sustainability

Article

Natural Disasters, Economic Growth and Sustainable Development in China—An Empirical Study Using Provincial Panel Data

Ji Guo [1,2,*], Hui Liu [2], Xianhua Wu [1,2], Jiong Gu [2], Shunfeng Song [3,4] and Yinshan Tang [5]

Received: 6 October 2015; Accepted: 10 December 2015; Published: 19 December 2015
Academic Editor: Yehua Dennis Wei

1 Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disasters, Nanjing University of Information Science & Technology, Nanjing 10044, China; wxhua_77@nuist.edu.cn
2 School of Economics and Management, Nanjing University of Information Science & Technology, Nanjing 210044, China; 001153@nuist.edu.cn (H.L.); 001213@nuist.edu.cn (J.G.)
3 Department of Economics, College of Business, University of Nevada, Reno 89557, NV, USA; song@unr.edu
4 School of Economics and Management, Tianjin Chengjian University, Tianjin 300384, China
5 Henley Business School, University of Reading, Reading RG6 6UD, UK; y.tang@henley.ac.uk
* Correspondence: guoji@nuist.edu.cn; Tel.: +86-25-5869-5600; Fax: +86-25-5873-1549

Abstract: Using a newly developed integrated indicator system with entropy weighting, we analyzed the panel data of 577 recorded disasters in 30 provinces of China from 1985–2011 to identify their links with the subsequent economic growth. Meteorological disasters promote economic growth through human capital instead of physical capital. Geological disasters did not trigger local economic growth from 1999–2011. Generally, natural disasters overall had no significant impact on economic growth from 1985–1998. Thus, human capital reinvestment should be the aim in managing recoveries, and it should be used to regenerate the local economy based on long-term sustainable development.

Keywords: Economic growth; geological disasters; meteorological disasters; human capital; physical capital

1. Introduction

In recent decades, natural disasters have become international concerns. The Richter magnitude 9.0 earthquake and the subsequent tsunami in Japan in 2011, the Indian Ocean tsunami in 2004, Hurricane Katrina in 2005, and the earthquakes in Haiti and Chile in 2010 resulted in substantial losses in terms of finance and human lives. In China, many disasters occurred during a period of rapid economic growth. Recent events include the catastrophic earthquake in Sichuan Province in 2008, the severe droughts in Yunnan, Guizhou, and Sichuan Provinces in 2009 and 2010, another earthquake in Yushu County, Qinghai Province in 2010, and an unprecedented storm in Beijing on 21 July 2012. The causes of the high frequency of severe natural disasters have become popular research topics, and the findings have improved the understanding of the relationship between human activities and the environment. However, the exploration into the relationship between natural disasters and long-run economic growth in China has been minimal. This paper fills this gap by investigating the economic effects of post-disaster rebuilding activities in the current Chinese economic environment.

Published works have divided the long-run economic effects into three different groups, namely, negative, positive, and inconclusive effects. In defining the negative effects, frequent natural disasters are linked to low economic growth rates (Benson and Clay [1] and Yu Xiao [2]) and enduring consequences (Gall *et al.* [3], Coffman and Noy [4] and Okuyama [5]). Natural disasters reduce household consumption over time without any sign of economic recovery (Dercon [6] and Mechler [7]). Furthermore, natural disasters reduce real gross domestic product (GDP) per capita in the long term (Raddatz [8]), reduce national welfare (Arndt *et al.* [9,10]), increase socioeconomic instability (Porfiriev [11]), and create poverty traps (Hallegatte and Dumas [12]). Area-specific studies in Central America and the Caribbean regions have shown that less democratic countries suffer more losses on imports and exports after natural disasters (Gassebner *et al.* [13], Strobl [14]). Evidence shows that natural disasters increase poverty by 1.5%–3.6%, and has a significant negative effect on the Human Development Index in Mexico (Rodriguez-Oreggia *et al.* [15]). A negative effect on knowledge spillovers is also observed between developing and developed countries (Cuaresma *et al.* [16]), although a "creative destruction" process could occur in developed countries (Skidmore and Toya. [17]). With regard to positive effects, natural disasters, through the rebuilding and recovery process, promote economic growth, improve agricultural and construction outputs and capital formation, and address fiscal and trade deficits (Albala-Bertrand [18,19]; Dacy and Kunreuther [20]; Otero and Marti [21]; Tol and Leek [22]). Such positive effects are evidenced by the accumulation of human capital, growth of GDP per capita, and total factor productivity (Skidmore and Toya [17]; Dacy and Kunreuther [20]; Wang [23]; Kim [24]; Bradley *et al.* [25]). For instance, Dacy and Kunreuther [20] pointed out that the GDP of the damaged area would increase after the disaster. That's because natural disasters may lead to casualties and economic losses, while on the other hand, new technology may be developed for post-disaster reconstruction, thus promoting economic growth. Skidmore and Toya [17], based on the Schumpeter's creative destruction, proposed that natural disasters would create opportunities for the rejuvenation of capital and encourage people to adopt new techniques. They also pointed out that natural disasters would lower the expected return to physical capital, which would drive people to invest in human capital, a key factor in economic growth (Lucas [26]). Bradley *et al.* [25] found that the reconstruction of commercial and residential housing and infrastructure in Oklahoma City after the 3 May 1999 tornado stimulated the labor market and increased the average employment rate. Older facilities are more vulnerable to damage, and thus the reinvestment in such facilities will have a positive effect on overall economic growth and productivity in the long run (Okuyama [27]; Okuyama *et al.* [28]). Different authors have also reported the inconclusive relationships between natural disasters and economic growth. From a macroeconomic perspective, no links have been established between the Kobe earthquake in Japan in 1995 and capital stock (Horwich [29]). A negative effect on short-term economic growth is found, but not on long-term growth (Zou [30]). Companies in regions hit by floods show a higher growth in total assets and employment with a negative impact on productivity than those in unaffected regions (Leiter *et al.* [31]). Different disasters have different impacts in different regions of the world (Loayza *et al.* [32]). Shabnam [33] also reported a similar classification in his recent review.

The resulting regional economic status after a natural disaster can be influenced heavily by how the recovery activities are managed. Management of these activities is a process that is also linked to the national wealth and political system of a country. In relation to these considerations, China, a newly developed economic superpower, possesses distinctive culture, ethical characteristics as well as a different governing system. China's situation is distinct because of three aspects, namely, the relatively frequent disasters, increasing innovation abilities, and powerful rebuilding supports from the government. With these characteristics, will natural disasters have positive effects on the long-term economic growth in China? What are the mechanisms for such impacts? What can be done to promote a long-term sustainable development, particularly in the places of China where natural disasters have become more frequent in recent years? The purpose of this research is to answer these questions.

2. Data, Disaster Indicator and Hypotheses

In this section, we describe the data used in the paper, construct the indicator that measures the effects of natural disasters, and propose hypotheses on the relationship between natural disasters and economic growth.

2.1. Data

Emergency Events Database (EM-DAT) provides comprehensive and updated information on natural disasters around the world (Guha-Sapir and Below [34]). In this study, disaster related data were collected from EM-DAT, which is maintained by the Center for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain, Belgium. Natural disasters (NDs) are separated into two different groups, namely, meteorological disasters and geological disasters. Meteorological disasters (MDs) are those created by deviations in the normal water cycle and atmospheric processes, including floods, landslides (the classification of EM-DAT, where landslide is categorized into meteorological disaster, is adopted in this paper), cyclones, hurricanes, tornadoes, and typhoons and storms, including ice snow storms. Geological disasters (GDs) are those caused by geological processes, including volcanic eruptions, natural explosions, avalanches, and earthquakes. MDs occur more frequently and are more predictable and regularly occurring than geological disasters. GDs are more difficult to predict, limiting the effectiveness of evacuation procedures. MDs are a reasonable proxy of risk to physical capital, and GDs may be perceived as a threat to both people's lives and properties (Skidmore and Toya [17]).

A limitation of the EM-DAT data is the highlight on a region instead of an individual province. If an earthquake affects many provinces, the EM-DAT provides damage records of this group of provinces, instead of an individual province. Thus, the data on the losses of each province are collected from *China Meteorological Disasters Book* (Wen, K.G. [35])and previous literature (Disaster Information Department of China National Disaster Reduction Center [36], The State Flood Control and Drought Relief Headquarters Office [37]). It is necessary to point out that *China Meteorological Disasters Book* (Wen, K.G. [35]) only records the data before 2000, thus those after 2000 are mainly from the previous literature in *Disaster Reduction in China* (Disaster Information Department of China national Disaster Reduction Center [36], The State Flood Control and Drought Relief Headquarters Office [37]) except a small part from China's Civil Affairs Network or China Seismic Information. The proportions of each province's losses are calculated and then the total losses of each disaster in EM-DAT are allocated to each province in proportion (an example is given in Table A1). This study used the data collected from 30 provinces between 1985 and 2011. All data related to the economy, education, and population were derived from the *China Statistical Yearbook* (China's National Bureau of Statistics [38]) and *China Compendium of Statistics 1949–2008* (The National Economy Comprehensive Statistics Division of the National Bureau of Statistics [39]).

2.2. Disaster Indicator

How to evaluate the disaster comprehensively is an important content of disaster losses evaluation. Researchers have developed a number of indicators to evaluate the losses of disasters, such as disaster frequency (number of disasters) (Skidmore and Toya [17]; Wang [23]; Raddatz [9]; Kim [24]; Kellenberg and Mobarak [40]), disaster index based on maximum sustained wind velocity for hurricanes (Strobl [14]), economic losses (Cuaresma [16]; Li [41]), mortality (the number of deaths/total population), and loss rate (disaster losses/GDP) (Noy and Nualsri [42]). Although losses are effectively linked to the hazard-formative factors, hazard-formative environments, and hazard-affected bodies, limitations exist in these indicators. Zhao [43] suggested that two disaster events with the same intensity could have significantly different effects if one occured in a sparsely populated and less developed region, whereas the other occured in a densely populated and developed area. A magnitude 6.0 earthquake in China may produce the same level of losses as an

8.0 earthquake in Japan because Japan has more experiences and advanced technologies to prevent and reduce the losses. Therefore, we need an aggregative indicator to estimate the disaster. The frequency and the extent of damages are the most important in the selection of evaluation index of natural disasters. The frequency is often referred to as the number of disasters. The extent of damages includes two aspects, namely, death toll and economic losses. Actually, only the data on the number of disasters, death toll and economic losses can be found in all databases for natural disasters (EM-DAT, *China Meteorological Disasters Book* (Wen, K.G. *et al.* [35]) and other databases). Thus, the variables selected for the synthesized disaster indicator include the number of disasters, death toll, and economic losses.

What method to be adopted for integrating multiple indicators is also a problem. Thus, the entropy method, where a new aggregative indicator is obtained by weighting the number of disasters with the extent of damages, is adopted in this paper. The entropy method is an objective weighting method which holds that the more ordered a system, the smaller the information entropy. Therefore, the information entropy serves as a measurement of disorder degree in a system. The data size is a determinant of the reliability and accuracy of evaluation. In other words, the smaller the information entropy of an indicator, the more information the indicator offers. Then, the indicator will have a higher weight in the synthetical evaluation (Tang *et al*. [44] and Zhang *et al*. [45]).As argued by Burg [46], Darbellay and Wuertz [47] and Li *et al*. [48], synthesizing the indexes with entropy method has four advantages. First, adopting the entropy method to determine the index weight can avoid human interference factors and thus obtain more realistic assessment. Second, by calculating the entropy value of each indicator, it measures the amount of information of each indicator objectively. Third, by considering the correlation among samples and determining the weight based on multiple sample points, the entropy method reduces the impact of outliers on the assessment. Fourth, the entropy method enjoys a better adaptability because it can be applied to any situation that needs to calculate the weight. Therefore, a synchronous indicator with entropy weight has been suggested to improve the measure of severity of disasters (Tang *et al.* [44]. Zhang *et al.* [45]).

The steps for obtaining the synthetical value through entropy method are as follows: (1) calculate the proportion of disaster indicator; (2) calculate the value of information entropy of the disaster indicator; (3) calculate the weight of the disaster indicator; and (4) obtain the synthetical value. First, we calculated the proportion of disaster indicator (j) in region (i):

$$y_{ij} = x_{ij}/\sum_{i=1}^{n} x_{ij}, (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m) \tag{1}$$

where i represents 30 Chinese provinces and central municipalities, j is an indicator of NDs (the number of disasters, death toll, and economic losses), and x_{ij} is the value of the disaster indicator (j) in region (i). Then, we calculated the value of information entropy of the disaster indicator (j):

$$e_j = -K\sum_{i=1}^{n} y_{ij}\ln y_{ij} \tag{2}$$

where K is a constant, $K = 1/\ln n$, n is the number of regions used in this paper, and $n = 30$. The information utility value of disaster indicator (j) is:

$$d_j = 1 - e_j \tag{3}$$

The evaluation is more vital because the information utility value is larger. The weight of the disaster indicator (j) is:

$$w_j = d_j/\sum_{j=1}^{m} d_j \tag{4}$$

Using a weighted summation method, we obtained:

$$U = \sum_{j=1}^{m} x_{ij} w_j \tag{5}$$

where U is the synthetic value calculated from the three natural disaster indicators. Finally, we used a weighted model to obtain a new indicator to measure the degree of NDs. In the following empirical analysis, the new disaster indicators used are *ND* (degree of total natural disasters), *GD* (degree of geological disasters), and *MD* (degree of meteorological disasters).

2.3. Hypotheses

As mentioned in the introduction, many researchers held that the correlations between economic growth and different natural disasters vary. Skidmore and Toya [17] and Zou [30] believed that there was a positive correlation between the MDs of some countries and regions and economic growth as the occurrence of MDs is evident and easy to forecast. Wang [23] and Li [41] held that there was a negative correlation between the GDs of most countries and regions and economic growth because the occurring regularity of GDs is hard to find out and the effect of MDs is wider than that of GDs in regions. As there is little research on the correlation between MDs (or GDs) and economic growth in China, this paper attempts to obtain some new findings by verifying the correlation with China's data and analyze the possible reasons for the correlation. To determine the role of different NDs in regional economic growth, this paper included all three measures of NDs (*ND*, *MD*, and *GD*) in the analytical model. Specifically, *ND* or *MD* and *GD* were factored into the classical growth model.

H_1: Meteorological and geological disasters have different effects on economic growth.

NDs may affect investment decisions on production, and thus affect the economic growth. Leiter [31], based on difference-in-difference (DID) approach, found that physical capital accumulation was significantly higher in regions experiencing a major flood-event. Albala-Bertrand [18] proposed that NDs might have brought a bad influence to the economy in the short run, however, the demands expanded by the capital inflow for post-disaster constructions would definitely promote economic growth eventually. Kunreuther and Kleffner [49] and Wisner [50] held that the productivity restoration of post-disaster economy was directly related to the government's expenditure on disaster prevention and reduction which is conducive to the national security and public welfare. Moreover, the government's investment in disaster prevention and reduction is a key factor for promoting economic growth. Though physical capital investment may be reduced because of the temporary impact of disasters, the government will rapidly increase physical capital investment afterward because China has strong rescue system. A higher saving rate in the short run may promote the accumulation of physical capital. In addition, Okuyama [27] pointed out that NDs might have damaged the previous production system, while old facilities destroyed might also need to be reinstalled or upgraded so as to resume production, in which case NDs was a catalyst for capital investment and industry upgrade, thus, increasing physical capital investment. This assumption leads to the second hypothesis.

H_2: The occurrence of NDs leads to faster accumulation of physical capital.

We also analyzed the impact of NDs on human capital investment. Wang [23] found that NDs had a huge impact on macro-economic activities mainly through affecting the investing behavior of human capital. Li [41] held that when an economy suffered from NDs, new equipment and technologies would be introduced and adopted, which might improve the efficiency of the laborers. Furthermore, Skidmore and Toya [17] believed that people might choose investment between human capital and physical capital in the endogenous growth framework. When people are threatened by NDs, they may reduce the investment in physical capital and opt to invest in human capital. The economy may allocate more resources to improve the human capital. Moreover, Bradley [25] believed that post-disaster reconstruction increased employment rate which would accelerate the accumulation of human capital. Accordingly, the third hypothesis is proposed.

H_3: The occurrence of NDs leads to a faster accumulation of human capital.

3. The Empirical Analysis

According to the number of disasters in the EM-DAT, we summarized the frequency and distribution of NDs in China. From 1985 to 2011, the average number of MDs is 17 each year. The lowest frequency is nine in 1989 and the highest is 30 in 2006. Compared with the number of MDs, the number of GDs is much less frequent. The average number of GDs is four every year. The lowest frequency is one in 1986 and 2007 and the highest is 11 in 2003. The remaining years have less than eight GDs.

All provinces in China suffer from MDs. The highest number of MDs is 95 in Guangdong and the least is three in Tianjin and Ningxia. Examining the most to least frequent occurrences revealed that the number of MDs is bigger than 30 in 11 provinces, including Guangdong, Sichuan, Hunan, Fujian, Zhejiang, Hubei, Jiangxi, Guangxi, Yunnan, Anhui, and Guizhou. Most of them are located in the central and southeast coastal regions of China. Among them, 21 provinces are located in the inland regions of China, and have suffered from GDs during the period from 1985–2011. These provinces are Yunnan (with a frequency of 38), Xinjiang (19), Sichuan (17), Gansu (8), Qinghai (5), Shanxi (5), Hebei (4), Inner Mongolia (4), Tibet (4), Guizhou (3), Jiangxi (3), Hubei (2), Guangdong (2), Liaoning (2), Ningxia (2), Fujian (1), Guangxi (1), Henan (1), Hunan (1), Shannxi (1), and Zhejiang (1).

Figure 1 shows the number of NDs over the period from 1985–2011 (We attempted to analyze the impacts of natural disasters on economic growth based on the data from 30 provinces during the period from 1985 to 2011. There are no statistically significant results for disaster variables and some control variables. In addition, due to the lack of data and changes of statistics caliber on relevant variables over the years, we are unable to collect comparable data before 1985). An upward shift in the frequency around 1998 is revealed. The average frequency of NDs from 1999–2011 is 1.62 times of that from 1985–1998. Since the catastrophic flood in 1998, the Chinese government has established observation networks for NDs by constructing more facilities for the disaster prevention and resilience, on the other hand, the institutional construction has been enforced by issuing laws and regulations on disaster prevention and damage reduction. The disaster prevention and damage reduction has stepped into a new stage since 1998 (Jiang [51]).Therefore, 1998 can be seen as a demarcation point for the impact of natural disasters on economic growth. To verify if 1998 is also a structural break point regarding the relationship between NDs and economic growth, we performed the Chow test to the data using the per capita GDP growth rate as the dependent variable and the frequency of NDs as the independent variable. At the 1% significance level, the null hypothesis of no breakpoint in 1998 is rejected. Therefore, the study period can be statistically divided into the first period (from 1985 to 1998) and the second period (from 1999 to 2011). Accordingly, we summarized the empirical evidence for these two sub-periods.

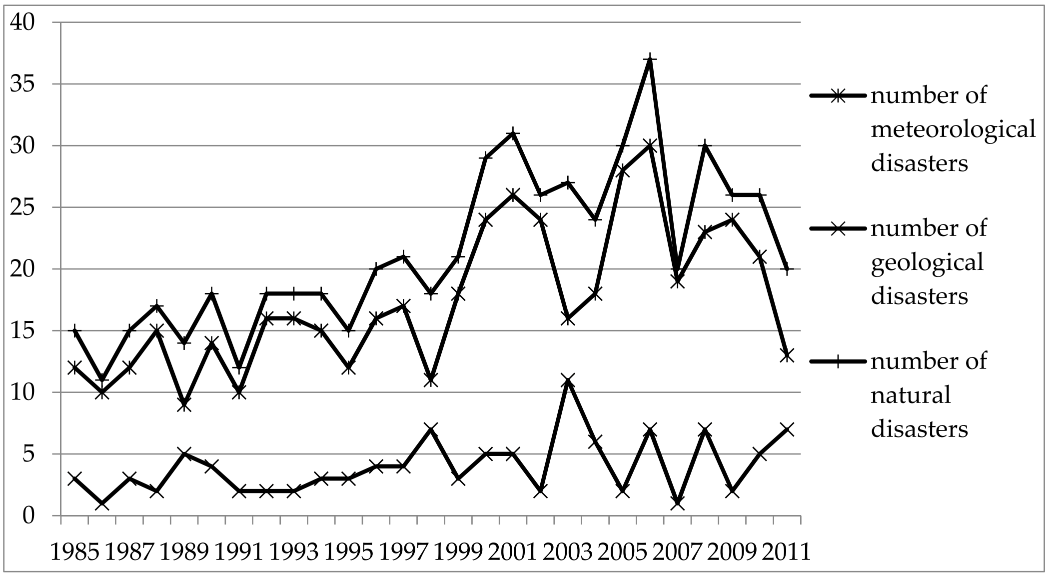

Figure 1. Number of disasters from 1985 to 2011.

To empirically investigate the relationship between NDs and economic growth, after reviewing the studies conducted by Skidmore and Toya [17], Wang [23], Kim [24], Gassebner *et al*. [13], Guo [52], and Liu *et al*. [53], a regression analysis based on production function was used with the data of different disasters and a number of economic variables. Let's us say that y is production, K is capital input, and H is labor input, then the expression of Cobb–Douglas production function is written as:

$$y = f(K, H) \tag{6}$$

According to the research of Skidmore and Toya [17], by bringing the endogeneity of NDs into model, we get:

$$y = f(K, H, ND) \tag{7}$$

where y is measured by per capita GDP growth rate, K is measured by investment growth rate, and H is measured by Education degree. After reviewing the studies of Barro and Lee [54], Guo [52], and Lin *et al*. [55], we chose control variables that include openness (total volume of foreign trade/GDP), SOE (the number of state-owned enterprises), and birth rate.

From the viewpoint of factor inputs, the role of investment in economic growth can be concluded in two aspects, the pulling effects of investment demand and the driving effects of investment supply. Extensive investment demands can produce positive pulling effects to the economic growth and social consumption, whereas adequate investment supply can inject new production factors directly to the social reproduction process, increase the supply of production materials, and provide the material conditions for expanded reproduction, which will directly promote the growth of the gross national product. A larger percentage of output used as investment will stimulate fast economic growth (Kim [24]) (this finding is consistent with the Say Law, *i.e.*, supply creates demand). The growth rate in fixed-asset investment is used as the control variable to measure investment.

Human capital is a key factor for economic growth (Lucas [26]). Generally, either the average education years based on expenditure approach or the average wage based on income approach is used for evaluating human capital. In this paper, the average education years is adopted and the formula of it is written as below (in this paper, the average education years is adopted for calculation instead of educational expenditure because the data of the former is easier to get (Wang [23]). Moreover, as the statistical caliber of average wage changed in 1998 (only includes the wages of on-post staffs), thus, it is quite hard to obtain the comparable data of average wage.):

$$E = \sum P_h \times N_h / \sum P_h, (h = 1, 2, \ldots, 5) \quad (8)$$

where P_h is the population of each education level, N_h is the number of years in each education level, and h is the education level comprising illiteracy, primary education, lower secondary education, upper secondary education, and tertiary education.

Openness is also a determinant of economic growth. Openness is an important channel to introduce advanced technological knowledge from abroad, which serves as a proxy for the local international trade level and the degree of competitiveness to a certain degree. Good economic openness can introduce advanced technology and equipment, which will greatly improve the labor productivity and save development costs. Consequently, economic growth is promoted. Openness can also provide new opportunities in relation to the overcapacity of domestic market and further stimulate domestic production capacity. Accordingly, the total volume of foreign trade/gross provincial product (GDP) is used as the control variable for openness.

With the efficiency loss and soft budget constraint, Kornai [56] argued that the government cannot bail out the loss-making state-owned enterprises, and state-owned enterprises (SOEs), which may disrupt the development of private enterprises and decelerate economic growth (Liu *et al.* [53]). Soft budget constraints lead to efficiency loss, which can further induce the creation of moral hazard of local governments and SOEs, leading to low efficiency, lack of innovation, and economic shortage (Lin *et al*. [55]). Soft budget constraints can also cause excessive bad debts, the portfolio of risk assets, and financial crises. The number of SOEs was used as the control variable in our calculations (due to the lack of data, we are unable to use data on production value of state-owned enterprises; nevertheless, to a certain degree, the number of state-owned enterprises reflects the condition of state-owned capital in the economic structure).

Birth rate was also used as a control variable. According to parents' utility functions with characteristics of altruism provided by Becker and Barro [57], high birth rates can raise discount rates of future consumption and reduce the degree of altruism of each child for parents, which will not be conducive to human capital investment on their children. A high birth rate will increase the burden on societies and families, reduce the level of investment per capita, and create a negative impact on education, and thus affect the rate of economic growth because of the large population in China (Guo [52]). To consider the induced effect of birth rate on the economy, we chose this factor as a control variable (in our analysis, we tried to include other variables such as foreign direct investment and household consumption; however, they were excluded in this paper because these variables suffered too many missing observations at the provincial level before 1997).

Unit root tests with ADF and PP methodologies were performed to avoid spurious regression. Table A2 shows that parts of some variables were rough at the initial level. After the first difference, they returned to smoothness.

Based on the test results in Table A2, we used the following panel model to examine the determinants of economic growth rate. After correlation analyses among economic variables, we found that only the education degree and birth rate were highly correlated (their correlation coefficient is –0.781857 (p = 0.0000)). To avoid the multi-collinearity, the birth rate is eliminated in Equations (9) and (10):

$$G_{it} = c_1 + c_2 ND_{it} + c_3 I_{it} + c_4 E_{it} + c_5 O_{it} + c_6 S_{it} + \varepsilon_{it}, \\ (i = 1, 2, \ldots, 30; t = 1, 2, \ldots) \quad (9)$$

where G_{it} is the per capita GDP growth rate in region (i) in period (t) (the base year is1985), ND_{it} is the degree of NDs in region (i) in period (t), I_{it} is the investment (investment in the fixed assets) growth rate in region (i) in period (t) (the base year is 1985), E_{it} is the education degree in region (i) in period (t) in region (i) in period (t), O_{it} is the degree of openness (total volume of foreign trade/GDP) in region (i) in period (t) (O_{it} is rough in the second period, and then replaced with ΔO_{it}, the degree of openness at the first difference level), S_{it} is the number of SOEs (the number of state-owned and state-holding industrial enterprises) in region (i) in period (t), $c_z(z = 1, 2, \ldots, 6)$ is the regression coefficient, and ε_{it} is the error term.

Column 1 of Table 1 reports Panel Generalized Least Squares (GLS) results (the random-effect model was used in this paper, and we eliminated heterocedasticy with Generalized Least Squares (GLS) and autocorrelation with cluster robust standard error). The estimated coefficient of ND is statistically insignificant. Therefore, when MD and GD are grouped together, ND neither hinders nor promotes economic growth. The estimated coefficients of openness and SOE are statistically insignificant. Both education degree and investment has a positive effect on per capita GDP growth rate.

Table 1. Panel data regression results (Equations (9) and (10)).

Dependent Variable	Per Capita GDP Growth Rate			
Period	**The First Period (1985–1998)**		**The Second Period (1999–2011)**	
C	0.095202 *** (0.0000)	0.092598 *** (0.0000)	0.085283 *** (0.0000)	0.084266 *** (0.0000)
Degree of natural disasters *ND*	0.00000126 (0.8169)		0.00000136 (0.1481)	
Degree of meteorological disasters *MD*		0.000000837 (0.8791)		0.0000164 ** (0.0267)
Degree of geological disasters *GD*		0.000248 (0.1044)		0.00000142 (0.3085)
Growth rate of investment *I*	0.228303 *** (0.0000)	0.229056 *** (0.0000)	0.174843 *** (0.0000)	0.168970 *** (0.0000)
Education degree *E*	0.005103 * (0.0930)	0.005430 * (0.0740)	0.005968 ** (0.0114)	0.006027 ** (0.0102)
Openness *O*	−0.00000382 (0.2591)	−0.00000380 (0.2218)		
D (openness) ΔO			0.000135 *** (0.0005)	0.000132 *** (0.0007)
SOE *S*	−0.00000214 (0.2591)	−0.00000219 (0.2475)	−0.0000241 *** (0.0000)	−0.0000246 *** (0.0000)
R^2	0.311052	0.315356	0.261843	0.269959
Obs	420	420	360	360

Note: a. Probs are reported in brackets; b. The symbols *, **, and *** stand for 10%, 5%, and 1% significance, respectively.

Column 3 of Table 1 presents the GLS results in the second period. Similarly, the estimated coefficient of *ND* is statistically insignificant. All other control variables show the expected results. Education degree, investment and international trade promote economic growth, whereas SOE hinder economic growth.

To further examine the different impacts of different disasters on economic growth, we separated ND into MD and GD. Accordingly, Equation (9) is expressed as:

$$G_{it} = c_1 + c_2 MD_{it} + c_3 GD_{it} + c_4 I_{it} + c_5 E_{it} + c_6 O_{it} + c_7 S_{it} + \varepsilon_{it}, \quad (i = 1, 2, \ldots, 30; t = 1, 2, \ldots) \tag{10}$$

where MD_{it} and $GD_{it}GD_{it}$ are new independent variables, MD_{it} is the degree of MD in region (i) in period (t), and GD_{it} is the degree of GD in region (i) in period (t). Other variables are the same as those in Equation (6).

The results in Column 2 of Table 1 indicate the absence of significant evidence of any correlation between the disaster variables (*MD* and *GD*) and GDP growth. The results of other control variables are similar to those obtained by Equation (9). In the second period, the results from GLS are summarized in Column 4 of Table 1. *MD* has marginally positive significant estimated coefficient (at 5% level), whereas *GD* has no significant effect on per capita GDP growth rate. This finding suggests that MDs can marginally promote economic growth, whereas GDs can not. The results of other control variables are similar to those obtained by Equation (9).

A few possible reasons may help to explain why MDs marginally affected economic growth in the second period from 1999 to 2011 in stead of the first period from 1985 to 1998. First, the annual average frequency of MDs in the first period (13.21) was much smaller than that in the second period (21.85). Second, the volatility of MD frequency in the first period (sd = 2.66) was much lower than that that in the second period (sd = 4.90). Third, prevention and reconstruction were relatively weak in the first period. Since 1998, the Chinese government has systematically formulated and promulgated a series of laws, rules, and regulations, including *Disasters Mitigation Plan of the People's Republic of China (1998–2010)* (The State Council of the People's Republic of China [58]), *Earthquake Disaster Mitigation Law of the People's Republic of China* (The State Council of the People's Republic of China [59]) and *National Disaster Relief Emergency Plan* (China Flood Control and Drought Relief [60]).They help the Chinese government improve the modern system of disaster relief and prevention (Jiang [51]), which reduced the impact of disasters on economic growth.

We further investigated the mechanism of how ND affected economic growth in the second period. We analyzed the relationship between NDs and physical capital. We chose investment growth rate as the dependent variable to measure physical capital and employed the following panel model:

$$I_{it} = c_1 + c_2 MD_{it} + c_3 GD_{it} + c_4 G_{it} + \varepsilon_{it}, \quad (i = 1, 2, \ldots, 30; t = 1, 2, \ldots) \tag{11}$$

The GLS results in Column 1 of Table 2 show that neither MDs nor GDs are significantly correlated with investment growth rate. Thus, MDs and GDs may not have affected economic growth through increasing physical capital investment.

Table 2. Panel data regression results in the second period (1999–2011) (Equations (11) and (12)).

Dependent Variable	Growth Rate of Investment	Education Degree
C	0.086913 *** (0.0000)	9.743637 *** (0.0000)
Degree of meteorological disasters *MD*	0.00000811 (0.5846)	0.000177 * (0.0534)
Degree of geological disasters *GD*	−0.000000397 (0.9561)	−0.000000613 (0.6564)
Per capita GDP growth rate *G*	0.876742 *** (0.0000)	
Birth rate *B*		−0.148292 *** (0.0000)
D (income level) ΔIN		18.97086 *** (0.0001)
R^2	0.218076	0.235808
Obs	390	360

Note: a. Probs are reported in brackets; b. The symbols *, **, and *** stand for 10%, 5%, and 1% significance, respectively.

Skidmore and Toya [17] reported that meteorological disasters may promote investment in human capital. Suppose a society can choose the level of investment for factors of production, human capital investment will be more attractive because society can invest more in human capital when physical capital is destroyed by MDs. Human capital investment mainly includes investment in education, health, training, and labor force flow. Human capital investment can improve the abilities of workers to use new technologies and equipment, which can enhance the output efficiency of physical capital, and thus promote economic growth. In return, economic development can help workers gain a larger human capital investment and further promote the accumulation of human capital. Therefore, human capital and economic growth are inseparable.

We used the degree of education to measure human capital because education is one of the main ways to form human capital. Human capital is greater when the levels of education of individual workers are higher. According to the household production function model, birth rate is negatively related to economic development. Higher birth rates will increase the burden on society and family, and thus affect the education level (Guo [52]). The income level is also a key factor because income is the foundation of education investment. Lu *et al*. [61] have pointed out that low income will lead to credit constraints, which will further reduce education levels. We used education degree as the dependent variable and birth rate and income level as control variables to examine the relationship between human capital and NDs.

$$E_{it} = c_1 + c_2 MD_{it} + c_3 GD_{it} + c_4 B_{it} + c_5 \Delta IN_{it} + \varepsilon_{it}, \quad (i = 1, 2, \ldots, 30; t = 1, 2, \ldots) \tag{12}$$

where ΔIN_{it} is the income level (general budget revenue/GDP) at the first difference level in region (i) in period.

The results from GLS are shown in column 2 of Table 2. Two conclusions can be derived from the results. First, our empirical results confirm the finding of Skidmore and Toya [17] which holds that MDs promote investment in human capital. Second, GDs have no significant relationship with education level. These two conclusions suggest that MDs promote economic growth not through increasing physical capital investment, but by improving human capital, whereas GDs do not promote economic growth because these events neither increase physical capital investment nor improve human capital. One possible reason is the much smaller number of GDs recorded during the study period. Most GDs occurred in less developed western parts of China. In less developed regions, the post-disaster relief tends to focus more on "disaster recovery" (such as repairing the houses and making arrangement for the victims' life) than on "economic development" (such as large-scale construction of road, post-disaster migration, educational training and further improvement on the system of disaster prevention and reduction). Therefore, reliefs received after disasters may have only been used for short-term recovery instead of long-term development.

To further verify the robustness of the estimates, this paper has, based on the experience of Skidmore and Toya [17], conducted regression estimation after including five control variables in Equations (10) and (12), respectively. The five variables are listed below: (1) Control variable: population density. Disasters with the same extent differ from each other in damages. The higher the population density, the more serious the damages (Ma [62]). (2) Dummy variable: whether the province is along the Yangtze River Basin or the Yellow River Basin (yes = 1; no = 0). According to the data from EM-DAT between 1985 and 2011, flood is the most frequent and serious disaster both in the Yangtze River Basin and the Yellow River Basin (Hong [63]). (3) Dummy variable: whether the province is along coastal areas (yes = 1, no = 0). Compared with inland areas, the economy in coastal areas is more prosperous and the people here have a better educational background (Wei [64]). (4) Control variable: longitude and latitude. The frequency of disasters may also be partly determined by geographical factors (Skidmore and Toya [17]). As shown in Tables 3 and 4 after these five control variables are included, the degree of meteorological disasters MD and the degree of geological disasters GD in Equation (10) and Equation (12) remain the same. In addition, to reduce possible endogeneity of the disaster data with respect to economic performance (growth), according to Coffman and Noy(2011) [4], and Noy *et al*. (2007) [42], setting different lagged dependent variables will eliminate endogeneity of the disaster data with respect to economic performance (growth), and the econometric analysis carried out by us also shows that the results have no significantly changes.

Table 3. Per capita GDP growth rate and Disasters: Robustness Tests in the second period (1999–2011).

Variable	Per Capita GDP Growth Rate				
Degree of meteorological disasters *MD*	0.0000157 ** (0.0285)	0.0000173 ** (0.0196)	0.0000130 * (0.0780)	0.0000172 ** (0.0270)	0.0000174 ** (0.0161)
Degree of geological disasters *GD*	0.00000138 (0.23212)	0.00000130 (0.3529)	0.00000125 (0.3650)	0.00000141 (0.3121)	0.00000130 (0.2565)
Population density	–0.0000224 *** (0.0003)				
Coasts		–0.010654 * (0.0658)			
Rivers			0.016849 *** (0.0031)		
Latitude				0.000135 (0.7627)	
Longitude					–0.000548 * (0.0848)
Obs	360	360	360	360	360
R^2	0.298119	0.277010	0.287935	0.270151	0.275212

Note: The symbols *, **, and *** stand for 10%, 5%, and 1% significance, respectively. Other explanatory variables used in Table 1 are included but not reported here.

Table 4. Education degree and Disasters: Robustness Tests in the second period (1999–2011).

Variable	Education Degree				
Degree of meteorological disasters *MD*	0.000183 ** (0.046)	0.000177 * (0.0562)	0.000178 * (0.0534)	0.000183 ** (0.0481)	0.000177 * (0.0535)
Degree of geological disasters *GD*	–0.00000022 (0.8752)	–0.00017700 (0.732)	–0.00000056 (0.6868)	–0.00000058 (0.6754)	–0.00000034 (0.8092)
Population density	0.00128 *** (0.0016)				
Coasts		0.449103 * (0.0948)			
Rivers			–0.131637 (0.6421)		
Latitude				0.033031 (0.1438)	
Longitude					0.034393 (0.2207)
Obs	360	360	360	360	360
R^2	0.324237	0.240256	0.235699	0.239488	0.244169

Note: The symbols *, **, and *** stand for 10%, 5%, and 1% significance, respectively. Other explanatory variables used in Table 2 are included but not reported here.

To summarize, the regression analysis with the control variables reveals robust correlations between per capita GDP growth rate and disasters, and education degree and disasters. From another perspective, to check the robustness of our empirical findings and further explore the relationship between MDs and economic growth in the second period, we examined the causal relationship among variables using the Granger causality test. We used the Akaike Info Criterion (AIC) to determine the optimal lag. Table 5 shows the results of the Granger causality test.

Table 5. Granger test in the second period (1999–2011).

Null Hypothesis:	Lags	Obs	*F*-Statistic	Prob.	Result
Meteorological disasters are not Granger cause of GDP growth rate	6	210	2.46543	0.0254 **	Reject the null hypothesis
Education is not Granger cause of GDP growth rate	6	210	4.06220	0.0007 ***	Reject the null hypothesis
GDP growth rate is not Granger cause of Education			11.7246	0.0000 ***	Reject the null hypothesis
Meteorological disasters are not Granger cause of education	4	270	2.20990	0.0683 *	Reject the null hypothesis

Note: The symbols *, **, and *** stand for 10%, 5%, and 1% significance, respectively.

From the above, the results demonstrate that MDs influence education and GDP growth rate, and education level and GDP growth rate influence each other. These regression analyses confirm that MDs influence economic growth mainly through human capital investments.

4. Conclusions and Discussion

Using a novel synthesized disaster indicator and the panel data of 30 Chinese provinces, this paper examined the impacts of NDs on China's economic growth during two periods. The empirical results show that in the first period, neither MDs nor GDs have significant relationship with GDP growth rate. In the second period, MDs have a marginally positive and causal relationship with GDP growth rate through human capital investment rather than physical capital investment. GDs have no impact on GDP growth rate.

Why could MDs promote economic growth through the accumulation of human capital while GDs are not related to economic growth since 1999? There are two possible explanations. First, the Chinese government places an increasing emphasis on the physical infrastructure, laws and regulations and public education of disaster prevention and reduction since 1999. The comprehensive observation system with a combination of ground-based, air-based and space-based observation has been established, which has greatly improved the accuracy and quality of predication and forecast of MDs. Since 1999, the Chinese government has successively promulgated about 40 laws, regulations and emergency response plans, such as "Disasters Mitigation Plan of the People's Republic of China" (1998–2010), *etc.* (Zhang *et al.* [65]), and carried out multi-level education of disaster prevention and reduction in different units, schools and communities. The public awareness of disaster prevention and reduction has been enhanced unceasingly and the quality of human capital has been improved accordingly. Second, MDs often occurred in richer coastal areas where the ocean–atmosphere and land–atmosphere interactions are relatively intensive. When they occurred, local governments put great emphasis on the post-disaster construction of infrastructures, raising public awareness of disaster prevention and reduction, and improving human capital investment. All would promote long-term economic growth.

The current economic, social, and cultural situations of China may support speedy recovery after disasters through physical capital in the short term. However, accumulating human capital in the long term is the vital key to the adoption of new technology and improvement of productivity toward economic recovery and sustained economic development after disasters. The counterpart-support policies with Chinese characteristics can ensure the speed and scale of the reconstruction work after disasters. For example, 4121 counterpart-support projects from 19 provinces with RMB 84.38 billion financial support were implemented after the Wenchuan earthquake in 2008. The funds from counterpart-support together with central government funds were invested mainly in the physical capital, which promotes economic growth. Although the current system ensures a speedy recovery, we have found that maintaining long-term sustainable economic growth is a challenge. Thus, we propose that the local officials or decision makers should not only pay attention to the immediate recovery of the economy, but also to the improvement of the investments in human capital and the quality of human resources. Shang [66] has concluded that the lack of knowledge of farmers to counter drought following disasters increases the damage of drought. Zhao [67] has determined that the education levels of family members have a significant influence on the improvement of the economy after a disaster in the long term. Reducing the vulnerability of future disasters, human factor plays an essential role in the recovery and the long-term economic development after each natural disaster.

Three caveats need to be mentioned. First, the EM-DAT does not have complete economic damage data. Tremendous effort was exerted to calculate or estimate some of the missing data to carry out the study. Second, some EM-DAT data and economic statistics data have different scopes in relation to the spatial and temporal dimensions. The duration of most NDs, such as earthquakes, is short, while the time span of economic statistics data is long. Moreover, NDs often occur in one location, whereas the related reconstruction involves the support of other provinces. Crowding-out may occur. Therefore, obtaining the uniform standard data is difficult. Finally, death toll and economic losses are related to the income level. With advanced medical treatment, strict building laws, and other safety rules, the impact of NDs may be reduced in the developed regions. Thus, future research should search for a better indicator that can reflect both income levels and the actual level of disasters.

Acknowledgments: This research was supported by: The Natural Science Foundation of China (71373131, 71140014, 11371292, and 91546117); National Social and Scientific Fund Program (14BJY043 and 15BTJ019); National Soft Scientific Fund Program (2011GXQ4B025); National Industry-specific Topics (GYHY200806017 and GYHY201506051); Scientific Research Foundation for the Returned Overseas Chinese Scholars of MOE (No.2013-693, Ji Guo); and Tianjin Higher Education Innovation Team Program (TD12-5063). This research was also supported by the Priority Academic Program Development of Jiangsu Higher Education Institutions and the Flagship Major Development of Jiangsu Higher Education Institutions. Sincere thanks should be given to the editor, three anonymous reviewers and Yehua Dennis Wei for their constructive comments and suggestions that greatly helped to improve the quality of this article.

Author Contributions: Ji Guo and Xianhua Wu originated the study and led the writing of the article. Hui Liu and Jiong Gu collected data and conducted the qualitative analysis. Shunfeng Song and Yinshan Tang analyzed data and contributed to the writing of the article.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix

The data on the Wenchuan earthquake in EM-DAT are listed in Table A1.

Table A1. Decomposed damage results of Wenchuan earthquake on 12 May 2008.

Location	EM-DAT		Previous Literature (Yuan, 2008 [68])		Computed Value	
	Death Toll	Economic Losses (1000 US$)	Death Toll	Economic Losses (100,000,000 Yuan)	Death Toll	Economic Losses (1000 US$)
Sichuan(Chongqing)	87,476	850,000	68678	6231.52	86,854	765,512.0186
Gansu			365	442.8	462	54,395.83309
Shaanxi			122	228.14	154	28,025.89287
Yunnan			1	16.82	1	2066.255449
Shanxi			0	0	0	0
Guizhou			0	0	0	0
Hubei			1	0	1	0
Hunan			1	0	1	0
Henan			2	0	3	0

According to the data on the earthquake from relevant literature, the loss of each province is calculated through the following formula:

$$L_{cij} = \frac{L_{pij}}{\sum_{i=1}^{30} L_{pij}} \times L_{Ej}, (i = 1, 2, ..., 30; j = 1, 2) \quad (13)$$

where i refers to 30 different provinces; j refers to the death toll and economic loss; L_{cij} refers to the computed value of j of Province i; L_{pij} refers to the value of j of Province i retrieved from previous literature; and L_{Ej} refers to the total value of j of all provinces recorded in EM-DAT.

Table A2 contains all variables used in Equations (6)–(9).

Table A2. Unit root tests.

Variable	Test for unit root in	Method	in the First Period (1985–1998)		in the Second Period (1999–2011)	
			Statistic (Prob.)	Result	Statistic (Prob.)	Result
Per capita GDP growth rate G	Level	ADF-Choi Z-stat	−5.30819 (0.0000)	Smooth	−2.20509 (0.0000)	Smooth
Degree of natural disasters ND	Level	ADF-Choi Z-stat	−6.29742 (0.0000)	Smooth	–4.97697 (0.0000)	Smooth
Degree of meteorological disasters MD	Level	ADF-Choi Z-stat	−6.30789 (0.0000)	Smooth	−5.04097 (0.0008)	Smooth
Degree of geological disasters GD	Level	ADF-Choi Z-stat	−6.57734 (0.0000)	Smooth	−5.64198 (0.0000)	Smooth
Investment growth rate I	Level	PP-Choi Z-stat	−8.68497 (0.0000)	Smooth	−3.31127 (0.0005)	Smooth
Openness O	Level	ADF-Choi Z-stat	−4.35787 (0.0000)	Smooth	1.83879 (0.8520)	Rough
D (Openness) ΔO	1st Difference	ADF-Choi Z-stat			−6.81695 (0.0000)	Smooth
SOE S	Level	ADF-Choi Z-stat	−4.12426 (0.0000)	Smooth	−11.9920 (0.0000)	Smooth
Birth rate B	Level	ADF-Choi Z-stat	−4.19320 (0.0000)	Smooth	−2.15761 (0.0155)	Smooth
Income level IN	Level	ADF-Choi Z-stat		Smooth	9.89938 (1.0000)	Rough
D (Income level) ΔIN	1st Difference	ADF-Choi Z-stat		Smooth	–3.00439 (0.0013)	Smooth
Degree of education E	Level	PP-Choi Z-stat		Smooth	–5.32522 (0.0000)	Smooth

References and Notes

1. Benson, C.; Clay, E. *The Impact of Drought on Sub-Saharan African Economies: A Preliminary Examination, Geneva and New York*; World Bank Technical Paper; The World Bank: Washington, DC, USA, 1998.
2. Xiao, Y. Local economic impacts of natural disasters. *J. Reg. Sci.* **2011**, *51*, 804–820. [CrossRef]
3. Gall, M.; Borden, K.A.; Emrich, C.T.; Cutter, S.L. The unsustainable trend of natural hazard losses in the United States. *Sustainability* **2011**, *3*, 2157–2181. [CrossRef]
4. Coffman, M.; Noy, I. Hurricane Iniki: Measuring the long-term economic impact of a natural disaster using synthetic control. *Environ.Dev. Econ.* **2011**, *17*, 187–205. [CrossRef]
5. Okuyama, Y. Disaster and economic structural change: Case study on the 1995 Kobe earthquake. *Econ. Syst. Resear.* **2014**, *26*, 98–117. [CrossRef]
6. Dercon, S. Growth and shocks: Evidence from rural Ethiopia. *J. Dev. Econ.* **2004**, *74*, 309–329. [CrossRef]
7. Mechler, R.; Hochrainer, S.; Asjorn, A. A risk management approach for assessing adaptation to changing flood and drought risks in Europe. In *Making Climate Change Work for Us: European Perspectives on Adaptation and Mitigation Strategies*; Hulme, M., Neufeld, H., Eds.; Cambridge University Press: Cambridge, UK, 2009; pp. 200–229.
8. Raddatz, C. *The Wrath of God: Macroeconomic Costs of Natural Disasters*; World Bank Policy Research Working Paper No. 5039; Central Bank of Chile: Santiago, Chile; The World Bank: Washington, DC, USA, 2009.
9. Arndt, C.; Tarp, F.; Thurlow, J. The economic costs of climate change: A multi-sector impact assessment for Vietnam. *Sustainability* **2015**, *7*, 4131–4145. [CrossRef]

10. Arndt, C.; Asante, F.; Thurlow, J. Implications of climate change for Ghana's economy. *Sustainability* **2015**, *7*, 7214–7231. [CrossRef]
11. Porfiriev, B. Economic issues of disaster and disaster risk reduction policies: International *vs.* Russian perspectives. *Int. J. Disaster Risk Reduct.* **2012**, *1*, 55–61. [CrossRef]
12. Hallegatte, S.; Dumas, P. Can natural disasters have positive consequences? Investigating the role of embodied technical change. *Ecol. Econ.* **2009**, *68*, 777–786.
13. Gassebner, M.; Keck, A.; Shaken, R. Not stirred: The impact of disasters on international trade. *Rev. Int. Econ.* **2010**, *18*, 351–368. [CrossRef]
14. Strobl, E. The economic growth impact of natural disasters in developing countries: Evidence from hurricane strikes in the central American and Caribbean regions. *J. Dev. Econ.* **2012**, *97*, 130–141. [CrossRef]
15. Rodriguez-Oreggia, E.; de la Fuente, A.; de la Torre, R.; Moreno, H.A. Natural disasters, human development and poverty at the municipal level in Mexico. *J. Dev. Studies* **2013**, *3*, 442–455. [CrossRef]
16. Cuaresma, J.C.; Hlouskova, J.; Obersteiner, M. Natural disasters as creative destruction? *Evidence from developing countries. Econ. Inquiry* **2008**, *46*, 214–226.
17. Skidmore, M.; Toya, H. Do natural disasters promote long-run growth? *Econ. Inquiry* **2002**, *40*, 664–687. [CrossRef]
18. Albala-Bertrand, J.M. *Political Economy of Large Natural Disasters: With Special Reference to Developing Countries*; Oxford University Press: Oxford, UK, 1993.
19. Albala-Bertrand, J.M. *Disasters and the Networked Economy*; Routledge: Oxford, UK, 2013.
20. Dacy, D.C.; Kunreuther, H. *The Economics of Natural Disasters-Implications for Federal Policy*; The Free Press: New York, NY, USA, 1969.
21. Otero, R.; Marti, R. The impacts of natural disasters on national economies and the implications for the international development and disaster community. In *Disaster Prevention for Sustainable Development: Economic and Policy Issues*; Munasinghe, M., Clarke, C., Eds.; The International Bank for Reconstruction and Development: Geneva, Switzerland; The World Bank: Washington, DC, USA, 1995; pp. 11–40.
22. Tol, R.; Leek, F. Economic analysis of natural disasters. In *Climate, Change and Risk*; Downing, T.E., Olsthoorn, A.J., Tol, R.S., Eds.; Routledge: London, UK, 1999.
23. Wang, Y.M.; Chen, M.L.; Wang, X. The impacts of natural disasters on long-term growth: Theoretical and empirical study. *Econ. Manage.* **2008**, *19*, 144–150.
24. Kim, C. The effects of natural disasters on long-run economic growth. *Michi. J. Bus.* **2010**, *41*, 15–49.
25. Bradley, T.E.; Jamie, B.K.; Mark, A.T. Twister! Employment responses to the 3 May 1999 Oklahoma city tornado. *Appl. Econ.* **2009**, *41*, 691–702.
26. Lucas, R. On the mechanics of economic development. *J. Monetary Econ.* **1988**, *22*, 3–42. [CrossRef]
27. Okuyama, Y. Economics of natural disasters: A critical review. *Resear. Paper* **2003**, *12*, 20–22.
28. Okuyama, Y.; Hewings, G.J.D.; Sonis, M. Measuring economic impacts of disasters: Interregional input-output analysis using sequential interindustry model. In *Modeling the Spatial and Economic Impacts of Disasters*; Okuyama, Y., Chang, S.E., Eds.; Springer: New York, NY, USA, 2004; pp. 77–101.
29. Horwich, G. Economic lessons of the Kobe earthquake. *Econ. Dev. Cult. Change* **2000**, *48*, 521–542. [CrossRef]
30. Zou, X.H. Research on the Influence of Natural Disasters on Economic Growth in China. Master's Thesis, University of Xiamen, Xiamen, China, 2009.
31. Leiter, A.M.; Oberhofer, H.; Raschky, P.A. Creative disasters? Flooding effects on capital, labor and productivity within European firms. *Environ. Resour. Econ.* **2009**, *43*, 333–350. [CrossRef]
32. Loayza, V.N.; Olaberria, E.; Rigolini, J. Natural disasters and growth: Going beyond the averages. *World Dev.* **2012**, *40*, 1317–1336. [CrossRef]
33. Shabnam, N. Natural disasters and economic growth: A review. *Int. J. Disaster Risk Sci.* **2014**, *5*, 157–163. [CrossRef]
34. Guha-Sapir, D.; Below, R. *The Quality and Accuracy of Disaster Data: A Comparative Analyses of Three Global Data Sets, Technical Document*; The ProVention Consortium: Geneva, Switzerland; Disaster Management Facility: Washongton, DC, USA; The World Bank: Washongton, DC, USA; WHO Centre for Research on the Epidemiology of Disasters: Brussels, Belgium; University of Louvain School of Medicine: Brussels, Belgium, 2002.
35. Wen, K.G. *China Meteorological Disasters Book*, 1st ed.; China Meteorological Press: Beijing, China, 2008.

36. Disaster Information Department of China national Disaster Reduction Center. *The National Disaster Monthly Report 2008–2011*; China Disaster Reduction: Beijing, China, 2008–2011.
37. The State Flood Control and Drought Relief Headquarters Office. *The National Flood Disasters 2001–2011*; China Flood Control and Drought Relief: Beijing, China, 2001–2011.
38. China's National Bureau of Statistics. *China Statistical Yearbook 1986–2012*; China Statistics Press: Beijing, China, 1986–2012.
39. The National Economy Comprehensive Statistics Division of The National Bureau of Statistics. *China Compendium of Statistics 1949–2008*; China Statistics Press: Beijing, China, 2009.
40. Kellenberg, D.K.; Mobarak, A.M. Does rising income increase or decrease damage risk from natural disasters? *J. Urban Econ.* **2008**, *63*, 788–802. [CrossRef]
41. Li, H. An empirical study on relationship between natural disasters and economic growth—based on the 14 countries panel data in 1970–2008. *Prices Mon.* **2011**, *1*, 47–51.
42. Noy, I.; Nualsri, A. *What do Exogenous Shocks Tell Us about Growth Theories*; SCCIE Working Paper Series; Santa Cruz Center for International Economics: Santa Cruz, CA, USA, 2007.
43. Zhao, A.X.; Ma, Z.J. Appraising study for the loss evaluation system of natural disasters. *J. Nat. Disasters* **1993**, *3*, 1–7.
44. Tang, W.B.; Han, Z.J. A comprehensive evaluation method of financial position based on information entropy. *J. Nanjing Univ. Sci. Tech.* **2001**, *25*, 650–653.
45. Zhang, S.; Zhang, M.; Chi, G.T. The science and technology evaluation model based on entropy weight and empirical research during the 10th Five-Year of China. *Chinese J. Manag.* **2010**, *7*, 34–42.
46. Burg, J.P. Maximum Entropy Analysis. Ph.D. Thesis, Stanford University, Stanford, CA, USA, 1975.
47. Darbellay, G.A.; Wuertz, D. The entropy as a tool for analysing statistical dependences in financial time series. *Phys. A: Sta. Mech. Its Appl.* **2000**, *287*, 429–439. [CrossRef]
48. Li, L.; Liu, F.; Li, C. Customer satisfaction evaluation method for customized product development using entropy weight and analytic hierarchy process original research article. *Comput. Ind. Eng.* **2014**, *77*, 80–87. [CrossRef]
49. Kunreuther, H.; Kleffner, A. E. Should earthquake mitigation measures be voluntary or required? *J. Regul. Econ.* **1992**, *4*, 321–333. [CrossRef]
50. Wisner, B. Risk and the neoliberal state: Why post-mitch lessons didn't reduce EI Salvador's earthquake losses. *Disaster* **2001**, *25*, 251–268. [CrossRef]
51. Jiang, J.W. Disaster Relief and Reduction Work in China since 1978. Ph.D. Thesis, Central Party School of China, Beijing, China, 2009.
52. Guo, J. Human capital, the birth rate and the narrowing of the urban-rural income gap. *Soc. Sci. China* **2005**, *3*, 27–38.
53. Liu, R.M.; Shi, L. The dual efficiency loss of state-owned enterprises and economic growth. *Econ. Resear. J.* **2010**, *1*, 127–137.
54. Barro, R.; Lee, J. *Data Set for a Panel of 138 Countries*; Harvard University: Cambridge, MA, USA, 1994.
55. Lin, Y.F.; Li, Z.Y. Policy burden, moral hazard and soft budget constraint. *Econ. Resear. J.* **2004**, *2*, 17–27.
56. Kornai, J. *Economics of Shortage*; North-Holland: Amsterdam, The Netherlands, 1980.
57. Becker, G.S.; Barro, R.J. A reformulation of the economic theory of fertility. *Quart. J. Econ.* **1988**, *103*, 1–25. [CrossRef]
58. Notice by the PRC State Council on "Disasters Mitigation Plan of the People's Republic of China (1998–2010)". The State Council Bulletin of the People's Republic of China, 1998, 12, 526–539.
59. Earthquake Disaster Mitigation Law of the People's Republic of China. The State Council Bulletin of the People's Republic of China, 1997, 39, 1680–1688.
60. National Disaster Relief Emergency Plan. China Flood Control and Drought Relief, 2006, 01, 29–34.
61. Lu, M.; Chen, Z.; Wan, G. Equality for the sake of growth: The nexus of inequality, investment, education and growth in China. *Econ. Resear. J.* **2005**, *12*, 4–14.
62. Gao, W.X.; Gao, Q.H.; Ma, Z.J. Mitigating natural disasters will be an industries to develop in the 21st century. *Optim. Cap. Constr.* **1998**, *19*, 5–7.
63. Hong, W.T. Study on flood Disasters Risk Management System in China. Master's Thesis, Wuhan University, Wuhan, China, 2012.

64. Wei, Q.; Wang, A.; Wang, J. The Rise of China's coastal areas: Power of market. *Econ. Resear.* **2014**, *8*, 170–183.
65. Zhang, P.; Li, N.; Fan, B.H.; Liu, X.Q.; Wen, Y.T. The evolution of quantity and enact time of Disaster laws and Regulations in Recent 30 years in China. *Disaster* **2011**, *3*, 109–114.
66. Shang, Y.R. The analysis of drought, agricultural drought disaster and the farmhouses' vulnerability: Taking the typical farmhouse of Xingtai county as an example. *J. Nat. Disasters* **2000**, *9*, 55–61.
67. Zhao, Y.D. Social capital and post-disaster recovery: A sociological study of natural disaster. *Soc. Studies* **2007**, *5*, 164–187.
68. Yuan, F. Loss assessment of Wenchuan earthquake. *J. Earthq. Eng. Eng. Vib.* **2008**, *5*, 10–19.