, the causal effect can be assessed as $A_{1,t} = S_{1,t} - \Sigma_{j=2}^{j+1} w_j S_{j,t}$ for the treated unit at time t in the post-intervention period.

Although the synthetic control method has never settled the long debate over "the best overall approach of comparative studies", there is emerging consensus that the synthetic control method offers superiorities over other approaches in many aspects.[36] The method is deemed to be a theoretically sound as well as empirically feasible connection between quantitative and qualitative approaches in comparative case studies, and its application is becoming increasingly popular in diverse research areas.[37]

Data and Definition of Variables

The research purpose is to capture the short- and long-term effects of the 2008 Sichuan earthquake on household savings. The analysis will focus primarily on the rural household saving rate for several considerations. First, the epicentre (Wenchuan county) is located in a rural district surrounded by dozens of other villages, which subsequently became the worst devastated regions. According to official statistics and anecdotal evidence, mountainous and underdeveloped areas in Sichuan province suffered the most in terms of both economic losses and casualties during the shock. Second, due to the lack of insurance systems as well as the fluctuation in agricultural income, rural residents rely more on household savings as a self-insurance mechanism and have a greater need for precautionary savings. On the other hand, urban residents have highly subsidised social securities and alternative financial approaches to fall back on, and this has posed challenges to capture the disaster impact only by specifying

[35] For a detailed discussion on different procedures for computing "V", see Abadie and Gardeazabal, "The Economic Costs of Conflict"; Abadie, Diamond and Hainmueller, "Synthetic Control Methods for Comparative Case Studies"; Abadie, Diamond and Hainmueller, "Comparative Politics and the Synthetic Control Method"; Ashok Kaul, Stefan Klößner, Gregor Pfeifer and Manuel Schieler, "Synthetic Control Methods: Never Use All Pre-Intervention Outcomes as Economic Predictors", 2015, unpublished, at <http://www.oekonometrie.uni-saarland.de/papers/SCM_Predictors.pdf> [14 April 2018]; Stefan Klößner, Ashok Kaul, Gregor Pfeifer and Manuel Schieler, "Comparative Politics and the Synthetic Control Method Revisited: A Note on Abadie et al.(2015)", *Swiss Journal of Economics and Statistics* 154, no. 1 (2018): 11.

[36] Jessica Saunders, Russell Lundberg, Anthony A. Braga, Greg Ridgeway and Jeremy N.V. Miles, "A Synthetic Control Approach to Evaluating Place-based Crime Interventions", *Journal of Quantitative Criminology* 31, no. 3 (2015): 413–34; Laurent Gobillon and Thierry Magnac, "Regional Policy Evaluation: Interactive Fixed Effects and Synthetic Controls", *Review of Economics and Statistics* 98, no. 3 (2016): 535–51; Susan Athey and Guido W. Imbens, "The State of Applied Econometrics: Causality and Policy Evaluation", *Journal of Economic Perspectives* 31, no. 2 (2017): 3–32; Javier Gardeazabal and Ainhoa Vega-Bayo, "An Empirical Comparison between the Synthetic Control Method and Hsiao et al.'s Panel Data Approach to Program Evaluation", *Journal of Applied Econometrics* 32, no. 5 (2017): 983–1002.

[37] Interested readers can refer to Kaul, Klößner, Pfeifer and Schieler, "Synthetic Control Methods" for a comprehensive survey of the empirical applications of the synthetic control method.

the disaster impact on urban household savings. The rural saving rate suits the research purpose better in assessing the precautionary motive as well as the adverse impact of the earthquake.

The household saving rate, which is the outcome variable of interest, is calculated in a traditional manner as the average ratio of household savings to household disposable income by prefecture. The estimation also includes several standard determinants of saving behaviour as predictors (i.e. the contents in matrix), including the share of housing and education expenditures, sex ratio (the ratio of males to females), transfer income ratio (share of inter-family and government transfers in total disposable income), level (logged) and growth rate of disposable income, bank lending (proportion of total bank lending in prefectural nominal gross domestic product [GDP]), and the lagged terms of the outcome variable.[38] These variables are selected due to their outstanding explanatory power on Chinese household saving rates.[39] More importantly, control variables are needed to account for the effects of external aid and post-earthquake reconstruction (which can lead to the underestimation of the disaster impact; see the second section). For instance, housing expenditure is incorporated to account for housing reconstruction; transfer income would account for victims' receipt of donations and government compensation; and the level and growth of income would account for the fluctuation in household income due to the earthquake.

The analysis is based on China's provincial data sets comprising 30 units (i.e. provinces, autonomous regions or municipalities) and which cover the period from 1995 to 2015; the data sets are separate for rural, urban and provincial economies (due to data limitation, several indicators are recorded only at the provincial level and have been employed in different parts). The data sets provide a pre-event period of 13 years (from 1995 to 2007) and an after-event period of eight years (from 2008 to 2015). In the robustness tests, the observation period was extended to 1990 by employing alternative indicators. All variables were taken and constructed directly from statistics published by the National Bureau of Statistics of China—the Chinese statistical yearbooks, population and employment statistics yearbooks, and finance and banking yearbooks (Table 1). The authors have also tested other potential saving predictors, such as the dependency ratio, urbanisation ratio, life expectancy, inflation rate, foreign direct investment and consumer price indexes. As different model specifications have reached similar conclusions, the results are thus not reported due to space limitations.

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[38] For a comparison between explanatory power of different saving determinants, see Kevin Luo and Tomoko Kinugasa, "Counterintuitive Facts Regarding Household Saving in China: The Saving Glut", Discussion paper no. 1815, Graduate School of Economics, Kobe University, 2018.

[39] According to Kaul et al., in the application of the synthetic control method, the introduction of *all* outcome lags as separate predictors might generate bias and lead to invalid implications; see Kaul, Klößner, Pfeifer and Schieler, "Synthetic Control Methods". For conservativeness, the estimations have incorporated less than three lags—a reasonable setting adopted in the works of Abadie et al.; see Abadie and Gardeazabal, "The Economic Costs of Conflict"; Abadie, Diamond and Hainmueller, "Comparative Politics and the Synthetic Control Method".

In the robustness tests, the authors exploit the level and growth of cash deposits and total retail sales of consumer goods as alternative indicators. Table 1 displays the descriptive statistics on the incorporated variables.

TABLE 1
DESCRIPTIVE STATISTICS

Variable	N	Mean	SD	Min	Max	Variation decomposition	
						Cross provinces	Over time
(Part 1: Rural household saving behaviour)							
Savings	630	0.309	0.149	–0.162	0.656	39%	61%
Education	630	0.072	0.023	0.005	0.160	47%	53%
Housing	630	0.121	0.041	0.018	0.255	38%	62%
Sex ratio	630	1.046	0.036	0.923	1.204	47%	53%
Income	630	3.576	0.304	2.945	4.366	49%	51%
Transfer	630	0.068	0.050	0.010	0.292	30%	70%
Income-G	630	0.115	0.074	–0.117	0.507	20%	80%
Investment	630	2.115	0.844	2.037	0.851	68%	32%
Bank lending	651	1.120	0.615	1.008	0.091	54%	46%
(Part 2: Urban household saving behaviour)							
Savings	609	0.248	0.059	0.129	0.402	35%	65%
Education	609	0.090	0.017	0.047	0.145	37%	63%
Housing	609	0.079	0.028	0.031	0.238	21%	79%
Sex ratio	609	1.046	0.036	0.923	1.204	50%	50%
Income	609	4.024	0.287	3.457	4.724	27%	73%
Transfer	609	0.236	0.057	0.091	0.375	45%	55%
Income-G	609	0.109	0.047	–0.023	0.313	15%	85%
Investment	630	2.115	0.844	2.037	0.851	68%	32%
Bank lending	651	1.120	0.615	1.008	0.091	54%	46%
(Part 3: Robustness tests)							
Deposit (Level)	754	0.657	0.208	0.144	1.781	51%	49%
Deposit (Growth)	609	0.098	0.059	–0.268	0.645	31%	69%
Consumption	754	0.368	0.071	0.124	0.727	45%	55%
Income	754	3.455	0.383	2.633	4.366	31%	69%
Investment	630	2.115	0.844	2.037	0.851	68%	32%
Bank lending	754	1.101	0.570	0.091	4.893	60%	40%
Income-G	754	0.123	0.088	–0.173	0.635	6%	94%

Sources: The variables in Parts 2 and 3 (except for bank lending) were taken and constructed directly from the statistics available in the online database of the National Bureau of Statistics of China (missing values were supplemented by the Chinese Statistical Yearbooks and the Population and Employment Statistics Yearbooks). Statistics on provincial cash deposits, retail sales of consumer goods, and bank lending were from the Finance and Banking Yearbooks.

One drawback of the data set is that several indicators are not available for specific administrative units over particular periods. For instance, the unit "Tibet" is eliminated in the robustness tests due to the problem of missing values; Chongqing city became independent from Sichuan province in 1997, thus some figures were not

recorded until 1997. Moreover, the synthetic control group has to be constructed as a weighted average of the *unaffected* units. Accordingly, Chongqing city and Gansu province, which were also significantly affected by the earthquake, are not likely to serve as suitable comparison units (Figure 1). Accordingly, researchers need to make sure that the weights of the affected regions are sufficiently small or simply have them removed from the donor pool.

Of primary concern, the data sets appear highly inconsistent across the observation period, due to systematic changes in statistical approaches—the revisions of China's statistical systems in 1992, 2002 and 2012. To address this problem, one might be tempted to smooth the data trends instead of attempting to retain all the time-series information. However, the inconsistency in statistical standards does not lead to biased estimates, since the revisions are in essence "exogenous shocks" that took place simultaneously. In other words, as long as the revisions lead to indiscriminate overstatements or understatements on the economic indicators, the structural processes will be eliminated through the DID procedure in the application of the synthetic control method (to be confirmed in the next section).

RESULTS

The 2008 Sichuan earthquake is one of the most economically significant disasters in human history; it is arguably the least predictable type of natural event causing grave consequences in a relatively short time. From an economic point of view, the Sichuan earthquake offers a feasible natural experiment to study the otherwise unquantifiable disaster impact. To estimate the disaster impact, the authors use the synthetic control method to construct the "synthetic Sichuan" that closely reproduces the characteristics of the treated unit preceding the event. For compactness, all the obtained results are summarised in Table 2 and Figure 2.

TABLE 2
OVERVIEW OF PREDICTOR MEANS

Variables	Sichuan province		Average of control groups
	Observed	Synthetic	
(Panel 1: Rural household saving rate)			
Education	0.075	0.075	0.072
Housing	0.091	0.091	0.121
Sex ratio	1.049	1.038	1.046
Income	3.315	3.323	3.576
Transfer	0.046	0.046	0.068
Income growth	0.109	0.109	0.115
(Panel 2: Rural household saving rate; controlled for external aid)			
Education	0.075	0.075	0.072
Housing	0.091	0.096	0.121
Sex ratio	1.049	1.048	1.046
Income	3.315	3.329	3.576
Transfer	0.046	0.041	0.068

(*cont'd overleaf*)

TABLE 2 (*cont'd*)

Variables	Sichuan province		Average of control groups
	Observed	Synthetic	
Income growth	0.109	0.107	0.115
Investment	1.875	2.115	2.165
Bank lending	0.924	0.833	1.115
(Panel 3: Urban household saving rate; controlled for external aid)			
Education	0.104	0.104	0.090
Housing	0.075	0.084	0.079
Sex ratio	1.049	1.019	1.046
Income	3.804	3.865	4.024
Transfer	0.226	0.223	0.236
Income growth	0.099	0.101	0.109
Investment	1.875	1.903	2.165
Bank lending	0.924	0.941	1.115
S (2007)	0.217	0.220	0.274
(Panel 4: Ratio of cash deposits)			
Income	3.158	3.170	3.455
Investment	1.886	1.923	2.165
Bank lending	0.868	0.864	1.101
Income growth	0.115	0.115	0.123
Deposit (1995)	0.469	0.473	0.539
Deposit (2000)	0.672	0.669	0.686
Deposit (2006)	0.816	0.815	0.731
(Panel 5: Ratio of growth in cash deposits)			
Income	3.184	3.188	3.364
Investment	1.886	1.843	2.165
Bank lending	0.880	0.908	1.068
Income growth	0.114	0.114	0.098
Deposits growth (1995)	0.138	0.138	0.145
Deposits growth (2000)	0.077	0.076	0.063
Deposits growth (2005)	0.124	0.123	0.093
(Panel 6: Consumption ratio)			
Income	3.279	3.355	3.364
Investment	1.887	2.081	2.165
Bank lending	0.928	0.917	1.068
Income growth	0.106	0.103	0.098
Consumption (1995)	0.374	0.368	0.355
Consumption (2000)	0.380	0.381	0.368
Consumption (2006)	0.404	0.403	0.328

Notes: All variables are averaged over 1995–2007 by prefecture and group. The last column presents the national average (excluding Sichuan) from 1995 to 2007. S (2007) denotes the average provincial household saving rate and so on. The ratio of cash deposits is calculated as the proportion of total cash deposits in the annual GDP by prefecture; the ratio of deposits growth is calculated as the proportion of the growth in total cash deposits in the annual GDP by prefecture; the consumption ratio is calculated as the proportion of total retail sales of consumer goods in nominal GDP by prefecture.

In analysing the disaster impact on Sichuan's rural household saving rate, it is important to scrutinise the similarity between the treated and synthetic control groups. Panel 1 in Table 2 demonstrates the pre-intervention characteristics of rural Sichuan, the national rural average (rural Sichuan excluded) and the synthetic control group. A comparison of rural Sichuan and the national average indicates that an equally weighted combination of all the rural regions fails to serve as a proper control group for the treated unit. For instance, compared to the national average, rural residents in Sichuan have a considerably lower share of housing expenditure and a lower proportion of transfer income.

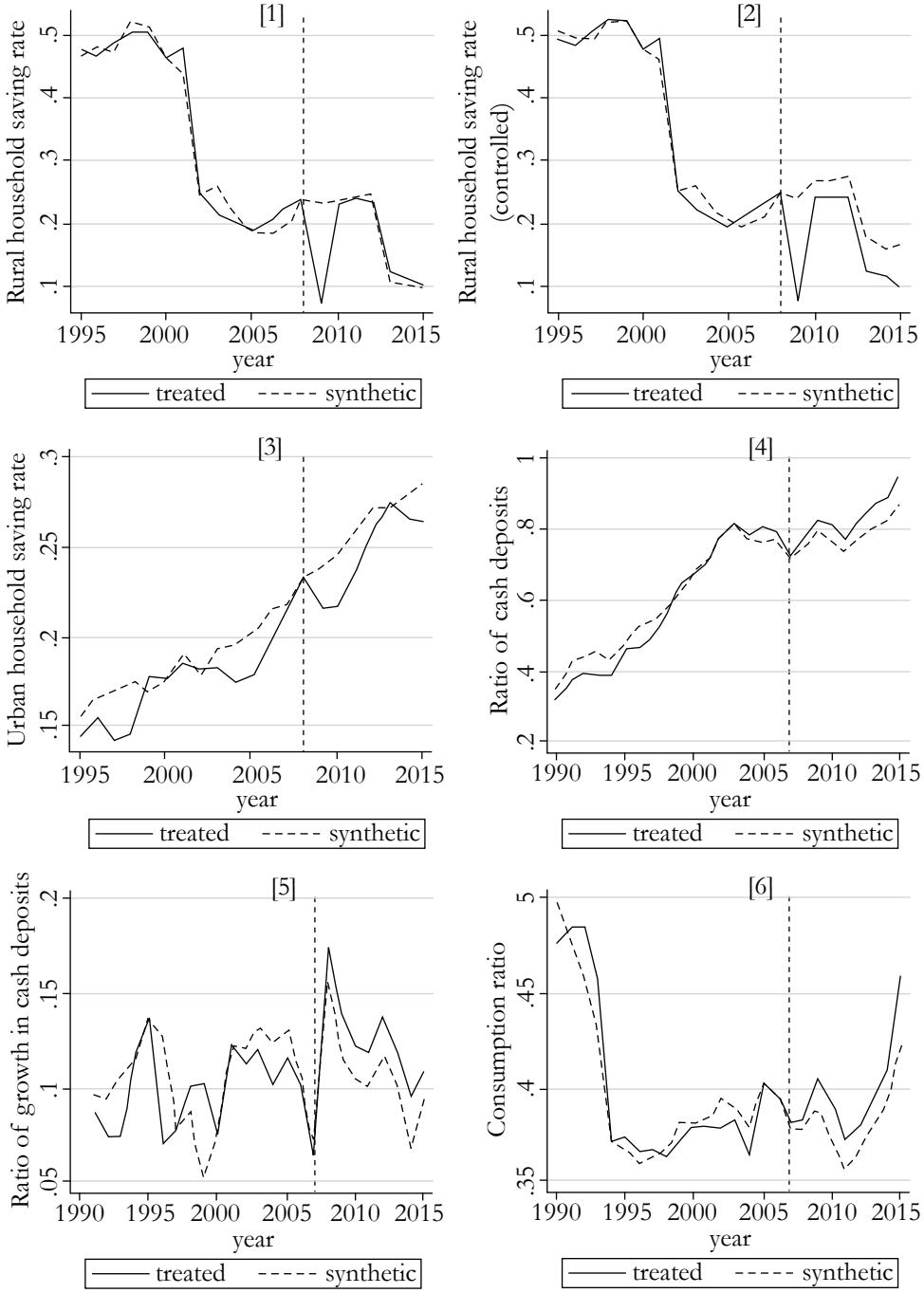
On the other hand, the synthetic Sichuan accurately replicates the pre-event characteristics of rural Sichuan (the "inner optimisation"), which verifies the validity and consistency of the synthetic control method. For instance, four predicted values of saving determinants are identical to the actual observations. The estimated weights of the control units (i.e. the vector) show that the pre-intervention trajectory of Sichuan's rural household saving rate is best reproduced by Inner Mongolia (58.1 per cent), Tibet (22.9 per cent), Fujian (11.8 per cent) and Ningxia (6.7 per cent). These regions were not directly affected by the Sichuan earthquake, nor had they experienced significant shocks over the post-intervention period. These features satisfy the restrictions of the synthetic control method.

Subfigure 1 of Figure 2 plots Sichuan's rural household saving rate over the 1995–2015 period against the synthetic counterpart. The synthetic version closely tracks the actual trajectory over the pre-event period; in particular, it matches the recorded saving rate in 2008,[40] which implies a realistic approximation to the counterfactual that represents the outcome in the absence of the event (the "outer optimisation"). In the immediate aftermath of the earthquake, the recorded saving rate dropped noticeably from 24 per cent to seven per cent within one year (a decline of 71 per cent of propensity to save), whereas the synthetic trajectory appears to have been maintained at the same level after the shock. The discrepancy between the two trajectories indicates a pronounced negative impact on savings accumulation, due to the direct economic losses from the disaster. This finding is broadly in line with historical experience and previous evidence on the short-term savings impacts of natural disasters.[41]

[40] In the estimation, 2008 was set as the end of the pre-intervention period because there was no significant change in the saving rate in 2008 but the change occured in 2009. Due probably to the interruption of household surveys, the statistical offices have no choice but to rely on pre-intervention observations to complete their work. In this sense, the survey data are inclined to understate the short-term disaster impact. However, the main conclusion remains intact since even the underestimated effect suffices to verify its statistical significance (to be investigated later).

[41] For example, see Sawada and Shimizutami, "How Do People Cope With Natural Disasters? Evidence from the Great Hanshin–Awaji (Kobe) Earthquake in 1995"; Berlemann, Steinhardt and Tutt, "Do Natural Disasters Stimulate Individual Saving?"; and Filipski et al., "Living Like There's No Tomorrow".

Figure 2. Overview of the Model Fitness



According to Subfigure 1 in Figure 2, however, the saving rate rapidly recovered to its synthetic state value in the second year after the catastrophe, and the outcome almost exactly matches its synthetic counterpart in the subsequent period. This evidence has, to some extent, corroborated the "target savings" hypothesis,[42] which indicates that households tend to retain specific saving rates as a buffer against risk.[43] It also lends support to the prediction of traditional neoclassical models that exogenous shock is neutral to the steady-state growth and the temporary loss would be recovered in the future. In summary, the aforementioned findings imply that the earthquake has not significantly influenced the long-term saving propensity of the affected population.

However, the insignificant long-run disaster impact may be due to the effect of external aid (e.g. government compensation, disaster relief and adaptation policies). After the Sichuan earthquake and the global financial crisis in 2008, the Chinese government launched the "four-trillion-*yuan* stimulus package" on 9 November 2008, a quarter of which was allocated to the Sichuan post-earthquake reconstruction programme.[44] According to official statistics, transfer income receipts, government investment and bank lending in Sichuan increased sharply after the 2008 earthquake. The emergency fiscal support may have alleviated the disaster impact and led to underestimates of direct economic losses from the earthquake. To test this hypothesis, based on the same econometric settings, the model further incorporates the government investment and bank lending indicators to control for the effect of external aid.[45]

According to the results in Subfigure 2 in Figure 2 and Panel 2 of Table 2, the synthetic control has successfully replicated the pre-event characteristics of Sichuan after controlling for external aid, which suggests that the model is a good fit. As expected, the actual trajectory is slightly below the counterfactual counterpart over the after-event period, which indicates that the disaster impact could have been underestimated due to the lack of proper controls. However, the bias-adjusted estimate of the long-term impact remains muted, in comparison with the pronounced short-term effect. Overall, the results point towards a neutral long-term effect of the earthquake on household savings.

Are these findings empirically relevant? According to official statistics, Sichuan's nominal GDP growth increased steadily from 8.5 per cent to 14.5 per cent during the 2000–7 period, then dropped to 11.0 per cent in 2008, quickly rebounded to

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[42] The "target savings" hypothesis also refers to the "habit persistence", "habit formation" and "stickiness of consumption" hypotheses, proposed by Franco Modigliani, James Duesenberry, and other researchers.

[43] Marcos D. Chamon and Eswar S. Prasad, "Why are Saving Rates of Urban Households in China Rising?", *American Economic Journal: Macroeconomics* 2, no. 1 (2010): 93–130; Malhar Nabar, "Targets, Interest Rates, and Household Saving in Urban China", no. 11-223, International Monetary Fund, 2011.

[44] See <http://en.ndrc.gov.cn/policyrelease/> [10 March 2018]. Also, for the short-term effects of the "four-trillion-yuan stimulus package", Ouyang Min, and Peng Yulei, "The Treatment-effect Estimation: A Case Study of the 2008 Economic Stimulus Package of China", *Journal of Econometrics* 188, no. 2 (2015): 545–57.

[45] Government investment is expressed as the ratio of public investment to financial revenue by prefecture; bank lending is expressed as the proportion of total bank lending in prefectural nominal GDP.

14.5 per cent in 2009 and maintained at around 15 per cent until 2012. High domestic savings accumulation has long been one of the primary engines behind China's economic success. Sichuan's aggregate growth had evolved in a direction consistent with its savings cycle, which displays an acute "V-shaped pattern" over the turbulent period.

The results in Figure 1 may raise queries about the drastic declines in the recorded saving rates and whether the drastic declines had impaired the result reliability. As discussed in the preceding section, this inconsistency (triggered by China's revisions of statistical systems) has no effect on the statistical inference, since the structural process is spatially identical and will be eliminated in the DID process. It is evident that the synthetic trajectory has adequately reflected the abnormal fluctuations over the transition periods (the statistical system's revisions in 1992, 2002 and 2012).

Placebo Test

To derive the statistical significance of the estimate, the authors conduct an "in-space placebo test" frequently used in comparative case studies.[46] The strategy is to investigate whether other regions (the control units) have experienced even greater shocks relative to the treated unit, due to unclear mechanisms.[47] The placebo experiment applies the synthetic control method to every unit in the donor pool. That is, in each exercise, the intervention is artificially *re-assigned* to one of the control units, with the treated unit (Sichuan) shifted to the donor pool. Figure 3 displays the results, in which the grey line represents the divergence between the recorded value of saving rate and its synthetic counterpart for each region; the black line is the estimate for Sichuan, as obtained in Subfigure 1 in Figure 2.

The divergence over the pre-intervention period can be interpreted as "prediction error" in the context of comparative case studies. If the deviation is negligible, then the synthetic control is considered to have precisely reproduced the pre-intervention outcome for the treated unit, and the divergence over the post-intervention period closely approximates the disaster impact. As Figure 3 has made apparent, the prediction error in the estimate for Sichuan is minor, which verifies the validity of the methodology. The slump in Sichuan's rural household saving rate in 2009 is by far the largest shock registered among all of the estimates in the aftermath of the earthquake. Similarly,

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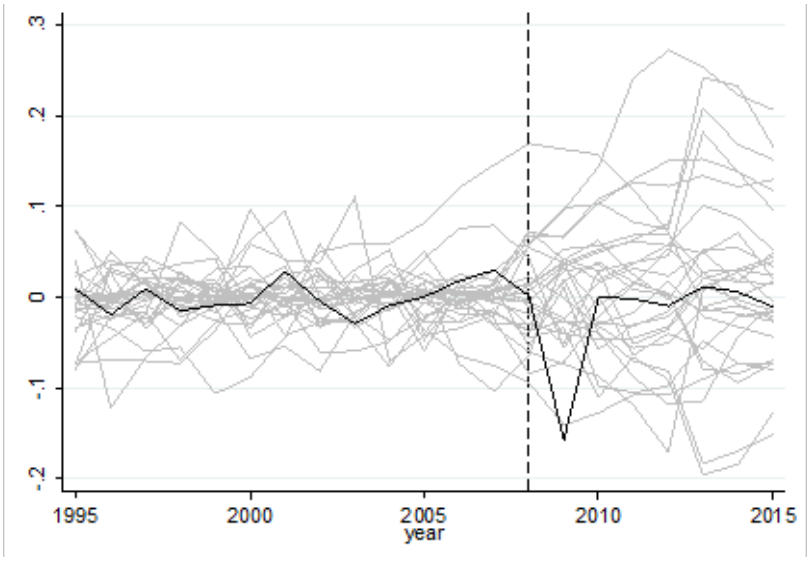
[46] Marianne Bertrand, Esther Duflo and Sendhil Mullainathan, "How Much Should We Trust Differences-in-differences Estimates?", *The Quarterly Journal of Economics* 119, no. 1 (2004): 249–75; Abadie, Diamond and Hainmueller, "Synthetic Control Methods for Comparative Case Studies"; Abadie and Gardeazabal, "The Economic Costs of Conflict"; Abadie, Diamond and Hainmueller, "Comparative Politics and the Synthetic Control Method".

[47] The earthquake may have non-negligible short-term effects on the saving rates of other regions, because some of them were directly exposed, although modestly, to the event (e.g. Shaanxi and Gansu). Moreover, the adverse disaster impact may not be restricted to Sichuan and its surrounding areas, since most of the administrative units had devoted their efforts in the post-earthquake reconstruction, which involved enormous resources and human capital costs. In this regard, the estimated results could be contaminated if the affected regions are identified as the synthetic control units.

2010 marked the most resilient and rapid recovery in the overall observations, although the actual deviations (prediction errors) in some estimates were sufficiently large before the intervention.

Figure 3. Prediction Error of the Synthetic Control Method



Notes: The lines represent the difference between the recorded saving rates and its synthetic counterpart for each region. The black line denotes Sichuan, and grey lines denote other regions.

The analysis follows the method proposed by Abadie et al. and Rosenbaum to obtain the statistical significance of the result.[48] Given that the experiment had generated 29 placebo runs for the control units, under the random permutation, the probability of receiving an adverse effect or a recovery effect—of the magnitude greater than those for Sichuan in 2009 and 2010—is considered to be less than 3.3 per cent (or 1 in 30) for each instance (a level of significance sufficiently large in the statistical sense). The placebo test affirms the significant short-term effect and the negligible long-term effect identified in the benchmark analysis.

Robustness Test

As Hayashi has proposed, in studying savings issues, the relevant concept to be considered is not only the household saving rate, but also other prominent features,

[48] Abadie and Gardeazabal, "The Economic Costs of Conflict"; Abadie, Diamond and Hainmueller, "Synthetic Control Methods for Comparative Case Studies"; Abadie, Diamond and Hainmueller, "Comparative Politics and the Synthetic Control Method"; Paul R. Rosenbaum, "Heterogeneity and Causality: Unit Heterogeneity and Design Sensitivity in Observational Studies", *The American Statistician* 59, no. 2 (2005): 147–52.

reflections and manifestations of "saving".[49] To test robustness of results, the authors utilise alternative outcome variables to replace the rural household saving rate. Robustness tests evaluate the extent to which the main conclusion is limited to particular outcome specifications. Overall, the estimated results in Table 2 and Figure 2 indicate that the selection of outcome indicators is robust for the main conclusion drawn.[50] It should also be noted that by shifting the analytical lenses from "the most affected" to "the least affected" and from "the micro" to "the macro", the adverse disaster impact diminishes and the estimates indicate that there is little long-term impact on the savings and consumption patterns.

Urban household saving rate

To test robustness of results, one basic solution is to study urban household saving. The authors use the same econometric settings (as employed earlier) to estimate the disaster impact on Sichuan's urban household saving rate. However, it is noteworthy that urban Sichuan is markedly different from other urban regions in many aspects. According to official statistics, urban residents in Sichuan have the lowest household saving rate and the highest share of leisure expenditure among all the urban regions (except Tibet). Moreover, Sichuan's urban population has long been known for its high proclivity towards consumption and an epicurean lifestyle. Since the synthetic control method is designed to replicate certain outcome variables for the treated unit by exploiting available information in the control units, it is crucial to ensure that the economic indicators of the treated unit are within the middle of the convex hull derived from the control units. However, the savings predictors for Sichuan's urban population are at either the low or high end among the overall observations. This feature makes it rather challenging to precisely track down the saving rate, since there is no combination of control units that could accurately reproduce an outlier (except by the saving rate itself or by allowing for negative weights; see fn [32]).

Panel 3 in Table 2 highlights the similarities across the groups of urban savings indicators. As expected, the results imply that the synthetic control has not efficiently approximated the characteristics of urban Sichuan. For several variables, the discrepancy between the actual value and the synthetic scenario turns out to be even larger than that between the actual value and national average. Moreover, Subfigure 3 in Figure 2 suggests that the prediction error is non-negligible. However, the results clearly point out that the urban saving rate also declined in the immediate aftermath and shortly after ascended to the synthetic state. The above findings suggest that the earthquake had significant short-term but insignificant long-term effects on household savings.

[49] Fumio Hayashi, "Why is Japan's Saving Rate So Apparently High?", *NBER Macroeconomics Annual* 1 (1986): 147–210.

[50] In each robustness test, placebo tests were also conducted but the results are not reported here due to space constraints. The tests served to corroborate the main conclusion that the earthquake has no long-term impact on savings accumulation.

Cash deposits and consumer goods

In the preceding section on urban household savings, household saving rates are employed as the outcome variables. In general, subjective measures of household surveys are often plagued by the problems of non-randomisation, reporting bias and sample attrition. By comparison, macroeconomic indicators are generally more reliable and considered to be instructive in mirroring the objective reality of saving behaviour. The following analysis delves into the disaster impacts on Sichuan's saving and consumption patterns. For provincial economies, the GDP and cash deposits can be interpreted as "income" and "savings", respectively. The analysis employs two measures of the provincial cash deposits ratio: the proportion of total cash deposits to annual GDP (the "stock"), and the proportion of growth in total cash deposits to annual GDP (the "flow"). The "flow" is more consistent with the conventional notion of household savings, which is a residual concept representing income flow. In a similar vein, the consumption ratio can be proxied by the proportion of total retail sales of consumer goods in nominal GDP, which captures the consumption propensity at the provincial level.

Panels 4 to 6 in Table 2 suggest that, under different outcome variables, the synthetic control units have effectively reproduced the pre-event characteristics of Sichuan, in which the discrepancy between the actual value and the synthetic version is only marginal. According to Subfigures 4 and 5 in Figure 2, the earthquake appears to have slightly promoted the stock and flow of provincial cash deposits, from which it can be inferred that the dis-saving effect was more than compensated by the growth effect at the aggregate level (see fn [1]). The net growth in cash deposits is likely a reflection of the post-earthquake reconstruction and disaster relief, in which the funds were primarily operated through the banking systems. Overall, the disaster impacts appear to be insignificant in consideration of the highly volatile nature of cash deposits. In Subfigure 6 in Figure 2, despite a seemingly large inconsistency in the provincial consumption propensity (due to the 1992 and 2002 revisions of China's statistical systems), the synthetic control again closely tracks the actual trajectory and perfectly matches the post-intervention trend. In summary, the results imply that the earthquake had not significantly influenced the savings and consumption patterns at the aggregate level.

CONCLUSION AND IMPLICATIONS

In this study, by exploiting the synthetic control method formalised in the 2003, 2010 and 2015 works of Abadie and colleagues, the authors estimate the short- and long-term impacts of the 2008 Sichuan earthquake on the saving behaviour of local residents. The results suggest that the earthquake had a significant short-term adverse impact on household saving rates, due to the direct economic losses from the disaster. However, the findings also reveal that the earthquake did not influence the savings and consumption patterns of the affected population in the long run, at both the household and aggregate

levels. The main conclusion is confirmed by a "placebo test" and a series of robustness tests that employ alternative outcome variables and saving predictors.

The insignificant long-term disaster impact has, to some extent, lent support to the "target savings" hypothesis that households tend to adhere to specific saving plans as a buffer against risks, contrary to the precautionary savings hypothesis that people will become more conservative and save more after extreme shocks. The findings also lend support to the prediction of traditional neoclassical models that exogenous shock is neutral to the steady-state growth, and the temporary disaster loss would be recovered in the future, other than a permanent growth slowdown predicted by the endogenous growth theories. Moreover, there are visible signs of savings accumulation and consumption growth at the aggregate level, consistent with the "creative destruction" and "build back better" hypotheses that destruction can boost replacement, construction and innovation in the aftermath of events.

This study explores a new angle to investigate the growth impact of natural disasters and presents suggestive evidence on the short- and long-run disaster impacts on saving behaviour. Some of the findings are probably useful in reconciling the diverse conclusions of recent studies. On the other hand, the authors would like to caution that there is only indirect evidence of neutral impact from natural disasters and of saving resilience against extreme shocks. Conversely, it could be that some victims suffered devastating losses whereas others moved ahead, with the overall effects being cancelled or balanced out. More importantly, there are possibilities that the statistical inferences could be contaminated by several aforementioned mechanisms, and the quick recovery in saving rates could be attributable to the generous disaster relief in the form of government compensation, external aids and income transfers.[51] Perhaps the most important concern in this regard is the unprecedented scale of social donations as well as the immediate emergency responses by the Chinese governments at all costs, irrespective of ideologies and affiliations. The warm-hearted and cool-headed assistance has unquestionably succeeded in lessening the adverse impacts of the earthquake.

In this study, the estimations have controlled for the potential downward bias and ruled out the confounding effects such as income fluctuations, enlarging housing expenses, receipt of income transfers, and the expansion in government investment and bank lending. However, due to data limitations, drawing a definitive conclusion on the subject is beyond the scope of this study. The authors are looking forward to conduct further research of the topic.

[51] For literature concerning the effectiveness of insurance markets and government compensation in coping with natural events, see Raschky and Weck-Hannemann, "Charity Hazard—A Real Hazard to Natural Disaster Insurance?"; Berlemann, Steinhardt and Tutt, "Do Natural Disasters Stimulate Individual Saving?"; Gignoux and Menéndez, "Benefit in the Wake of Disaster". This line of research presents comprehensive background surveys that help to draw an initial impression on the mechanisms of disaster relief in real-world economies.

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