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How Public Expenditure and Bank Credit Affect Growth: Provincial and Enterprise Level Causal Evidence from China's 2008 Wenchuan Earthquake

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The main difficulty in estimating the casual relationship between public expenditure, bank credit and economic growth is the two-way causality, omitted variable bias and other endogenous problems. The main findings are that in China's macro environment, the causal relationship between public expenditure and economic growth is aligned with the Keynesian hypothesis—GDP increases with an increase in public expenditure. Similarly, when bank credit is exogenous, increasing it can significantly increase GDP, whereas increasing public expenditure expands bank credit. Both fiscal and monetary policies are effective macro-control tools, and institutional innovation is needed to build synergy between them.

Key Words: Public expenditure; Bank credit; Economic growth; Causal inference.

JEL Classification Numbers: C19, E63, N00.

1. INTRODUCTION

The 2008 economic crisis caught governments unaware and led to a slowdown of global economic growth. To minimize the negative impact of the crisis, governments successively implemented various fiscal and monetary policies. However, scholars have long debated the effectiveness of these policies. Keynesianism advocates government intervention and emphasizes the role of fiscal policy; neoliberalism emphasizes the role of free markets and believes that fiscal policy is invalid and monetary policies are more economically stable; new Keynesianism affirms that both fiscal and monetary policies are effective. The myths about the effectiveness of fiscal and monetary policies concerning economic growth, the boundaries of policy

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functions, and the scope of these policies, are the foundation of these arguments. Thus, the causal relationship between public expenditure and bank credit and their effectiveness, which are important tools of fiscal and monetary policies and economic growth, must be clarified.

There is no consensus on the causal relationship between public expenditure, bank credit, and economic growth. First, there are two theoretical hypotheses regarding the causal relationship between public expenditure and economic growth: Wagner's law and Keynes' hypothesis. The former holds that in achieving national economic growth, if a country's per capita income increases, public expenditure will increase; consequently, economic growth is the cause and public expenditure is the result. The latter assumes that public expenditure is an exogenous policy tool, which can be used to accelerate growth and correct short-term and long-term cyclical fluctuations. With the increase in public expenditure, the national output also increases. In other words, public expenditure is the cause and economic growth is the result. These theoretical hypotheses have been extensively tested but the conclusions vary. Some studies support the "Keynesian hypothesis," that is, they verify the one-way causality between public expenditure to economic growth (Halicioglu, 2003; Babatunde, 2011), while others support Wagner's Law (Park, 1998; Kolluri and Wahab, 2008; Lamartina and Zaghini, 2011; Kuckuck, 2014). Others have found that public expenditure and economic growth have a two-way causal relationship (Dritsakis and Adamopoulos, 2004; Samudram, 2009).

Second, regarding the causal relationship between bank credit and economic growth, scholars generally agree that bank credit affects economic growth, but controversies about this mechanism persist (Minsky, 1986; King and Levine, 1993; Kiyotaki and Moore, 1997; Bernanke et al., 1999; Beck and Levine, 2002; Saci et al., 2009; Rousseau and Wachtel, 2011; Adu et al., 2013; Narayan and Narayan, 2013). This is primarily because of endogenous problems in the estimation of the relationship between the three economic variables, especially the two-way causality and omitted variable bias. These endogenous confounding factors may hinder the confirmation of the causal relationship between these variables and possibly lead to confusion of a causal relationship with a correlation.[1] Taking public expenditure and economic growth as an example, increasing public expenditure promotes economic growth, and economic growth expands the scale of public expenditure. This study considers the scenario following the 2008

[1]Correlation and causality are common terms used to explain relationships, but people often confuse the application of these two. However, due to endogeneity, we can only determine whether there is a correlation between the two variables; whether a causal relationship exists is unknown. This study aims to verify the causality and action direction between public expenditure, bank credit, and growth, which is not related to the correlation among variables.

Wenchuan earthquake, based on the Chinese government issuing a large number of fiscal and financial policies to ensure the basic livelihood of the affected people and the recovery and reconstruction of the affected areas. The study proposes the hypothesis that public expenditure and bank credit are exogenous variables compared with economic growth.

The Wenchuan earthquake was selected as the basis of this study for two reasons: First, it was one of the most devastating earthquakes in China, causing a direct economic loss of 845.1 billion yuan.[2] The Wenchuan earthquake not only resulted in significant direct losses to the affected area but substantial financial support due to the "large-scale, high-speed" reconstruction aid after the disaster.[3] The macroeconomic structure changed substantially after the earthquake, thereby exposing the causal relationship between economic variables. After the Wenchuan earthquake, the government issued various fiscal, taxation, financial, industrial, and employment policies. The first goal was to ensure that the affected people can resume their regular life as soon as possible and help the affected areas to recover and rebuild. As these policies were implemented due to the unforeseen earthquake and are unrelated to the original budget and financial credit plan, the conclusion that public expenditure and bank credit are exogenous relative to economic growth in the short term after the earthquake should be stronger.

Second, in anticipation of the direct GDP loss after the earthquake, the government used discretionary fiscal and monetary policies to stimulate economic growth. In our opinion, the post-earthquake policy has, to a certain extent, acquiesced that public expenditure and bank credit have affected economic growth. This study can verify the effectiveness of economic policies following the earthquake, that is, whether public expenditure and bank credit effectively promote economic growth, and determine the causal relationship between the variables.

To test the previous hypothesis, this study proposes two identification strategies: first, we focus on 2002-2015[4] based on the macro provincial data from China, and the systematic generalized method of moments (GMM) estimation is carried out to overcome the endogenous problem of two-way causality to a certain extent; the estimation results based on the data from 2007 to 2015 covering the window period and post-earthquake period of the Wenchuan earthquake are further compared. As the causality is stable and the correlation is variable, if the estimation results of different sample intervals in this study are consistent, it demonstrates that we have captured

[2]Data source: Sichuan Statistical Yearbook in 2008.

[3]This is consistent with Schumpeter's theory of creative destruction.

[4]As the proxy index of bank credit is RMB loans of financial institutions, there are missing data before 2002 and after 2015, and hence, the data range of this paper is 2002-2015.

the causality of public expenditure, bank credit, and economic growth. If anything, the exogenous impact of the Wenchuan earthquake exposed the causality between the economic variables.

Second, we use data from China's macro provincial and listed companies' data from 2002 to 2015 to test the impact of Sichuan provincial public expenditure and bank credit on the external financing dependence and total profits of enterprises in Sichuan province. The strategy is effective; first, the provincial public expenditure and bank credit may affect the debt ratio and growth of a single enterprise within its jurisdiction, and the growth of a single enterprise is also a component of the province's economic growth. However, a single company cannot significantly affect the province's public expenditure and total credit, that is, the two-way causality problem is avoided; second, by comparing the dependence of provincial public expenditure and bank credit on external financing of companies in Sichuan and other provinces, we can respond to the problem of sample self-selection. If the difference is not evident, the companies in Sichuan Province have no particularity in the degree of external financing dependence compared with the companies in other provinces. Then, this special hybrid interference is not in our causal analysis.

Finally, this study uses the synthetic control method (SCM) at the macro provincial-level and the propensity score matching difference-in-difference (PSM-DID) at the micro companies' level to overcome omitted variable bias and two-way causality. In this way, the specific changes of public expenditure, bank credit, and economic growth in Sichuan Province (and the enterprises in Sichuan Province[5]) after the earthquake are directly clarified and their consistency with the previous hypothesis is analyzed, to provide dual evidence of macro and micro-level for the causal relationship from the two identification strategies.

The remainder of the paper is structured as follows: Section 2 provides the background and introduces the research hypotheses. Section 3 presents the data and variables. Section 4 presents the empirical analysis. Section 5 details the robustness test performed. Section 6 concludes the paper.

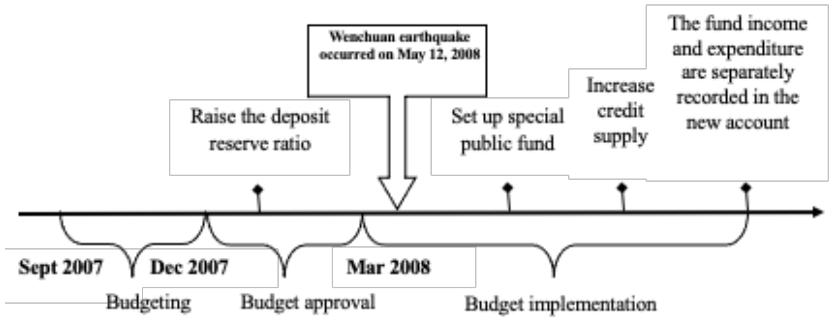
2. BACKGROUND AND RESEARCH HYPOTHESES

In the United States and other federal countries, state and local governments are usually responsible for disaster-relief and emergency response. In contrast, as a unitary country, China's disaster reduction and relief system has clear administrative advantages, that is, after the occurrence of

[5]At the company level, the corresponding analysis are the changes in financial subsidy income, bank loans, and total profits of enterprises in the disaster area after the earthquake.

major and unpredictable disasters, the central government usually plays the role of decision-maker and organizer. Through a unified command and comprehensive coordination, the post-disaster reconstruction strategic planning, fund allocation, aid project content, reconstruction management, and other related responsibilities are entrusted to the local governments, which then carry out specific measures to promote the reconstruction of the disaster area. In this top-down disaster-relief mode, the authority of the central government is strengthened, which finally demonstrates China's strong mobilization system. The central government departments wield significant influence in the formulation of the financial and fiscal policy of the affected areas. The fiscal, taxation, financial, industrial, employment, and other policies issued after the earthquake can completely change the conventional fiscal budget system and financial credit plan of the affected areas. As the introduction of these central level policies is a consequence of the earthquake, a random natural disaster, we can "shift" the exogenous random attribute of the earthquake to these policies. China's post-disaster fiscal and credit policies are exogenous and provide the theoretical basis and premise for this study to examine the causal relationship between public expenditure, bank credit, and economic growth by taking the 2008 Wenchuan earthquake as the basis of its research. Moreover, we can further infer from the aforementioned facts that public expenditure and bank credit are exogenous relative to economic growth in the short term after the earthquake.

FIG. 1. Changes of fiscal budget system and financial credit policy before and after Wenchuan earthquake



2.1. Fiscal Policy as Exogenous after the Earthquake

China has an annual budget system where budget preparation is carried out one budget year in advance[6]. In principle, all public expenditures should be included in the budget. Figure 1 shows the budget data from 2008, the year of the Wenchuan earthquake, as an example. According to the 1997 budget law of the People's Republic of China, government departments at all levels had to prepare their budgets and submit them to the fiscal departments at the same level according to the unified format of departmental budgets before the end of September every year. The fiscal departments at all levels were to compile the budget (draft) after reviewing and summarizing all data and submit the final draft to the People's Congress at all levels for deliberation before December. In March 2008, the People's Congresses examined and approved the draft budget, and the statutory budget was formally introduced. Subsequently, government departments at all levels had to make public expenditures based on the approved budget. However, due to the unforeseen Wenchuan earthquake in May 2008, considering the urgency and necessity of post-disaster recovery and reconstruction, the government not only required all fiscal departments to open a "green channel" and allocate relief funds as soon as possible according to relevant regulations but also vigorously reduced the general public expenditure of the affected provinces[7] and used more resources for disaster-relief and post-disaster recovery and reconstruction.[8] Using fiscal tools to improve the efficiency of disaster-relief, the introduction of the above fiscal policy was specifically due to the earthquake, which is a random event, and it is relative to the exogenous impact of the original macroeconomic environment. With respect to disaster relief fund management, the "opinions on policies and measures to support the post-Wenchuan earthquake recovery and reconstruction" was issued in June 2008. This document outlines the requirements for the establishment of a special fund for the post-Wenchuan earthquake recovery and reconstruction to coordinate and guide all fiscal funds. The public revenue and expenditure of the post-Wenchuan earthquake recovery and reconstruction funds were separately calculated according to the fund channel and cost at present; the government set up a system of revenue and expenditure classified subjects; disaster relief donation funds were included in the special fiscal account to

[6]From the budget law of the people's Republic of China, 1997, http://jrs.mof.gov.cn/ppp/zcfbppp/201410/t20141030_1155100.html.

[7]Cai ban [2008] No.26 Emergency notice of the Ministry of Finance on strengthening the supervision of funds and materials for earthquake relief.

[8]Cai Yu [2008] No.89 Notice of the Ministry of Finance on increasing revenue and reducing expenditure.

implement the management of "two lines of revenue and expenditure."[9] In enterprise production recovery and reconstruction, the central government would arrange a certain proportion of the investment in disaster-damaged recovery and reconstruction to support the central state-owned key backbone, key industries, industry and commerce, tourism, financial institutions, and other enterprises managed by the State-owned Assets Supervision and Administration Commission of the State Council through capital injection, loan discounts, project investment subsidy, and so on.[10] Table 1 shows the public expenditure policies issued by the government after the Wenchuan earthquake. In summary, this study proposes the following:

TABLE 1.

Public expenditure policies issued by the government after the Wenchuan earthquake

Time	Policy Document Number	Content
May 22, 2008	Cai ban [2008] No.26	...Fiscal departments at all levels open "green channels" and allocate disaster relief funds as soon as possible in accordance with relevant regulations.
June 23, 2008	Cai Yu [2008] No.89	...Efforts should be made to reduce the general public expenditure and devote more resources to disaster relief and post disaster recovery and reconstruction.
June 29, 2008	Guo Fa [2008] No.21	...In 2008, the central government allocated 70 billion yuan for post disaster recovery and reconstruction; the central and local governments set up a special fund for post earthquake recovery and reconstruction after the Wenchuan earthquake, and the local governments allocated funds for post earthquake recovery and reconstruction in the budget.
September 3, 2008	Cai Yu [2008] No.389	...In addition to the fund for post disaster recovery and reconstruction, the central finance adjusts the budget structure to arrange the relevant expenditures that are inclined to the disaster areas.

Fact 1: Under the budget system and disaster-relief system led by the central government, the expenditure policy for the affected areas has become an exogenous shock relative to economic growth due to the random exogenous disasters.

The above exogenous fiscal policies were introduced intensively within three months after the Wenchuan earthquake, which should theoretically

[9]GF [2008] No.39 Notice of the general office of the State Council on strengthening the management and use of donations for Wenchuan earthquake relief.

[10]Guo Fa [2008] No.21 Opinions on supporting policies and measures for post Wenchuan earthquake recovery and reconstruction.

make the public expenditure scale of the affected provinces much larger than the original budget expenditure scale. At the same time, at the micro-level, the subsidy income of companies in the affected areas should also be increased significantly because of the government's policy support, such as granting loans and interest discounts. Based on Fact 1, this study proposes Hypothesis 1:

Hypothesis 1: In the short term after the Wenchuan earthquake, the increase in public expenditure led to economic growth, not vice versa.

2.2. Credit Policy as An Exogenous Variable after the Earthquake

Before the Wenchuan earthquake, the People's Bank of China emphasized a tightening of monetary policy at the economic and financial situation analysis meeting held on February 27, 2008, and then raised the RMB deposit reserve ratio of deposit financial institutions nationwide in March and April 2008. However, within seven days of the Wenchuan earthquake, the People's Bank of China and the China Banking Regulatory Commission jointly issued the Emergency notice on financial services in earthquake-stricken areas nationwide (No. 1), which implemented the special policy of restoring financial services in Sichuan, Gansu, Western Shaanxi, Chongqing, Yunnan, and other heavily affected provinces and cities. Meanwhile, national financial institutions were encouraged to strengthen the adjustment of credit resources within the system and increase credit investment in the affected areas. In addition, to support the recovery of production and reconstruction of enterprises in the affected areas, the People's Bank of China encouraged banking and financial institutions to increase credit in the affected areas and implemented a series of preferential credit policies for enterprises in the affected areas, including encouraging local legal banking financial institutions in the affected areas to make full use of funds to support the development of enterprises on the premise of meeting the requirements of capital adequacy ratio. Credit support was strengthened for key infrastructure, key enterprises, pillar industries, and small and medium-sized enterprises in the affected areas and for the development of agriculture, rural areas, and farmers in the affected areas. Preferential housing credit policies were also implemented in the affected areas[11]. In addition, to fully utilize the functions of capital and insurance markets, the affected institutions were provided support to raise funds for post-disaster reconstruction and stock market financing through the bond market, and insurance institutions were encouraged to participate in post-disaster re-

[11] Yinfa [2008] No. 225 Opinions of the people's Bank of China on financial support and service measures for post Wenchuan Earthquake Reconstruction.

covery and reconstruction.[12] At the same time, for the benefit of the overall financial credit level of the affected areas, according to the requirements of the State Council, the refinancing (rediscount) line was increased to 20 billion yuan in the affected areas, refinancing interest rates were reduced by another percentage point based on current interest rates, and preferential deposit reserve policy for financial institutions in the affected areas were implemented to enhance the loaning ability and credit funds of financial institutions in the affected areas.[13] Table 2 summarizes the bank credit policies issued by the government after the Wenchuan earthquake. The introduction of these credit policies was purely due to the earthquake, and hence, this study proposes the following:

TABLE 2.

Bank credit policies issued by the government after the Wenchuan earthquake

Time	Policy Document Number	Content
June 29, 2008	GuoFa [2008] No.21	...Increase the amount of refinancing (rediscount) of 20 billion yuan in the disaster stricken areas, reduce the refinancing interest rate by another percentage point on the basis of the current interest rate level, and implement a preferential deposit reserve policy for financial institutions in the disaster stricken areas, so as to enhance the loan ability and source of credit funds of financial institutions in the disaster stricken areas.
August 6, 2008	YinFa [2008] No.225	...Encouraging financial institutions to increase credit supply to the disaster areas, implement preferential and preferential credit policies to the disaster areas, increase credit support to key infrastructure, key enterprises, pillar industries, small and medium-sized enterprises, and disaster unemployed people, increase financial support to financial institutions in the disaster areas, and continue to implement preferential reserve policy to the disaster areas.
October 24, 2008	YinFa [2008] No.304	...Financial institutions should be based on the existing small loan management mechanism, combined with the actual situation of the disaster area, to further facilitate farmers' loans and meet the financial needs of the affected people.

[12]Guo Fa [2008] No. 21 Opinions on supporting policies and measures for post Wenchuan earthquake recovery and reconstruction.

[13]Guo Fa [2008] No.21 Opinions of the State Council on supporting policies and measures for post-Wenchuan earthquake recovery and reconstruction.

Fact 2: Under the budget system and disaster-relief system led by the central government, the credit policy for the affected areas has become an exogenous shock relative to economic growth due to random exogenous disasters.

The post-earthquake change in financial credit levels in affected areas can also be regarded as the result of exogenous credit policy, that is, the credit scale in affected areas is larger than the original scale (the original policy was credit contraction). Based on Fact 2, this study proposes Hypothesis 2:

Hypothesis 2: In the short term after the Wenchuan earthquake, the increase in bank credit scale caused and affected economic growth rather than vice versa.

3. DATA AND VARIABLES

The empirical tests comprehensively use provincial public expenditure, bank credit, and GDP data published by the National Bureau of Statistics of China and the statistical database of China Economic Net,[14] as well as the data of subsidy income, bank loans, and total profit in the database of Chinese listed companies.[15] When testing whether the information about the specific changes in public expenditure and bank credit in the two hypotheses is consistent with the real-world scenario, we made a double verification from the macro and micro levels: on the one hand, changes in macroeconomic variables are the result of post-earthquake policies; on the other hand, as the direct "undertaker" of post-earthquake policies, the changes in microeconomic variables eventually become the final changes in macroeconomic variables. Macro and micro data can roughly correspond with variables, which greatly enhances the comparability of measurement results at the two levels and ensures scientific and robust results.

[14]The statistical database of China economic network is a comprehensive and orderly large economic statistical database group, which is organized by China Economic Information Center by virtue of its cooperative relationship with the National Development and Reform Commission, the National Bureau of Statistics, the General Administration of Customs, the corresponding departments of various industries, and other government departments, through long-term data accumulation, relying on its own technology and resource advantages, and through professional processing. The official website is: https://db.cei.cn/.

[15]The database is compiled from the annual reports of Chinese listed companies on wind.

TABLE 3.

Macro and micro level variables

Variable Category	Variable Reference	Macro Variables (434 Observations in 31 Provinces)		Micro Variables (31 Provinces, 1926 Listed Companies, 26957 Observations)	
Dependent Variables	Economic Growth	GDP Rate(%)	GDP Growth	Total Profit	ROA
	Public Expenditure	General Public Expenditure	General Public Expenditure Growth Rate(%)	Subsidy Income	Subsidy Rate
	Bank Credit Loans of	Monthly RMB Loans of Financial Financial Institutions	Monthly RMB Loans Institutions Growth Rate(%)	RMB Bank	Debt Ratio
Control Variables		Human Capital (Billion Yuan) Physical Capital(Billion Yuan) Proportion of Investment in GDP(%) Proportion of Import and Export in GDP (%) Proportion of Secondary Sector in GDP (%) Proportion of the Third Sector in GDP(%) Birth Rate (%) CPI(Same Period of Last Year = 100)		Nature of Equity Asset Structure Total Asset Scale Number of Employees Tobin Q Book to Market Ratio Province of Office Province of Registration	

At the macro level, as shown in Table 3, we select Sichuan Province,[16] the main affected province of the 2008 Wenchuan earthquake, as the main research object to study the causal relationship between the three independent variables (GDP, General Public Expenditure, and Monthly RMB Loans of Financial Institutions) and dependent variables.[17] Among them, the provincial annual GDP and General Public Expenditure data are taken from the National Bureau of Statistics of China, and the Monthly RMB Loans of Financial Institutions are from the statistical database of China's economic network. The variables are selected from multiple dimensions and can comprehensively reflect the main characteristics of the macro-economy, including consumer price index (CPI), Proportion of Investment (private and public investment) in GDP, the ratio of annual average births per

[16]On September 25, 2008, the Information Office of the State Council issued a statement authorized by the general headquarters for earthquake relief of the State Council that the direct economic losses caused by the Wenchuan earthquake were 845.14 billion yuan, of which 91.3% was sustained in Sichuan, 5.8% in Gansu, 2.9% in Shaanxi, and less than 2 billion yuan in other provinces.

[17]This study considers the ending value of RMB Loans of Financial Institutions in December of each year in the statistical database of China economic network as the total amount of RMB loans of financial institutions in that year.

thousand people (Birth Rate), Proportion of Secondary Sector in GDP, Proportion of the Third Sector in GDP, total Human Capital (including students in school), total Physical Capital, and Proportion of Import and Export in GDP. From the perspective of economic fundamentals, we chose (1) CPI to reflect inflation, investment rate, and industry share; (2) Birth Rate to reflect the economic development level and structure of a province; and (3) Proportion of Import and Export in GDP to reflect the degree of opening up of the province. Simultaneously, to describe the distribution and development trends of human capital and physical capital in China more scientifically and systematically, we selected the provincial annual labor force Human Capital (including students) and total Physical Capital released by the project Measurement of China's Human Capital and Construction of Human Capital Index System, issued by the China Center for Human Capital and Labor Market Research as the measurement index of human capital[18].

At the micro-level, we considered listed companies with offices in Sichuan as the main research object to study the causal relationship between Subsidy Income, Bank Loans, and Total Profits from 2002 to 2015. Among them, the Subsidy Income, Bank Loans, and Total Profits are treated logarithmically. To further overcome the impact of different company sizes, this study also used the Subsidy Rate (subsidy income / total profit), Debt Ratio (bank loans / total assets), and ROA as alternative indicators to carry out re-estimation. In terms of control variables, we selected the Nature of Equity of the companies, that is, controlling whether the listed company is a state-owned, private, foreign, compound, or other eight equity nature differences, Asset Structure, that is (net fixed assets + net inventory) / total assets, Total Asset Scale, Number of Employees, Tobin Q, Book to Market Ratio, and the province where the companies are registered and located (Province of Office and Province of Registration). In the regression analysis, the natural logarithm of the Total Assets Scale and the Number of Employees were considered.

Table 4 shows the descriptive statistical results. The macro data included 31 provinces in China excluding Hong Kong, Macao and Taiwan, with a total observation value of 434. Among them, the average value of

[18]The research project was conducted by the China Center for Human Capital and Labor Research Center (CHLR). This result is obtained by using Jorgenson Fraumeni (j-f) lifelong income method and improving it, that is, based on j-f's life-long income method and using Mincer's basic income equation to estimate the income of all kinds of population according to gender and urban and rural areas. This calculation adopts the OECD discount rate of 4.58%. The national and provincial real values in the calculation results were obtained by deflating the nominal value with the consumer price index (CPI) considering 1985 as the base period, and the actual values of the inter provincial comparison results were obtained by the living cost index (LCI) adjustment based on 1985 as the base period.

TABLE 4.

Summary statistics

Variables	Mean	Std	Min	Max	Obs
GDP(Billion Yuan)	12477.41	12738.06	162.04	72812.55	434
General Public Expenditure(Billion Yuan)	2143.82	1897.75	92.26	12827.8	434
RMB Loans(Billion Yuan)	13970.28	14751.39	73.2	89289.27	403
GDP Growth Rate(%)	16	6	−0.7	32	403
General Public Expenditure Growth Rate(%)	20	9	−12	68	403
RMB Loans Growth Rate(%)	20	51	−9	995	372
Human Capital (Billion Yuan)	3595.23	2725.27	80.96	12686	434
Physical Capital(Billion Yuan)	890.35	948.35	18.64	6234.19	434
Proportion of Investment in GDP(%)	61	22	25	133	434
Proportion of Import and Export in GDP (%)	45	55	5	244	434
Proportion of Secondary Sector in GDP (%)	46	8	20	59	434
Proportion of the Third Sector in GDP(%)	42	8	28	80	434
Birth Rate (%)	102.6	2.07	97.7	110.1	434
Total Profit (100 Million Yuan)	8.34	87.75	−159.75	3632.35	26,957
Subsidy Income (100 Million Yuan)	0.36	4.01	0	502.92	26,957
RMB Bank Loans (100 Million Yuan)	21.30	97.69	0	4141.36	26,957
ROA(%)	85	14400.53	−214616	2350977	26,957
Subsidy Rate (%)	5.29	848.33	0	4018.37	26,957
Debt Ratio (%)	21.61	279.65	0	46019.23	26,957
Nature of Equity (1-8)	1.62	0.92	1	8	26,957
Asset Structure (%)	42	19	0	99.95	26,957
Total Assets Scale (100 Million Yuan)	116.11	823.85	0.002	47651.59	26,957
Number of Employees	5466.06	22515.83	0	552810	26,957
Tobin Q (%)	285	7409	15	175271	26,957
Book to Market Ratio (%)	42	19	0	99.95	26,957

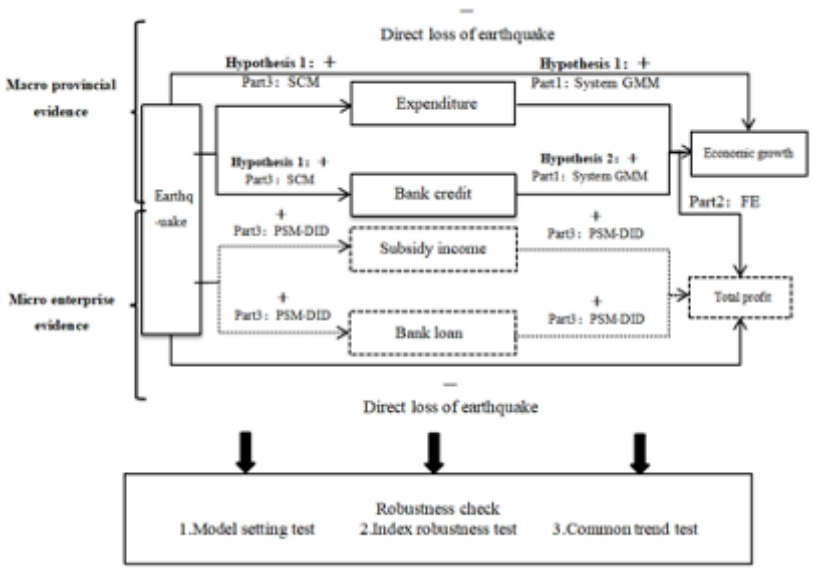
GDP, General Public Expenditure, and RMB Loans of China's provinces, which are the core variables we focused on, were 1247.41, 2143.82, and 1397.028 billion yuan, respectively. In terms of GDP growth rate, the average GDP growth rate of China's provinces in 2002-2015 was 16%, and General Public Expenditure Growth Rate and RMB Loans Growth Rate were approximately 20%. Microdata includes 31 provinces, 1,926 listed companies, and the total observation value is 26,957. Among them, the average Total Profit, Subsidy Income, and RMB Bank Loans of Chinese listed companies are 834, 36, and 2,130 million yuan, respectively, while the average of relative ratios such as ROA, Subsidy Rate, and the Debt Ratio are 85%, 5.29%, and 21.61%, respectively. In the regression analysis, we also winsorize the core variables by 1%.

4. EMPIRICAL ANALYSIS

4.1. Empirical Analysis Framework

Before the empirical analysis, we could not determine the causal relationship between public expenditure, bank credit, and economic growth, nor could we clarify the specific impact of the earthquake itself and the post-earthquake relief public expenditure and credit preferences on the economic variables of the affected areas. Therefore, the research hypotheses contain important information: first, the causal relationship between public expenditure, bank credit, and economic growth is unidirectional; second, in the short term after the earthquake, public expenditure and bank credit in the affected area have increased significantly.

FIG. 2. Empirical strategy



To test the hypotheses, as shown in Figure 2, the empirical analysis is divided into two stages and three parts. In the first stage, we design two identification strategies to overcome the potential problems of omitted variable bias and two-way causality, explore the causality between the three economic variables, and test the information in the hypotheses. Specifically, the first part uses the System GMM method to estimate and take the variable lag term as an instrumental variable, to overcome the inherent cumulative effect and ratchet effect between public expenditure, bank credit, and economic growth and to eliminate the potential two-way causality between variables as far as possible, to verify the hypothesis that public expenditure and bank credit are exogenous relative to economic growth. In

particular, because causality will not change with a change in the sample interval, we divide the sample interval into full sample, earthquake window, and post-earthquake sample and compare the GMM estimation results of the two groups of samples to observe whether they are consistent and the difference of coefficient size. If the coefficients are consistent and the difference is large, it indicates that the exogenous impact of the Wenchuan earthquake not only does not change the causality between economic variables but also highlights the causality, which is consistent with our expectation. The second part tests the impact of public expenditure and bank credit on the external financing dependence and total profits of companies in Sichuan Province by comprehensively using the data of China's macro provincial and listed companies and comparing it with the results of the entire sample of 31 provinces in China to re-verify the hypothesis that public expenditure and bank credit are exogenous relative to economic growth. The identification strategy aims to overcome the potential problems of reverse causality and sample self-selection. For reverse causality, a single enterprise cannot significantly affect the public expenditure and total credit of the entire province, but the public expenditure and total credit of the province often have a greater impact on a single enterprise. For the sample selection, we are concerned that the enterprises in Sichuan Province may have their particularity in the degree of external financing dependence compared with other provinces in China, and it is such particularity that interferes with the causal analysis of the three variables. Therefore, it is necessary to test whether Sichuan is distinct.

In the second stage, we conduct the empirical analysis of the third part, that is, to clarify the post-earthquake changes of the three economic variables from the macro and micro levels, to test whether the information about the specific changes in public expenditure and bank credit in the two hypotheses is consistent with reality. At the macro level, we use the synthetic control method, proposed by Abadie and Gardeazabal (2003), for counterfactual estimation. Specifically, this study constructed the "counterfactual" changes of public expenditure, bank credit, and economic growth under the condition of "if there is no Wenchuan earthquake in Sichuan in 2008" through the synthetic control method and then compared the differences between the real changes and counterfactual changes, to effectively control the endogenous bias caused by the omitted variables such as the different economic environment and the unbalanced development degree among provinces. In this way, we obtained the net processing effect of the Wenchuan earthquake on the three economic variables in the short term. At the micro-level, we used the PSM-DID method to overcome the potential omitted variables and two-way causal problems and directly determined the specific changes of subsidy income, bank loans, and total profits of enterprises in Sichuan Province after the earthquake.

There could be some problems in the benchmark regression analysis, such as model setting error, agent indicators at the micro-enterprise-level not being robust and biased, and if the synthetic control method and PSM-DID method meet the common trend assumption. Therefore, we designed three parts in the robustness test section to resolve these three problems. The first part concerns the model setting. First, the GMM model of the system has a possible model setting error. Therefore, we used the cross-lag model to verify the causal relationship and direction between public expenditure, bank credit, and economic growth. Second, the synthetic control method requires that the synthetic weight must be non-negative and not allow extrapolation, which may lead to the problem of a model setting error. In this study, the regression control method was introduced to estimate the net effect of the earthquake and disaster-relief policies on macroeconomic variables in the affected areas in the short term. Finally, to ensure that the estimation results of the PSM-DID model are not affected by the selection errors of controllable groups, we re-estimate the DID based on the common trend test.

The second part pertains to the robustness of the indicators. The proxy indicators of a single micro-enterprise-level are not robust and comparable with the macro variables. Therefore, this study chooses the subsidy rate, debt ratio, and ROA as alternative indicators to estimate the impact of the policies on the subsidy income, bank loans, and total profits of enterprises in Sichuan Province.

The third part is to test whether the synthetic control method and PSM-DID method meet the strong common trend hypothesis. The synthetic control method cannot control all the key variables that may affect the relationship between public expenditure, bank credit, and economic growth, such as time trends. In this case, we cannot determine whether the final change in public expenditure, bank credit, and economic growth is caused by the earthquake or the difference in time trends. To solve this problem, the placebo test is carried out in the robustness test to examine the "parallel trend" of the synthetic control method. For the PSM-DID method, the time trend diagram drawn in the benchmark regression results cannot accurately judge whether there are statistically significant differences between the pre-earthquake processing group and the control group. Therefore, this study used interactive regression to test the common trend hypothesis again to ensure the reliability of the results.

4.2. System GMM Estimation

In this study, first, through the System GMM method, with the help of data from China's central and western provinces from 2002 to 2015,[19]

[19]The division of eastern provinces and central and western provinces is based on the division plan of the Seventh Five Year Plan of the fourth session of the Sixth National

the GDP growth rate, public expenditure growth rate, and bank credit growth rate are regressed to verify the causal relationship between public expenditure, bank credit, and economic growth. Taking the impact of public expenditure growth rate on GDP growth rate as an example, since the growth rate of public expenditure in the previous period will have an impact on the current GDP growth rate, this study further used the System GMM model for analysis. The model is set as follows:

$$GDP_{it} = \beta_0 + \gamma \times GDP_{it-1} + \beta_1 \times Expend_{it} + \beta_2 \times X_{it} + \varepsilon_{it} \quad (1)$$

The dependent variable GDP_{it} represents the GDP Growth Rate of the province i in time t, and the independent variable $Expend_{it}$ represents the General Public Expenditure Growth Rate of the province in that year. X_{it} represents the set of control variables other than the General Public Expenditure Growth Rate, including RMB Loans Growth Rate, CPI, Proportion of Investment in GDP, Birth Rate, Proportion of Secondary Sector in GDP, Proportion of the Third Sector in GDP, Human Capital, Physical Capital, and Proportion of Import and $Export$ in GDP. ε_{it} is the error term.

In this study, the general to specific method, Arellano-Bond AR test, over recognition test, and the difference-in-Hansen test are used to determine the maximum lag order of the dependent variable in the GMM model. The specific lag order of each column is not identical. The GMM test results of the relationship between the three major macroeconomic variables are shown in Table 5. The results in columns (3) and (4) show that public expenditure has a significant positive impact on GDP rather than the opposite, which supports Hypothesis 1. The results in columns (7) and (8) show that bank credit also has a significant positive impact on GDP, which is consistent with Hypothesis 2. As for the causal relationship between public expenditure and bank credit, the results in columns (11) and (12) show that the increase of public expenditure increases bank credit. This study also used the data of central and western provinces from 2007 to 2015, which covers the window period and post-earthquake period, to verify the above conclusions again. It is found that after changing the time interval, the causal relationship between the three main variables remains stable. Public expenditure still has a positive impact on GDP, bank credit has a positive impact on GDP, and public expenditure has a positive impact on bank credit, consistent with Hypothesis 2. In particular, for the two groups of relationships between public expenditure and economic growth and between bank credit and economic growth, the estimated results of data only

People's Congress in 1986. The central and western provinces include Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

TABLE 5.

System GMM estimation

	Public Expenditure—GDP				Bank Credit—GDP				Public Expenditure—Bank Credit			
	2007-2015		2002-2015		2007-2015		2002-2015		2007-2015		2002-2015	
Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
General Public Expenditure Growth Rate	0.364*** (0.000)		0.136* (0.066)						0.299* (0.098)		0.367*** (0.003)	
GDP Growth Rate		−0.009 (0.987)		0.093 (0.786)		0.320 (0.477)		0.068 (0.891)				
RMB Loans Growth Rate					0.208** (0.040)		0.163** (0.049)			0.279 (0.260)		−0.009 (0.666)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR(1)	−1.73*	−3.11***	−1.43**	−2.33**	−1.57**	−0.52**	−0.47*	−2.24**	−1.43*	−2.58***	−1.78*	−2.25**
AR(2)	−1.54	0.92	−2.55	1.46	−2.29	2.10	−0.83	2.23	1.88	0.30	0.24	1.35
Hansen Test	14.03	15.64	18.25	18.43	17.53	15.93	13.95	18.70	14.56	14.95	18.58	17.67
Difference-in-Hansen	0.41	0.32	5.51	4.18	3.13	3.95	1.87	1.11	2.01	1.42	1.19	0.38

Note: Due to the limited space, this paper only reports the regression results of the core explanatory variables, and the results of the lagged items of the explained variables are slightly different. The explanatory variable in column (1) (3) (5) (7)is the growth rate of GDP; the explanatory variable in column (2) (4) (10) (12) is the growth rate of government expenditure; the explanatory variable in column (6) (8) (9) (11) is the growth rate of bank credit. P-value in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

covering the window period and post-earthquake period are higher than that of the entire sample data, that is, the coefficient of General Public Expenditure Growth Rate in column (1) is higher than that in column (3), and the coefficient of RMB Loans Growth Rate in column (5) is higher than that in column (7). This demonstrates that the 2008 Wenchuan earthquake does highlight the causal relationship among the three variables.[20] The results of GMM are not only the direct result of causality analysis but also the indirect data representation of the two facts.

How can public expenditure be increased to improve GDP? Existing literature has proposed different intermediary mechanisms, such as marginal productivity of capital and labor (Jones et al., 1993), distorted resource allocation (Barro, 1990), degree of fiscal decentralization (Zhang and Zou, 1998), and structure of public expenditure (Devarajan et al., 1996; Gong and Zou, 2002). There is abundant literature on the mechanism of bank credit on economic growth, which have pointed out that the proportion of short-term credit, enterprise financing and innovation, bank efficiency, cap-

[20]This study also makes a systematic GMM estimation of the pre-earthquake samples from 2002 to 2007, and the results are consistent with the results of the two-sample data from 2002 to 2015 and 2007 to 2015, and the corresponding estimation coefficients are the smallest. Detailed results are not available.

ital accumulation, and productivity improvement are important mediators for bank credit growth to promote economic growth (Levine and Zervos, 1998; Zhu et al., 2019).

4.3. Fixed-effect Model Estimation

The second identification strategy of causality uses the exogenous characteristics of provincial public expenditure and total bank credit relative to enterprise-level economic variables and first overcomes the problem of two-way causality. The question is how, if at all, can Sichuan's public expenditure and bank credit affect the total profits of enterprises located in Sichuan? We used the fixed-effect model, taking the provincial-level public expenditure and bank credit as the dependent variables and the total profit of the enterprise-level as the explained variables to control the time fixed-effect and enterprise fixed-effect, to clarify the causal relationship between public expenditure and economic growth, bank credit, and economic growth. It is worth noting that there is still a potential problem of sample self-selection, that is, compared with the enterprises in other Chinese provinces, whether the enterprises in Sichuan have a certain particularity in the degree of dependence on external financing. Does this particularity promote the impact of public expenditure and bank credit on the total profit of Sichuan enterprises? On the one hand, this study measures the dependence of enterprises on external financing by bank loans/total liabilities, which is also considered to be an explanatory variable. On the other hand, it uses the fixed-effect model of the whole sample to re-estimate and compares the results with the regression results of the Sichuan sample to observe whether there are particularities. Taking the explained variable as the total profit of enterprise as an example, this study establishes a fixed-effect model, as shown in equation (2):

$$interest_{ait} = \theta_0 + \theta_1 expend_{it} + \theta_2 loans_{it} + \varphi X + \mu_a + \gamma_t + \varepsilon_{at} \qquad (2)$$

The dependent variable $interest_{ait}$ represents the total profit of the enterprise a in the province i. The independent variables $expend_{it}$, and $loans_{it}$ are the General Public Expenditure and RMB Loans of the Province i in the year t, respectively. X represents the set of control variables at the enterprise-level, including the Nature of Equity, Asset Structure, Total Asset Scale, Number of Employees, Tobin Q, and Book to Market Ratio. μ_a is the firm fixed-effect, and γ_t is the time fixed-effect. ε_{at} represents the error term.

The regression results are shown in Table 6. First, by observing the results of only Sichuan enterprises, from column (1), we find that the public expenditure of Sichuan Province significantly reduces the dependence of Sichuan enterprises on external financing, which is intuitive. Since the increase in public investment may lead to private investment (Lora, 2007),

TABLE 6.

Fixed effect model estimation

Dependent Variable	Dependence on External Financing				Ln Total Profit			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Sichuan	All	Sichuan	All	Sichuan	All	Sichuan	All
Ln General Public Expenditure	-0.122^{***}	-0.096^{***}			0.036^{**}	0.034^{**}		
	(-11.042)	(-44.365)			(2.520)	(2.435)		
Ln RMB Bank Loans			0.001^{*}	0.002^{*}			0.286^{***}	0.013^{*}
			(1.116)	(1.731)			(4.333)	(1.818)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.300	0.226^{***}	0.802^{***}	0.949^{***}	-0.434	0.789^{***}	0.917	0.604^{***}
	(-1.362)	(5.866)	(3.606)	(24.097)	(-0.327)	(3.251)	(0.760)	(2.661)
Observations	848	20,887	848	20,442	706	18,525	706	18,147
R-squared	0.159	0.114	0.020	0.020	0.321	0.350	0.342	0.350
Number of Id	107	2667	107	2623	107	2650	107	2606

Note: T-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

enterprises may obtain additional funds through equity financing under the stimulus of the expenditure policy. The results of column (3) show that the increase of total credit in Sichuan Province significantly increases the dependence of individual enterprises on external financing. Looking at the change of total profit, we can see from columns (5) and (7) that the increase in public expenditure and bank credit in Sichuan Province has significantly increased the total profit of Sichuan enterprises. This finding is aligned with our expectations and supports our hypotheses. To eliminate the problem of sample self-selection (Table 6), we find that these results are identical to those of the sample of Sichuan enterprises pertaining to significance and direction of action, and the gap is not wide in the estimation coefficient, which also demonstrates that there is no special place in the degree of dependence on external financing of enterprises in Sichuan.

4.4. Evidence of Post-earthquake Changes in Three Economic Variables

Next, we analyzed whether the specific changes of public expenditure, bank credit, and economic growth in Sichuan Province after the earthquake are consistent with the hypotheses to supplement the evidence from the macro provincial-level for the above causality test. Therefore, we used the synthetic control method to determine the impact of the Wenchuan earthquake itself and the post-earthquake expenditure and credit prefer-

ential policies on public expenditure, bank credit, and economic growth in the affected areas.

Objectively, due to its strong assumptions and requirements for data and common trends, the popular double-difference method cannot be correctly applied to social science issues that occur at the overall level (country, region, town) and affect a small number of overall units, which greatly limits the development of social science policy evaluation research. How then do we estimate the processing effect using macro population unit data? How do we obtain the optimal control group of the unit sample? The synthetic control method provides a technical solution. Although any individual in the control group is not similar to the treatment group, each individual in the control group is given a weight, and then a "counterfactual" synthetic control region that is closest to the treatment group is constructed by linear combination and compared with the treatment group; the treatment effect of the policy can thus be calculated. The biggest advantage of this method is that it can reduce the bias of researchers' subjective selection of the control group. We used the synthetic control method to test the post-earthquake change in the direction of financial expenditure, bank credit, and economic growth in affected areas.

However, we cannot simply attribute the changes of macroeconomic variables in the disaster-stricken areas in 2008 to the Wenchuan earthquake for two reasons. First, in 2008, there were many major events affecting the macro-economic environment, such as a snow disaster, the Beijing Olympic Games, and an economic crisis. Therefore, it is not easy to distinguish the effect of Wenchuan earthquake alone. Second, the trend of macroeconomic changes in the affected provinces before the Wenchuan earthquake is not the same as that of other provinces (cities) in China. Therefore, this study specifically uses other provinces in China for its analysis.[21] The economic characteristics of the synthetic control group are as close as possible to the real group before the 2008 Wenchuan earthquake.

$$\begin{aligned} Y_{it} &= Y_{it}^{N} + \alpha_{it} D_{it} \\ \alpha_{it} &= Y_{it}^{I} - Y_{it}^{N} \end{aligned} \tag{3}$$

Assuming that the total number of provinces is $J+1$, only province 1 is impacted by the earthquake at t_0, and other J provinces not affected by the earthquake can be used as the counterfactual control group of province

[21] For synthetic control group selection, we initially consider the control areas of the rest of the country except Sichuan Province. However, Gansu Province and Shaanxi Province were the second worst hit provinces by the Wenchuan earthquake, so they were removed. Xinjiang Uygur Autonomous Region and Tibet Tibetan Autonomous Region were both special minority areas, so they were removed. Hunan Province was the key province affected by snow disaster in 2008, so it was removed.

1. In equation (3), Y_{it} represents the public expenditure, bank credit, and GDP of province i at time t; Y_{it}^N represents the public expenditure, bank credit, and GDP of province i without earthquake at time t; Y_{it}^I represents the public expenditure, bank credit, and GDP of province i experiencing earthquake at time t. D_{it} represents whether province i experienced an earthquake at time t. α_{it} represents province i experienced the processing effect of earthquake at time t. We further use Abadie et al. (2015) technical method and data-driven approach to take CPI, investment rate, birth rate, proportion of secondary industry, proportion of tertiary industry, human capital, material capital, and import and export proportion as observable explanatory variables. In the period before the Wenchuan earthquake intervention, the $(k \times 1)$ dimensional vector of the mean value of observable explanatory variables in province 1 is X_1. The $(k \times J)$ dimensional matrix composed of the mean values of the explanatory variables of other J provinces not affected by the earthquake is X_0. Therefore, the minimum distance function $\|X_1 - X_0 W\|$ can be obtained as:

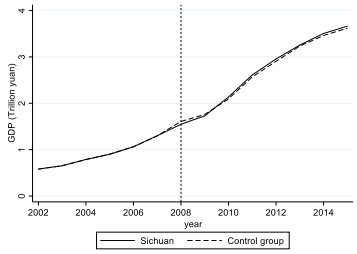
$$\min_W (X_1 - X_0 W)' V (X_1 - X_0 W) \ s.t. \ w_j \geq 0, j \in \{2, \ldots, 27\}, \sum_{j=2}^{27} w_j = 1 \quad (4)$$

$$\min_V \frac{1}{6} [Z_1 - Z_0 w^*(V)]' [Z_1 - Z_0 w^*(V)] \quad (5)$$

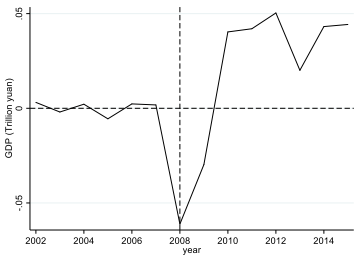
Let the optimal solution of Equation (4) be $W^*(V)$. $W^*(V)$ depends on the selection of diagonal positive semi definite matrix V. To calculate the optimal matrix V^*, which can minimize the estimated mean square prediction error, Z_1 was recorded as a (6×1)-dimensional vector, including the explanatory variables of province 1 in 2002-2007, and Z_0 is the (6×26)-dimensional matrix. The column j is the explanatory variable of region $j + 1$ in year 2002-2007. The most optimized V^* obtained by Equation (5) is then substituted into Equation (4) to obtain the optimal weight W^*. Next, through the above data-driven estimation of the optimal weight W^* of each province in the control group, we "artificially" constructed a synthetic control group province, which is most similar to the processing group in 27 regional characteristic variables. Then the processing effects of the earthquake at time t_0 on public expenditure, bank credit, and economic growth of province 1 were obtained as:

$$\alpha_{1t_0} = Y_{1t_0} - \sum_{J=2}^{J+1} W^* Y_{jt} \quad (6)$$

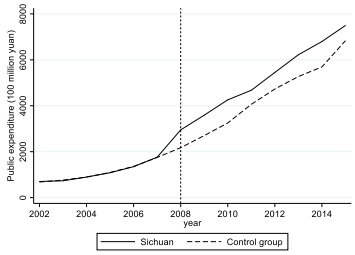
FIG. 3. The differences in the actual and counterfactual results in Sichuan (SCM method)



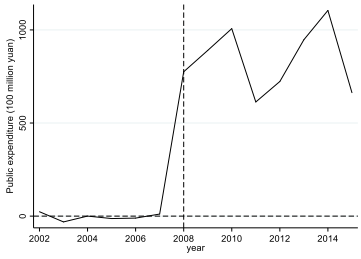
3a. GDP



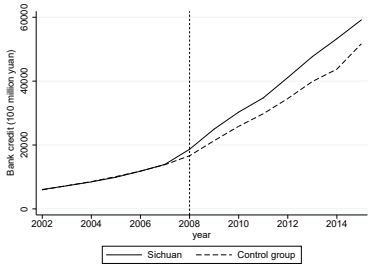
3b. GDP



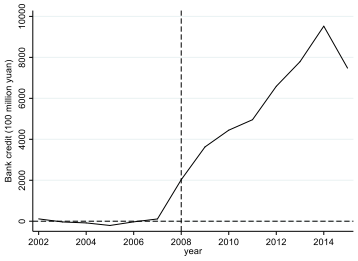
3c. Public Expenditure



3d. Public Expenditure



3e. Bank Credit



3f. Bank Credit

Figure 3 provides the result of SCM.[22] Before the Wenchuan earthquake, the total real GDP of Sichuan Province (solid line) and the total synthetic

[22]When GDP is taken as the explanatory variable, Hubei Province has the highest synthetic weight, that is, the similarity of GDP between Hubei Province and Sichuan Province is as high as 0.35, which is basically consistent with our intuitive feeling. The two provinces are very similar in geographical environment, economic development level, cultural construction and eating habits. When public expenditure is taken as the dependent variable, Henan Province has the highest synthetic weight, which is 0.446, which means that the total public expenditure of Henan Province and Sichuan Province is the closest, which is consistent with the fact that Henan Province is similar to Sichuan Province in terms of floating population scale and social security construction. Finally, when bank credit is used as the explanatory variable, Jilin Province has the highest synthetic weight, because Jilin and Sichuan provinces have similar levels of disposable

GDP (dotted line) almost coincide. After the Wenchuan earthquake in 2008, a significant difference is visible between them,[23] which shows that the earthquake had a significant impact on Sichuan's GDP. The impact was negative in 2008 and gradually decreased with time. Second, before the Wenchuan earthquake, the synthetic control group almost accurately duplicated the change track of the real group's public expenditure. The results show that the earthquake caused a sudden increase in the public expenditure of Sichuan Province, and public expenditure showed an increasing trend. Figure 3d draws the curve of the difference between the two over time. The public expenditure in Sichuan Province showed rapid growth from 2008 to 2011, and the growth rate of public expenditure fell after 2011; however, in the long run, the earthquake has increased the public expenditure in Sichuan. Finally, observing the synthetic result of bank credit, Figure 3e shows that before the earthquake, the bank credit of the real group and the synthetic control group were close. In 2008, bank credits in Sichuan Province increased by 200 billion yuan, and its growth trend continued to increase over time.[24] Therefore, the Wenchuan earthquake led to a substantial increase in bank credit in Sichuan.

At the micro-level, we also used the PSM-DID method to investigate the impact of the Wenchuan earthquake and post-earthquake policies on the economic activities of enterprises in the affected areas. At this time, the dependent variables are the agency variables of bank credit, public expenditure, and economic growth at the enterprise-leve — the RMB Bank Loans, Subsidy Income, and Total Profit of the enterprise — and the independent variables are the policy effect after the Wenchuan earthquake. First, there is the problem of choosing the optimal control group to satisfy the strict common trend assumption. The combination of the propensity score matching method and double-difference method "opens a door" to solve this problem. Propensity score matching can transform the observable multi-dimensional characteristic variables into one-dimensional variables to obtain the control group, which is "most similar" to the treatment group in multi-dimensional characteristic variables. Next, we can carry out a double differential estimation between the "most similar" control group

income, which has a direct impact on the economic growth, the scale of bank credit has been affected.

[23] Because the Wenchuan earthquake occurred in May 2008 and the macro-provincial data used in this study is the annual balance at the end of the period, the change results in 2008 in the synthetic control chart refer to the change in the first year after the earthquake.

[24] Considering the spillover effect of policy intervention after the earthquake, this paper also attempts to exclude Guizhou, Yunnan, Qinghai, Hubei and Chongqing provinces bordering Sichuan from the synthetic control pool, that is, 21 provinces with synthetic control pool. The synthetic control experiment of Sichuan Province is carried out again in the same way as the benchmark regression, and the results are consistent with the benchmark results.

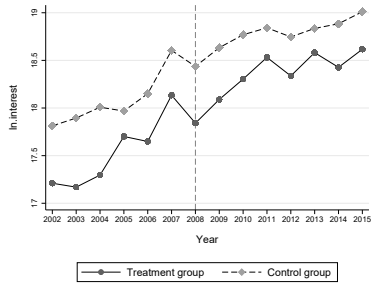
and the processing group. The propensity score matching double-difference method (PSM-DID) was first proposed by Heckman et al. (1997). Compared with the traditional double-difference method, it is easier to meet the strong common trend hypothesis and reduce the error of missing variables, and hence, it is more widely used. In this study, we used propensity score matching to obtain the control group samples. However, there are various methods of propensity score matching, including one-to-one nearest neighbor, one to many nearest neighbor, radius (caliper) matching, and kernel matching (Caliendo and Kopeinig, 2008; Busso et al., 2009). Therefore, we used one-to-one nearest neighbor matching and kernel matching to obtain the processing group and control group of the next stage double-difference estimation. Then, taking RMB bank loans as an example, the DID model is constructed as follows:

$$loan_{at} = c_0 + c_1 treat_a + c_2 period_t + c_3 treat_a period_t + \varphi X + \rho_a + \eta_t + \xi_{at} \quad (7)$$

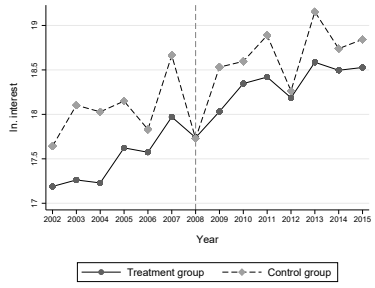
The dependent variable is the interaction term $treat_a \cdot period_t(DID)$ between the fictitious variable $treat_a(D)$ and the policy impact time variable $period_t(year08)$, which is affected by the post-earthquake policy. The coefficient c_3 represents the policy effect of the post-earthquake policy with double differential estimation. If the post-earthquake policy promotes the increase of RMB Bank Loans of enterprises in the disaster area, the coefficient should be significantly greater than 0. X represents a series of control variables at the enterprise level, which is identical to equation (2). η_t and ρ_a represent the fixed-effect of time and enterprise, respectively, c_0 is a constant term, and ξ_{at} is a residual term. Figure 4 shows the common trend of the enterprises in the treatment group and the control group after the earthquake policy impact in 2008. It is easy to identify that the two groups of enterprises have similar trends in total profits, whether through one-to-one nearest neighbor matching or kernel matching, indicating that the PSM-DID method can be applied to the analysis.

Next, based on the data of listed companies from 2002 to 2015, this study examines the impact of the Wenchuan earthquake and the post-earthquake policies on corporate bank loans, subsidy income, and total profits. The odd sequence in Table 7 is the DID estimation result after the control group is obtained by one-to-one nearest neighbor matching, and the even sequence is the DID estimation result after the control group is obtained by kernel matching. We find that when we analyze the impact of the post-earthquake bank credit policy on the bank loans of enterprises in the affected areas, the policy effect coefficient is 0.512 and passes the 1% significance test, which shows that compared with the control group of enterprises not affected by the policy, the enterprises in the affected areas under the impact of the post-earthquake credit policy receive more

FIG. 4. Common trends



4a. One to one nearest neighbor matching



4b. Kernel matching

TABLE 7.

PSM-DID estimation

DEPENDENT VARIABLE	Ln RMB Bank Loans		Ln Subsidy Income		Ln Total Profit		Ln Total Profit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year08	0.770***	1.062***	1.583***	1.835***	1.028***	1.304***	0.749***	0.735***
	(3.870)	(15.185)	(6.567)	(19.612)	(5.377)	(18.204)	(3.368)	(9.306)
D	−0.427***	−0.538***	−0.592***	−0.317**	−0.612***	−0.534***	−0.547***	−0.543***
	(−3.525)	(−5.710)	(−3.692)	(−2.387)	(−5.171)	(−5.399)	(−3.690)	(−4.900)
DID	0.512***	0.239*	0.333*	0.174*	0.259*	0.053***	0.126	0.195
	(3.308)	(1.935)	(1.734)	(1.828)	(1.743)	(5.418)	(0.718)	(1.386)
Ln Subsidy Income							0.117***	0.140***
							(4.375)	(17.081)
Ln RMB Bank Loans							0.211***	0.226***
							(8.125)	(24.353)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	15.487***	16.784***	11.442***	11.728***	13.655***	14.711***	9.079***	9.077***
	(55.945)	(187.350)	(33.997)	(97.328)	(51.093)	(160.625)	(16.523)	(46.618)
Observation	1,652	13,696	1,190	10,885	1,424	12,011	1,080	9,766
R-squared	0.259	0.215	0.227	0.230	0.294	0.242	0.363	0.321

Note: T-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

bank credit. Column (3) shows that compared with the control group, which is not affected by the public expenditure policy, the enterprises in the affected areas under the impact of public expenditure policy after the earthquake receive more subsidy income. The results of column (5) show that the Total Profits of enterprises in the affected area are still larger than those in the non-affected area, despite the direct losses caused by

the earthquake. Interestingly, when we control the two variables of RMB Bank Loans and Subsidy Income in column (7), our core parameter DID is no longer significant. This means that the earthquake increased the Total Profits of enterprises in the affected areas through increases in RMB Bank Loans and Subsidy Income. This finding also supports Hypotheses 1 and 2. The results of the even number column are consistent with those of the control group, indicating that the findings of this study are not affected by the differences in the selection methods of the control group. The above micro evidence is also consistent with the previous macro evidence, which jointly verifies and supports our research hypotheses.

5. ROBUSTNESS TEST

5.1. Model Setting Test

Because the System GMM method, synthetic control method and psm-did method have the possibility of model setting error, this paper uses cross lag model, regression control method and double difference method to re test the benchmark regression results. First, to ensure the robustness of the GMM estimation, we used the cross-lag model to test causality. This is because the change of the result variable lags and a high correlation between the two variables may cause the estimated correlation between variables to mislead the causal inference. Therefore, this study introduces the cross-lag model by obtaining the correlation coefficient of variables over time. Then, according to these correlation coefficients, to determine the cause variables and result variables, we further analyzed the causal relationships between public expenditure, bank credit, and GDP. Specifically, the essence of the cross-lag panel model is the structural equation model, which uses the data of the second period or later, controls the variance of the same period and different periods, and estimates the direct effect of the inter-period variable between variables, also known as the cross-lag effect (Kearney, 2017). According to the estimated results in Table 8, public expenditure and bank credit have a positive impact on GDP, and the increase in public expenditure increases bank credit. The results of the above specification test are consistent with the results of system GMM, which verifies the robustness of the interaction direction and causal conclusions between the three macroeconomic variables.

Secondly, this paper uses regression control method to fit the change trend of public expenditure, bank credit and economic growth after the Wenchuan earthquake. Regression control method is a new method proposed by Hsiao et al. (2012) to identify processing effects given limited information panel data. The principle of this method is that in the framework of factor model, the correlation between cross sections is attributed to some unobservable common factors, and then the counterfactual situation

TABLE 8.

Cross-lag model results of three groups' relationships (Years: 2007-2015)

Dependent Variable	Public Expenditure—GDP		Bank Credit—GDP		Public Expenditure—Bank Credit	
	(1)	(2)	(3)	(4)	(5)	(6)
L.Public Expenditure	0.715***	0.525***			0.643***	0.397*
	(0.000)	(0.007)			(0.000)	(0.074)
L.Bank Credit			0.907***	0.085**	0.012	0.907***
			(0.000)	(0.045)	(0.411)	(0.000)
L.GDP	0.024	0.864***	0.093	0.818***		
	(0.185)	(0.000)	(0.115)	(0.000)		
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.97	0.99	0.99	0.99	0.99	0.94
Conclusion	Public expenditure positively affects GDP		Bank credit positively affects GDP		Public expenditure positively affects bank credit	

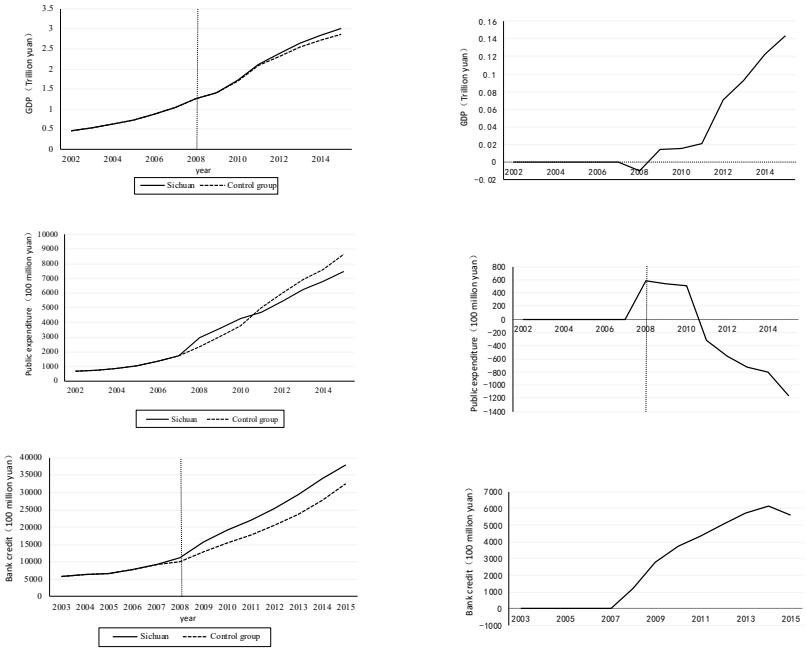
Note: P-values are indicated in parentheses. *, **, and *** are significant at 10%, 5%, and 1%, respectively.

is constructed by mining the correlation between cross sections. Similar to the synthetic control method, the regression control method was given that only one treatment group was intervened by exogenous policy at a certain time, while the other individuals were not intervened by policy during the whole study period. However, the difference is that the regression control method allows the synthetic weight to be non negative and extrapolation, which is more suitable for the situation that the observation time and cross section are relatively small, and there is mutual influence between economies. Therefore, it overcomes the possible weight setting error of the synthetic control method to a certain extent. The regression control effect is shown in Figure 5. The results in Figure 5 are consistent with those in Figure 3.

Finally, we used the DID method to verify the impact of the 2008 Wenchuan earthquake on bank loans, subsidy income, and total profits of micro-level enterprises. Specifically, we take Henan Province as the control group of Sichuan Province and conduct the DID estimation based on the common trend test.[25] Based on the data of listed companies from 2007 to 2015, we used the double-difference method to investigate the impact of policy shocks on RMB Bank Loans, Subsidy Income, and Total Profits after the Wenchuan earthquake. The results are shown in Table 9. Columns (1) and (2) show that the enterprises in the treatment group receive more bank credit and government subsidies than those in the control group. According to columns (3) and (4), the total profit of enterprises in the affected area is larger than that in the non-affected area. However, when we control the

[25]The results of the common trend test are brief and available.

FIG. 5. The differences in the actual and counterfactual results in Sichuan(RCM method)



two variables of RMB Bank Loans and Subsidy Income, the core parameter DID is no longer significant. This means that the earthquake increased the Total Profits of enterprises in the affected areas through increases in RMB Bank Loans and Subsidy Income. The above conclusions prove the robustness of the results and support the two hypotheses.

TABLE 9.

DID estimation

DEPENDENT VARIABLE	Ln RMB Bank Loans	Ln Subsidy Income	Ln Total Profit	Ln Total Profit
	(1)	(2)	(3)	(4)
Year08	0.385**	2.031***	−0.518**	−0.484*
	(2.168)	(5.957)	(−2.534)	(−1.882)
D	0.993*	2.053**	−1.462**	−1.010*
	(1.739)	(2.391)	(−2.402)	(−1.673)
DID	0.165***	0.606***	0.387***	0.285
	(3.504)	(2.861)	(3.140)	(0.863)
Ln Subsidy Income				0.051**
				(2.003)
Ln RMB Bank Loans				0.185***
				(5.124)
Control Variables	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Constant	8.044***	3.860	0.261	2.421
	(6.005)	(1.553)	(0.178)	(1.312)
Observations	1,410	1,019	1,198	907
R-squared	0.517	0.115	0.473	0.578

Note: T-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.2. Index Robustness Test

Since it is not robust and comparable to choose a single micro-enterprise-level proxy index as the corresponding macro variables, it is easy to cause errors in the measurement results. Therefore, we replaced the Subsidy Rate, Debt Ratio, and ROA as the three proxy indexes of Subsidy Income, RMB Bank Loans, and Total Profit and estimated the PSM-DID again. A Debt Ratio and Subsidy Rate were chosen as alternative indicators of RMB Bank Loans and Subsidy Income to eliminate the scale effect and control the influence of enterprise-scale and profit. In addition to the Total Profit, ROA is chosen as the comparative object of macroeconomic growth at the micro-level because it can appropriately reflect the business performance of enterprises as a profit index. The regression results are shown in Table 10, which are consistent with Table 7. The odd sequence is the DID estimation result after the control group is obtained by one-to-one nearest neighbor matching, and the even sequence is the DID estimation result after the control group is obtained by kernel matching. According to Table 10, compared with the control group of enterprises not affected by the policy, the Debt Ratio and Subsidy Rate of enterprises in the affected areas under the impact of the policy after the earthquake increased significantly. The

results of PSM-DID of nearest neighbor matching type demonstrate that there is no significant difference between the enterprises in the affected areas and those in the non-affected areas, but after controlling for the Subsidy Rate and Debt Ratio, the results are significantly negative; the results of PSM-DID of kernel matching type demonstrate that the enterprises in the affected areas still have significantly higher ROA than those in the non-affected areas, but after controlling for the Subsidy Rate and Debt Ratio, the difference is significant. The results are no longer significant. Both findings indicate that there is a positive mediating path between Subsidy Rate and Debt Ratio. Corresponding to the macro level, the path is that the earthquake improves the economic growth of the affected areas through increases in bank credit and public expenditure. This is consistent with Hypotheses 1 and 2.

TABLE 10.

Re-estimation of PSM-DID

DEPENDENT VARIABLE	Debt Ratio		Subsidy Rate		ROA		ROA	
Rate of change	Nearest neighbor matching	Kernel matching	Nearest neighbor matching	Kernel matching	Nearest neighbor matching	Kernel matching	Nearest neighbor matching	Kernel matching
Year08	-0.045^{**}	-0.024^{**}	-0.125^{***}	0.199^{***}	-0.009	0.172^{***}	-0.066^{***}	-0.049^{***}
	(-1.992)	(-2.291)	(-5.351)	(16.052)	(-0.673)	(10.967)	(-3.065)	(-6.472)
D	-0.016	-0.106^{**}	0.015	0.090^{*}	0.004	0.105	0.024^{*}	-0.006
	(-1.213)	(-2.440)	(0.242)	(1.732)	(0.491)	(1.604)	(1.862)	(-0.181)
DID	0.026^{*}	0.018^{*}	0.034^{*}	0.032^{*}	-0.013	0.051^{*}	-0.034^{**}	0.013
	(2.521)	(1.917)	(1.903)	(2.178)	(-1.382)	(1.721)	(-2.124)	(0.938)
Subsidy Rate							0.256^{***}	1.109^{***}
							(18.003)	(241.912)
Debt Ratio							0.763^{***}	0.104^{***}
							(33.191)	(18.963)
CONTROL VARIABLES	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TIME FIXED EFFECT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.563^{***}	0.919^{***}	-0.522^{***}	0.565^{***}	-0.204^{***}	0.020	-0.747^{***}	-0.510^{***}
	(9.462)	(20.091)	(-5.843)	(10.441)	(-5.771)	(0.299)	(-13.342)	(-15.252)
Observations	1,648	19,966	1,661	20,059	1,661	20,059	1,648	19,966
R-squared	0.078	0.061	0.352	0.175	0.155	0.188	0.569	0.820

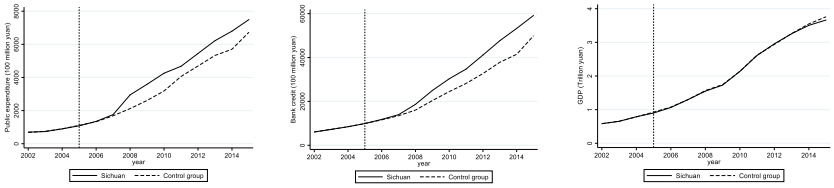
Note: T-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.3. Common Trend Hypothesis Test

Compared with the control group obtained by psm-did, the "synthetic control group" constructed by the synthetic control method through linear combination is almost the same as the processing group before the earthquake in terms of economic characteristics and variation trend. Therefore, it can be considered that this method has passed the traditional common trend hypothesis test perfectly. However, SCM cannot control all key variables that may affect the estimation of the relationship between public expenditure, bank credit, and economic growth, such as time trends and other unobserved variables. Therefore, we cannot determine whether the final change between public expenditure, bank credit, and economic growth is due to earthquakes or due to the omission of important variables, which weakens the predictive power of the model. To solve this problem, this study used the time-based placebo test in the robustness test. Specifically, the time point of the Wenchuan earthquake was virtually allocated to 2005, approximately three years earlier. This study used the same out-of-sample verification technique to compute the synthetic control and lagged the observable variables accordingly. Figure 6 shows the results of the time placebo test. The synthetic Sichuan almost exactly replicated the trajectory of GDP changes in the real Sichuan from 2002 to 2005. There was no obvious difference between the GDP trajectory of real Sichuan and synthetic Sichuan in 2006-2008. Therefore, compared with the actual Wenchuan earthquake in Sichuan Province in 2008, the placebo test in 2005 had no obvious effect. This suggests that the difference in the estimates in Figure 3 reflects the impact of the Wenchuan earthquake rather than the potential predictive capability of the synthetic control. Similarly, this study conducts the same time placebo test on public expenditure and bank credit separately, reallocates the time point of Wenchuan earthquake to 2005, and lags the forecast variable correspondingly. Figures 6a and 6b show there is no obvious difference between public expenditure and bank credit trajectories of real Sichuan and synthetic Sichuan during 2006-2008. This result verifies that the difference between Figures 3c and 3e in the benchmark analysis is caused by the occurrence of the Wenchuan earthquake in 2008 rather than the potential inadequate prediction ability of synthetic control method (omitted variable).

At the micro-level, we used the PSM-DID method to investigate the impact of the Wenchuan earthquake and post-earthquake policies on the economic activities of enterprises in the affected areas. Although Figure 4 shows the time trend of the mean values of the explained variables of the enterprises in the treatment group and the enterprises in the control group who were impacted by the post-earthquake policy in 2008, this result can only help us identify that there is no significant difference between the enterprise treatment group and the enterprise control group before the

FIG. 6. Comparison of time placebo test results with Sichuan Province



6a. Public Expenditure 6b. Bank Credit 6c. GDP

earthquake and cannot accurately judge whether there is a statistical difference. Therefore, we used interactive regression to test the common trend hypothesis again. We generated the interaction terms of the time dummy variable and processing variable D in 2003, 2004, 2005, 2006, and 2007 before the exogenous shock in 2008. The coefficient of the interaction term measures the difference between the treatment group and the control group in a specific year. According to columns (2)-(6) of Table 11,[26] the coefficients of the interaction term before the earthquake are not statistically significantly different from 0 (the 95% confidence interval contains 0 value), indicating that there is no significant difference between the pre-processing group and the control group of the 2008 Wenchuan earthquake. The common trend assumption of this study is that the enterprise processing group and the control group are comparable before the earthquake.

6. CONCLUSIONS

For a long time, regarding the importance of public expenditure and bank credit to economic growth, academia failed to reach a consensus on the causal relationship and influence direction among the three. The disagreement about the causal relationship between public expenditure and economic growth mainly revolves around two opposite theoretical hypotheses: Wagner's Law, which states that economic growth will increase public expenditure (Park, 1998; Kolluri and Wahab, 2007; Lamartina and Zaghini, 2011; Kuckuck, 2014; Fedeli, 2015), and the Keynesian hypothesis, which states that increase in public expenditure causes economic growth. There are different conclusions about the effect of bank credit on economic growth, such as significant promotion, little correlation, even negative correlation, and non-linear correlation. The impact of public expenditure on bank credit can be divided into three categories: an increase in public

[26]Limited by space, the results of the parallel trend test with subsidy income and bank loans as explanatory variables are slightly different, but both show that the enterprise processing group and the enterprise controlling group are comparable before the earthquake.

TABLE 11.

Parallel trend test of enterprise total profit

	(1)	(2)	(3)	(4)	(5)	(6)
i	2008	2007	2006	2005	2004	2003
d	-0.612^{***}	-0.566^{***}	-0.687^{***}	-0.707^{***}	-0.665^{***}	-0.507^{*}
	(-5.171)	(-4.303)	(-4.630)	(-4.147)	(-3.072)	(-1.951)
$d * year \cdot i$	0.259^{*}	0.168	0.312	0.315	0.244	0.064
	(1.743)	(1.069)	(1.039)	(1.174)	(1.062)	(0.237)
year08	1.028^{***}					
	(5.377)					
year07		1.069^{***}				
		(5.538)				
year06			1.003^{***}			
			(5.143)			
year05				1.002^{***}		
				(5.053)		
year04					1.035^{***}	
					(4.994)	
year03						1.116^{***}
						(5.144)
CONTROL VARIABLES	Yes	Yes	Yes	Yes	Yes	Yes
TIME FIXED EFFECT	Yes	Yes	Yes	Yes	Yes	Yes
Constant	13.655^{***}	13.631^{***}	13.679^{***}	13.691^{***}	13.670^{***}	13.604^{***}
	(51.093)	(50.788)	(50.816)	(50.314)	(49.197)	(47.564)
Observations	1,424	1,424	1,424	1,424	1,424	1,424
R-squared	0.294	0.293	0.294	0.294	0.293	0.293

Note: T-statistics in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

expenditure will reduce bank credit, public expenditure can promote the expansion of bank credit, and the relationship between them depends on the economic environment.

The biggest challenge in exploring the causal relationship between public expenditure, bank credit, and economic growth is solving the potential two-way causality, omitted variable bias, and other endogenous problems among the three variables. Using the Wenchuan earthquake as the research window, this study proposes the core research hypotheses under two scenarios in China, that is, in the short term after the Wenchuan earthquake, the scale of public expenditure and bank credit in the affected areas significantly increased, both of which cause and affect economic growth. Then, we use the macro provincial data and micro-enterprise data of China from 2002 to 2015, adopt two types of identification hypotheses and comprehensively use the System GMM method, fixed-effect model, synthetic

control method, and PSM-DID method to overcome the endogenous problems. The results show that public expenditure and bank credit have a significant positive impact on regional economic growth and total profits of micro-enterprises, respectively. The increase in public expenditure increases bank credit. Specifically, after the Wenchuan earthquake, public expenditure and bank credit in Sichuan Province increased significantly, while GDP showed a negative change after combining the negative impact of direct loss and the positive driving effect of public expenditure and bank credit.

This study makes the following contributions. First, using an earthquake, a random natural disaster, this study clarifies the causality of three core macroeconomic variables and further clarifies the direction of change based on causality, to provide more reliable evidence from China for existing research disputes. Second, this study also clarifies the actual impact of public expenditure and credit preferences on the economic growth of Sichuan and other affected provinces, which is helpful in the study of disaster economics. Third, our conclusions have implications for understanding the effectiveness of fiscal and monetary policies in an uncertain real world. From the perspective of causality, we emphasize that fiscal and monetary policies are effective macro-control tools, and they can be coordinated to form a unified macro-control framework. We should make full use of the existing policy framework to highlight the synergy of fiscal and monetary policies through institutional innovation.

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