Chapter 3

Is there rural-to-urban migration following a sudden natural hazard ? A Case Study on Wenchuan earthquake using Synthetic Control Method

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Abstract

This paper uses Wenchuan earthquake as a natural experiment for investigating the impact of sudden natural hazards on rural-to-urban migration pattern, within a Chinese province. Since migration is rather temporary following rapid-onset events and precise data are needed, I use satellite data capturing annual light density at night to proxy rural-to-urban migration. Using the Synthetic Control Method, the results show that rural-to-urban migration decreases following the shock. Inhabitants of affected areas fall into a poverty trap after the earthquake, because of the loss of their income source, that prevents them from migrating to more prosperous cities. It is consistent with the great migratory restrictions in China due to institutional constraints. I also find that the natural disaster does not affect permanently migration behaviors, since the rural-to-urban migration trend goes back to normal three years after the shock.

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1 Introduction

When facing natural hazards, people have three possible adaptation strategies: either they stay put, waiting for the disaster to end, accepting related costs; they stay put but have risk mitigation strategies that lower the costs; or they flee from the devastated areas, that is to say, home. Their choice depends on their ability to mitigate the costs but also to migrate. In the literature, developed countries have better mitigation abilities thanks to technological progress. At the opposite, developing countries are less likely to mitigate the risk because they often lack of wealth or technological skills (Reuveny, 2007). With close to three natural disasters per month in average between 2000 and 2016, China multiplies climate-related risks[1]. Chinese inhabitants may have recourse to migration to adapt to natural hazards and secure their income in the sort-run. The purpose of this paper is to look for any migratory response following a destructive natural event, in China.

To best visualize the potential of migration as a coping strategy against natural hazards, this study focuses on the most destructive disaster since 1976, Wenchuan earthquake. On May 12, 2008, a 8.0 magnitude earthquake occurs at the center of Sichuan province, 80 kilometers away from the provincial capital Chengdu. It is the deadliest earthquake that hits China, since the 1976-one in Hebei, that killed over 240,000 persons, and the strongest since 1950-earthquake that stroke Tibet with a 8.5 magnitude [2]. Fifteen million persons lived in the affected area, and approximately one third were left homeless after the earthquake. Indeed, sudden natural disasters, as this one, turn a livable place into an unfit one for human habitation, for a finite length of time [3](Bates, 2002; Black et al., 2011). It took over three years to rebuild areas destroyed by the earthquake. Then, Wenchuan earthquake is de facto responsible for forced movement. The discussion focuses on whether this movement is temporary or permanent.

For migration to become permanent, the implicit assumption is that natural disasters impact households income. An extensive literature exists on the impact of natural disasters on economic proxies. As summarized by several meta-analysis, a consensus holds on the negative impact of natural disasters on GDP per capita in the short-run (Lazzaroni and van Bergeijk, 2014; Klomp

[1] Calculated using Emergency Events Database (EM-DAT) thoroughly discussed in Section 3 and 4.
[2] From EM-DAT (2018) listing.
[3] Are also part of that list all sudden-onset disasters such as floods, volcanic eruptions, earthquakes, tornadoes, wildfires, tsunamis (Bates, 2002).

and Valckx, 2014). Indeed, a sudden natural disaster implies great losses in terms of infrastructure, economic activities and therefore reduces if not cuts out sources of income for inhabitants. Economic factors being predominant in the decision-making to migrate, sudden natural disasters could impact migration through the decline of household income. Two types of migratory response are possible: either this loss of earnings is an additional incentive to migrate-out and becomes the final push for rural workers to try their luck in prosperous cities (1) ; or that loss of earnings is a final push for the farmer toward the poverty trap, restraining their liquidity in the short-run and hindering out-migration (2). In the former case, migration becomes an adaptation strategy to maintain the household income. In the second scenario, migration is made impossible because of lack of finances following the natural shock. Developing countries, by being more economically fragile, can either be more favorable to migratory response, since they have fewer mitigation systems to prevent the natural hazards to cause tremendous economic costs (Reuveny, 2007). Or developing countries can also be an opportune environment for natural disasters to push people toward poverty traps. Felbermayr and Gröschl (2014) find the poorer the country, the larger the negative impact of natural hazards is on per capita GDP.

To estimate if migration is a coping strategy in China, I aim at assessing the impact of Wenchuan earthquake on rural-to-urban migration within Sichuan province. To tackle this topic, two issues were raised. First, looking into migration implies the use of precise data, especially when trying to capture temporary migration. Census data have large time intervals that do not suit the search for temporary movement. Going through the literature for creative solutions, I decide to use annual density of nighttime lightening to proxy city sizes. If the density increases over time, it means that the lighter the cities get, the more illuminated houses there are, the more inhabitants there are. Second, it is difficult to isolate the impact of a natural disaster alone on migration patterns. To do so, I match Sichuan province with a counterfactual built using the Synthetic Control Method (SCM). It enables me to create a virtual counterfactual that has similar migration patterns pre-shock. Therefore, the differences post-shock can be interpreted as due to the earthquake. Also, in this paper, I focus on intra-province migration based on the literature. After sudden natural shocks, migration is rather short-distanced, people move within their state if not county (Smith and McCarty, 1996; Smith et al., 2006; Black et al., 2011). . In China's case particularly, between 75 to 78% of migration is intra-provincial anyway (Wang et al., 2003; Zhao, 2005). So the scale of the study fits Chinese migratory history.

In a nutshell, this paper provides evidence of small negative effects of the Wenchuan earthquake on rural-to-urban migration. Indeed, even though I manage to isolate the impact of the earthquake on the light density, the effect is short-lasting. In 2011, three years after the shock, the effects on migration are null. Thus, a rapid-onset natural disaster has no permanent impact on migration patterns. This result is consistent with Chinese migratory context. Indeed, strong institutional constraints restrict migration to cities or toward other provinces. These constraints and their impact will be thoroughly discussed in the next section.

The rest of the paper is organized as follows. Section 2 details the state of knowledge on migration after natural shocks along with some literature on Chinese particular features in terms of migration. In section 3, I present all the variables used in this paper and defend the use of a satellite variable as the outcome. Section 4 describes the empirical strategy to isolate the effect of the shock on migration patterns. Section 5 shows the main results that came out of this study, to later leads to further discussion in Section 6.

2 A fragile link between natural disasters and migration

2.1 State of knowledge

No clear consensus arise from the literature when investigating the impact of a sudden natural disaster on migration[4]. Some papers do find a higher rate of out-migration from the damaged area, following an earthquake. Bohra-Mishra et al. (2014) investigate the effects of both weather variations and sudden natural disasters on migration using a household panel data from Indonesia. They follow 7,185 households over 15 years and find that although weather variations do affect permanently migration, natural disasters like earthquakes have small if not nonexistent impact. At

[4]This case study focuses on earthquake impact on migration. These case studies being not so frequent in the literature, I might refer to other analysis focusing on other types of natural shocks. Natural disasters with a sudden onset (such as tropical cyclones, earthquakes, etc.) are comparable since they have similar patterns in terms of destruction and can trigger similar responses from the population. I will therefore quote papers on tornadoes and hurricanes along with the earthquakes ones.

the opposite, some studies provide empirical proof of the absence of any effect of natural disasters on migration. For instance, Paul (2005) analyzes out-migration following the 2004-tornado in Bangladesh. He used survey data, with 291 respondents from eight different villages affected by the tornado. The results suggest that no one from these areas migrated to other places. Reasons for this outcome would be the constant aid flow from both the government and non-governmental organizations. Therefore, the victims chose not to leave their homes. Logan et al. (2016) results also go toward this direction. They study the impact of hurricanes on population change in the affected areas between 1970 and 2005 in the U.S. Gulf Coast region. They find that even though population growth is indeed significantly reduced three years after the shock, especially in areas where the damages where the greatest, this conclusion does not hold for all groups of individuals. There is evidence of a resilience effect for some layers of the population. The most advantaged groups of population are more likely to out-migrate from the affected areas, whereas more socially vulnerable groups have fewer options to cope with the disaster. They are trapped and have to stay put because of lack of financial means.

In many cases, authors isolate economic forces as the transmission channel between disaster shocks and migratory decision. Indeed, the migration response following a natural event depends on whether the income source has been affected or not. For instance, comparing 2004-hurricanes and Katrina, Smith and McCarty (1996); Smith et al. (2006) find that Katrina created more permanent migration than the 2004-hurricanes that occurred in Florida, USA. The rationale for this finding is that Katrina was far more damaging economically than the 2004-hurricanes. It implied more job losses and therefore, more motivation to migrate[5]. Differently, looking at a tropical cyclone in Dominican Republic in 1979, Belcher and Bates (1983) question households on their intention to migrate in a survey. People do not necessary migrate if the tremendous damages strike their community, but do migrate if the annual harvest has been destroyed. The ones who intended to stay put, despite the disaster, also grow crops that can be harvest several times a year. Hence, this category of people did not entirely lose their source of income because of the disaster.

From the literature, I also learn that data precision is crucial to arrive to concrete conclusions.

[5]For both events, it is important to note that when they moved, it mostly remained temporary and within a short-distance (within the same state if not county). It is an extra motivation for looking at intra-provincial migration in Chinese case.

In that matter, most studies used survey data to tackle the effects of natural disasters on migration. Others used less precise and frequent data such as census ones, which made it difficult to draw any conclusion. It is the case for Boustan et al. (2012), who used 1920s and 1930s US census data to look at the population response to hurricanes, earthquakes, floods and tornadoes. Even thought they find that tornadoes trigger out-migration from young men, no conclusion can be made concerning earthquakes given their rarity in between the census periods. In his book, to reach a conclusion, Burton (1993) focuses on two major earthquakes in Central America (in Managua, Nicaragua, 1972) and uses a population census two years after the shock to seize how many displaced people went back home. There were 420,000 inhabitants in Managua before the earthquake, in 1972. Half of that amount were displaced because of destroyed infrastructures. In 1974, Managua population had grown to 650,000. Therefore, Burton (1993) considers that most of the initially displaced population came back home. Still, with census data, the author can reach an intuitive conclusion but no causal effect can be approached. As a creative solution when the author has no access to rigorous datasets, Klomp (2016) uses satellite data and more precisely nighttime light intensity to assess the impact of natural disasters on multiple countries. This cross-country analysis emphasizes negative impact of natural disasters on light density in the short-run, to later on have no effect at all on the outcome.

2.2 The special case of China

China is a particular country to study when talking about migration.

First, migration in China is mostly a rural-to-urban movement. According to the National Bureau of Statistics in China (NBSC), China's urbanization has grown from 19.4% to 52.6% between 1980 and 2012. Rural-to-urban migration alone is responsible for 75% of the urban growth from 1978 until 1999 (Zhang and Shunfeng, 2003). Part of the explanation is the large income difference between rural areas and urban ones. As Ngai et al. (2016) investigate, migration in China is mostly migration out of agriculture because of the wide productivity gap between urban and rural employment, which, down the road, leads to huge difference of revenues. Indeed, in 1980, rural income was in average only 45% of urban income, according to NBSC data. In 2015, despite greater labor mobility which should promote relative productivity between both types of job, rural income only equals to 37% of the urban revenue. Therefore, migrants keep shifting from off-farm work within rural areas to engage in temporary low-qualified urban jobs such as street cleaning, retail services, housekeeping services and construction (Chan and Zhang, 1999). Another line of explanation for the migration to be largely from rural-to-urban in China, is the uneven provision of infrastructure. Due to preferential policies from both local and central governments (Zhang and Zou, 2012), rural areas benefit from a poor network of infrastructure (Liu et al., 2009). It goes from the access to secondary or higher education institutions in rural areas (Banerjee et al., 2012), to the access to credit (Yuan and Xu, 2015), to road network and access to electricity (Shenggen and Zhang, 2004) and to access to health facilities (Gong et al., 2012). Many papers document the widening gap in health status between urban and rural dwellers in China (Shen et al., 1996; Yan-Ping et al., 2009; Liu et al., 1999; Luo et al., 2009). According to the 2011 Edition of the Chinese Health Statistical Digest, as a consequence of uneven healthcare availability, neonatal mortality, infant mortality and the mortality of children older than than 5 years old are greater in rural areas compared to urban ones (respectively 10% vs 4%; 16% vs 6%; 20% vs 7%). Therefore, incentives to migrate to cities are high when willing to pursue higher education, access to health facilities or reach a greater standard of living. In addition, the land tenure system remains highly informal in China, increasing the cost of migration for anyone willing to migrate to rural areas. Land allocation in rural areas being discretionary (Rozelle and Li, 1998), obtaining land-use rights for a migrant remains quite uncertain. Also, overtime, lands are used as a source of municipal revenue. For this reason, they are sold to entrepreneurs by local governments (Lichtenberg and Ding, 2009). Added with the increasing degradation of soil quality (Reuveny and Moore, 2009), it results in a shortage of farmland. As discussed by Zhao (1999), it is the major reason for labor migration out of rural areas and further reasons why migration to rural areas is unlikely in China.

Second main pattern of Chinese migration, migration rates remain quite low in China due to institutional obstacles. The biggest of all is the *Hukou* system. It is a Household Registration System where the residence status depends on the place of birth. For instance, when migrating in a different administrative region, Chinese citizens lose access to many services such as the official housing market, educational structure, medical care, some public subsidies and so on (Wang, 2004). This residence permit (the *Hukou*) is delivered by the police and can change over time. Yet, converting a *Hukou* from a rural to an urban one is difficult, and it is even truer when targeting a large city. With this system, the central government prevents mass migration, but also hinders a rural dweller to seek for a better-paid job by legally moving to neighboring urban areas. This system keeps being reformed and softened since 1970, but remains a major obstacle for permanent migration in China. Another major institutional barrier for migration would be the Chinese tenure system. Indeed, in China, private property is not widespread. Farmers families have a right to use the land, but do not own it. Therefore, it raises two types of concerns when willing to migrate. First, people out-migrating from rural areas can have their land-use rights seized in their absence, without any compensation Mullan et al. (2011). If not loosing the land, migration could result in a redistribution of part of the household land, because the size of their household got smaller, so redistribution of some hectares could be enforced to preserve "egalitarian land holdings" (Rozelle and Li, 1998). Second, with such insecure land tenure system, the land rental market is still very limited. Though, renting the left-behind farm usually represents a great way to offset the loss of the agricultural income. The inability to rent the land here, further increases the opportunity cost of leaving the farm (Hu et al., 2011). In a word, the uncertainties around the land tenure system in China skyrocket the cost of migration out of rural areas. Therefore, it comes as no surprise that economists prove that land rights insecurity not only constrain migration but also shortens out-migration duration for rural dwellers, in China (Yang, 1997; Zhao, 1999; Oi, 1999; De La Rupelle et al., 2009; Mullan et al., 2011) In a word, migration in China is circular *i.e.* it is a temporary movement rather than a permanent settlement (Zhao, 1999).

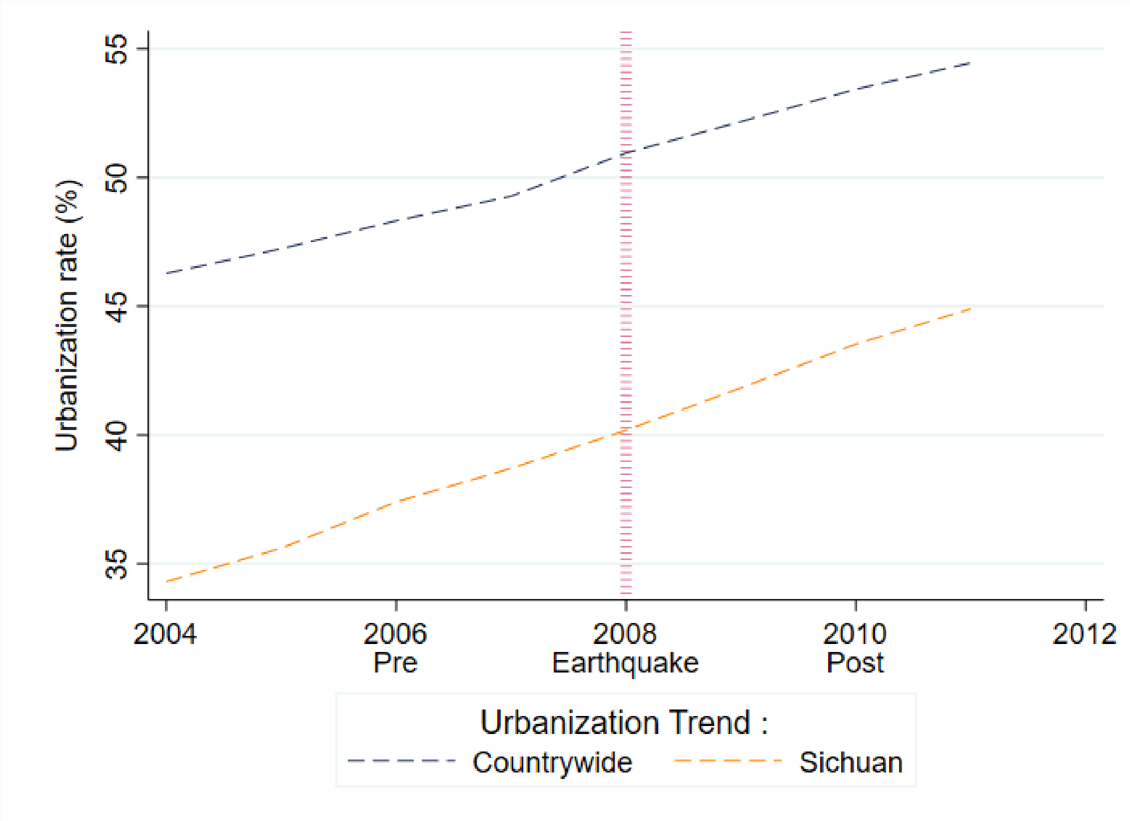
3 Data and stylized facts

3.1 Nighttime Lights (NTL)

In this subsection, I describe the outcome variable and defend its use as a proxy for urbanization.

To assess the impact of a shock on urbanization, I need data available on a high frequency basis. The NBSC provides annual data on urban and total population, making it possible to compute an annual urban ratio. But as depicted in Figure 1, these data are calculated using linear interpolation, based on much less frequent census data. This calculation technique leaves no possibility to catch any variation in migration following a shock. Further more, due to institutional constraints explained above, migration is rather temporary in China (Zhao, 1999). To capture any migration movement, sensitive and frequent data are needed. The urban ratio as collected by the NBSC is not suitable for this study.

Figure 1: The Urbanization rate over time as defined by the NBSC in Sichuan and China



Notes: The *Urban rate* is the ratio of urban dwellers in the total population. This data is collected by the National Bureau of Statistics of China from census data.

In this context, I use a measure of light intensity at nighttime to monitor the variation in city size. This measure captures outdoor but also indoor light[6]. It is made available in the DMSP-OLS Nighttime Lights Time Series (Version 4) by the National Oceanic and Atmospheric Administration (NOAA). This dataset, composed of 30x30 arc-second grids, covers -180 to 180 degrees in longitude

[6]Cloud-free imagery is used, so that a thick smog in big cities would have no impact on the intensity of the light captured.

and -65 to 75 degrees in latitude worldwide. Data is available annually from 1992 and up to 2013. Here, I use an aggregated version of this data at the province level. Therefore, in a province, the nighttime light intensity is an integer varying from 0 (no light) to 63 (in dense areas). Even though NTL seem more reliable than the statistical definition of urbanization provided by the NBSC, it remains a highly controversial indicator. Some concerns need to be accounted for before pursuing this paper.

First, the NTL are not a perfectly accurate representation of the amount of light emitted by the city (called true radiance). Indeed, the light sensor saturates when it reaches 63. One can not observe the growth of a large city, that already reached 63, but keeps expanding. For this reason, it is challenging to monitor very big cities, such as some Chinese ones. Also, the city size can be overestimated due to blooming. To be precise, the light can be magnified around certain type of terrain such as water or snow cover. The light would reflect on water, and bright lighter than the same amount of light nearby another type of terrain. Yet, with aggregated data at provincial level, the light sensor never approaches saturation (see the summary statistics in Table 2 for information on the maximum value of NTL in the sample). To make sure there is no saturation issue in the sample, I run the synthetic control without the provinces owing big saturated cities *i.e.* Shanghai, Beijing, Chongqing, Guangdong, the results remain unchanged. The chances that over-glowing affect my results are low.

Second source of concern, the NTL, here used as a proxy for urbanization, have been widely used in the literature as a measure for economic activity (Henderson et al., 2012). Looking at the data, NTL are more correlated to the urban share that it is to GDP (see Table 1), which make NTL a more suitable proxy for urbanization than economic activity in China's case. Looking at the literature, NTL are also considered as a convincing proxy for city size. Zhang and Seto (2013) compare Google Earth images with NTL data and find NTL reliable to proxy city size. More precisely, "where urbanization occurred, NTL have a high accuracy (93%) of characterizing these changes". Also, NTL are more accurate in predicting expansion for urban and peri-urban areas, because they are characterized by a great density of lights. Monitoring the growth of poorly lit areas such as countryside, with NTL variations, is not relevant. At the opposite, in China, migrants go from rural areas to urban and already densely lit areas. In this context, NTL are a good fit to proxy rural-urban migration.

Table 1: Comparaison of correlation rates between urban and economic proxies

Variables	*NTL*	*Urb. rate*	*Urb. pop.*	*Rural pop.*	*GDP*	*GDP Prim.*	*GDP Sec.*
NTL	1.00						
Urban rate	**0.81***	1.00					
Urban pop.	0.23*	0.23*	1.00				
Rural pop.	-0.18*	-0.34*	0.73*	1.00			
GDP	**0.38***	0.37*	0.92*	0.52*	1.00		
GDP Prim.	-0.07*	-0.11*	0.80*	0.84*	0.75*	1.00	
GDP Second.	0.33*	0.30*	0.91*	0.55*	0.99*	0.78*	1.00

Notes: *NTL* is the Nighttime Lights variable, used as a proxy to assess city size in China. The *Urban rate* is the ratio of urban dwellers in the total population. GDP is the gross domestic product. *GDP Prim.* and *Second.* are respectively the GDP of the primary and secondary sectors. The GDPs are expressed in 100 million of yuan. See further detailed definition of the variables in Table 6 in Appendix.

As also conclude Xu et al. (2014), NTL might be an imperfect measure of urbanization, but it still is a convincing indicator to watch urban growth over time.

3.2 Descriptive statistics

Table 2 shows the variables used to obtain a close match between Sichuan and its counterfactual. To get a clear image of the data used in this paper, besides the basic descriptive statistics included in Table 2, detailed definitions of the variables are presented in Table 5 in Appendix.

Studying thoroughly the data, NTL did decrease in Sichuan, following the 8.0 magnitude earthquake. As depicted in Figure 2, NTL decline between 2008 and 2009. This decline in NTL is not a countrywide tendency [7]. It is not even a tendency among the provinces significantly affected by the earthquake, let alone Sichuan. On Figure 3, are painted in red all the provinces affected by the earthquake[8]. They could experience significant variations of their NTL in 2009. Though, they do not suffer from drastic declines in NTL trends and seem less affected than Sichuan. As the

[7] Only two other provinces had decreasing NTL between 2008 and 2009, one of them -Henan- being considered as severely impacted by the earthquake according to EM-DAT database, and therefore, is not used to build Sichuan counterfactual. The other province, Hebei, has not been considered as significantly affected by Wenchuan earthquake according to the Emergency Events Database (EM-DAT). So it is part of the provinces usable to construct Sichuan counterfactual. Nevertheless, the SCM did not select this province to build Sichuan counterfactual, given that they do not have enough similarities (the province has no weight in the donor pool).

[8] Are considered as significantly affected by the earthquake, all the provinces that suffered economic damage or human fatalities following the disaster. Such a list is available in the EM-DAT database.

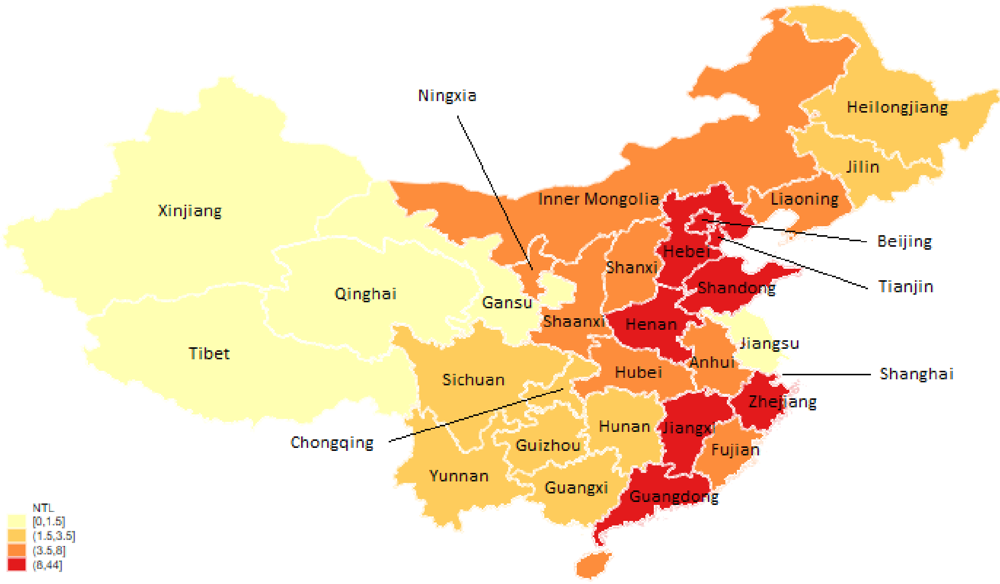
Table 2: Summary statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
NTL	6.53	8.60	0.02	45.98
Birth rate	11.39	2.80	5.71	17.94
GDP per capita	24760.40	16410.35	4317	85213
Educational Achievement	99.15	2.60	88.90	108.70
Transport	242.46	190.62	0.20	784.59

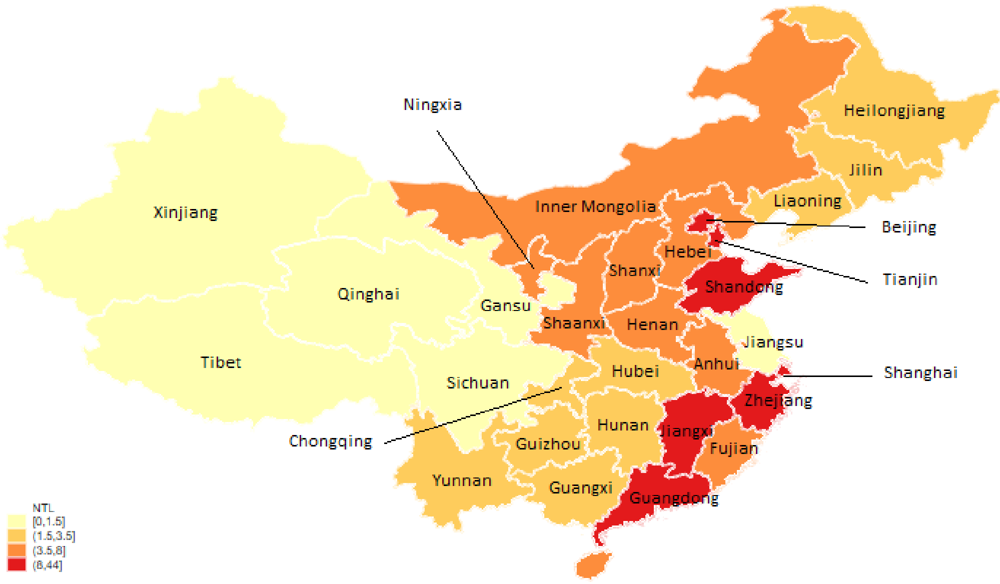
Notes: *NTL* refers to Nighttime lights within a province. The nighttime light intensity in each province is represented by an integer varying from 0 (no light) to 63 (dense and therefore bright areas). The *Death Rate* is the ratio of the number of deaths to the average population in a year. The *GDP per capita* is expressed in yuan per person. The proxy for *Educational Achievement* refers to the percentage of graduates of primary schools that actually enter to secondary schools. The *Transport* proxy equals to the volume of passengers transported by the railway system every year. It is expressed per 100 million passengers.

epicenter of the earthquake, Sichuan stands out as an exception. This study aims at thoroughly investigating the impact of Wenchuan earthquake on internal migration in Sichuan.

Figure 2: Trends in Nighttime Ligths countrywide



(a) 2008



(b) 2009

Note: The legend has been computed by Stata using NTL quantiles in 2009. Source: Author's elaboration on NOAA data.

4 Empirical strategy

In this section, I intend to assess the impact of a natural disaster on urbanization in China. To do so, I use the SCM to select a group of provinces that have the same NTL trend, and therefore, would have the same behavior in the absence of any natural disaster. I will refer to this group of provinces as the donor pool or control group. From this group of provinces, I can build a convincing counterfactual, and, down the road, assess the impact on Sichuan rural-to-urban migration, actually due to Wenchuan earthquake. Therefore, I refer to Sichuan as the treated province, the treatment being the earthquake that occurred in the province. To apply the SCM, I process in three steps. First, I select the Chinese provinces suitable for the donor pool. Indeed, to be part of the donor pool, the provinces must not be impacted by the same treatment than Sichuan that is to say, by the earthquake. Second, I compute the synthetic control group i.e. the weighted average of provinces that will represent Sichuan counterfactual. With a data-driven method, I build a virtual province that closely matches Sichuan NTL trends in the pretreatment period that is to say, right before Wenchuan earthquake in 2008. Lastly, I compare Sichuan NTL trends with those of Sichuan counterfactual, in the post-treatment period *i.e.* fom 2009 to 2012. Comparing the counterfactual with the observed NTL integer in Sichuan, after 2008, offers an estimation of the treatment effect. Below, I describe in details how I carry out theses steps.

First, to create a virtual Sichuan that suffer from no treatment effect, I compile a group of Chinese provinces that are not significantly affected by Wenchuan earthquake. I use the Emergency Events Database (EM-DAT) to exclude from the donor pool all the provinces affected by the earthquake. The EM-DAT database lists worldwide natural disasters and their human and economic impacts, provided by the Centre for Research on the Epidemiology of Disasters (CRED) and the Catholic University of Louvain. The provinces considered as affected by the earthquake experienced either economic damage (relatively to properties, crops, livestock) or human casualties following the event[9]. Even though the whole territory felt the shock tremors[10], I do not exclude any other provinces from the donor pool than those listed in the EM-DAT since it takes significant economic damages in an area to impact local migration. Simple tremors do not cause that much impact. Therefore, are included in the donor pool the following 21 provinces: Anhui, Beijing, Fujian, Guangdong, Guangxi, Hainan, Hebei, Heilongjiang, Inner Mongolia, Jiangsu, Jiangxi, Jilin, Liaoning, Ningxia, Qinghai, Shandong, Shanghai, Tianjin, Tibet, Xinjiang and Yunnan (colored

[9]In Figure 3, are depicted as "Other provinces" all the areas – other than Sichuan – affected by Wenchuan earthquake.

[10]Some buildings in Shanghai financial district were evacuated because of strong tremors felt after the 8.0 magnitude earthquake in Sichuan, state local reporters (Chaney and Klamann, 2008).

in blue in Fig. 3). They are the control provinces.

Figure 3: Sichuan and the donor pool

Notes: The other provinces painted in red on the Figure are all the provinces that are also affected by the Wenchuan earthquake, and can therefore not be used to build Sichuan counterfactual. As a consequence, they do not belong to the donor pool. Source: Author's elaboration.

Second step is to compute the synthetic control unit. Following Abadie et al. (2015), suppose that J is the number of control provinces (the 21 provinces that were never significantly affected by the earthquake) that is to say, the donor pool. Let X_1 be a $(Kx1)$ vector containing characteristics of the treated unit. More precisely, it is composed of predictors of NTL variations in Sichuan between 2004 and 2008. Province level predictors for the NTL integer are: the pretreatment value of NTL (the value of NTL in 2005), the birth rate ratio, the GDP per capita, a proxy for schooling, and a proxy for the transportation system[11]. Let X_0 be a $(K \times J)$ be the matrix containing the values of the same variables for the provinces in the control group. W is a $(J \times 1)$ vector of nonnegative weights $(w_1, ..., w_J)$ such as $w_1 + ... + w_J = 1$. W determines the relative importance of the control provinces in the donor pool and it is defined so that the characteristics of the treated province resembled as closely as possible to those of the synthetic control. Hence, the intuition is

[11]Here, I use standard predictors to match the control provinces with Sichuan: the past value of NTL being one of the most important factor that predicts future level of NTL, then the birth rate being a proxy for natural growth rate of the population, the GDP being an economic proxy, a schooling proxy, and an infrastructure proxy. These are the educational, infrastructure, economic proxies that minimize the matching errors between Sichuan and its counterfactual (see Section 5).

to minimize the difference between $X_1 - X_0W$ *i.E.* the difference between Sichuan characteristics and those of the synthetic Sichuan, in the pretreatment period[12].

Therefore, I follow Abadie et al. (2015) and choose the $\boldsymbol{W^*}$ that minimizes the following expression[13]

$$\sum_{m=1}^{k} v_m (X_{1m} - X_{0m}W)^2 \quad with \quad \sum_{j=1}^{J} w_j = 1,\ w_j \geq 0 \tag{1}$$

For $m = 1, ..., k$, X_{1m} represents the value of the m-th predictor for the treated province and X_{0m} is the $(1 \times J)$ vector containing the values of the m-th variable for the control provinces. v_m corresponds to the weight that captures the relative importance of each m-th predictor in the synthetic counterfactual. The more predictive power a variable has on the outcome (*i.e.* Sichuan NTL) in the pretreatment period, the highest weight it gets assigned. Suppose that Y_0 and Y_1 are the outcome matrices respectively for the control provinces and Sichuan, then, the counterfactual outcome equals to $\boldsymbol{Y_1^*} = Y_0W$. It represents the NTL progression in Sichuan after 2008, in the absence of a 8.0 magnitude earthquake. Knowing this, one can estimate the treatment effect *i.e.* the effect of the natural disaster on NTL trend in Sichuan. It can be calculated by taking the difference between $\boldsymbol{Y_1^*}$ and Y_0.

5 Results

In this section, I assess the impact that a natural disaster can have on urban-to-rural migration in Sichuan. Most of SCM identification validity relies on the ability to compute a counterfactual that best matches Sichuan trends in NTL in the pretreatment period (that is to say, between 2004 and 2008). So I first check that synthetic counterfactual is close enough from Sichuan in the pretreatment period, to get to solid conclusions later on. Then, I present the main results of this paper. In the last subsection, I check that these results are not due to hazard.

[12] According to Abadie and Gardeazabal (2003), estimating a synthetic counterfactual that is a combination of control units is a better approximation of the treated region than using another region alone. Nevertheless, one needs to be careful because the identification strategy mainly relies on matching the behavior of the outcome variable of interest during the pretreatment period. See Table 3 to monitor this point.

[13] It is equivalent to saying that I select the weights that minimize the Root Mean Square Prediction Error (RMSPE), see Abadie et al. (2015). The RMSPE measures the lack of calibration between the trend of the outcome variable for the treated unit and its synthetic counterfactual, in the pretreatment period.

5.1 Building a convincing counterfactual

As detailed in the methodological section, I chose the $\boldsymbol{W^*}$ that minimizes the RMSPE. By approaching zero (0.047 to be precise), the weight matrix does validate this condition. In other words, the gap between the trend of the outcome variable of Sichuan and the one of synthetic Sichuan are close to be null in the pretreatment period, with the selected weight matrix. Another manner to check that the gap is small between NTL tendencies of Sichuan and synthetic Sichuan is to graph both of them. Figure 4 supports that there is a reasonably good match between Sichuan and its counterfactual, since both trends are principally overlapping between 2004 and 2008.

Table 3 compares the pretreatment characteristics of Sichuan to those of synthetic Sichuan and the rest of China. In columns (1) and (3) are reported characteristics for Sichuan and China, respectively. Between 2004 and 2008 -the pretreatment period-, there is no common trend between Sichuan and the rest of China, regarding the predictors. Sichuan has a lower birth rate, per capita GDP and a less efficient railway system. At the opposite, it has a higher rate of achievement between the primary and secondary school. With such pretreatment differences, no conclusion can be made regarding the impact of the treatment on Sichuan's NTL by simply analyzing the variations of these same predictors, post-treatment. On the other side, Table 3 suggests that synthetic Sichuan provides a better comparison pre-treatment than China. Synthetic Sichuan offers a closer if not identical pre-treatment NTL level, GDP per capita and education achievement rate. Overall, synthetic Sichuan represents a close match, close enough to interpret the differences between Sichuan and its counterfactual post-treatment, as the treatment effect.

Table 4 reports the weight of each province in the synthetic version of Sichuan, before 2008. The closest match for Sichuan corresponds to a weighted average of Xinjiang, Jiangxi and Jilin[14]. All the other provinces in the donor pool obtain zero weights. These weights are obtained by minimizing the RMSPE, that is to say, the potential errors made when matching Sichuan and its virtual counterfactual, before the treatment.

[14]Note that all three provinces are located in very different areas of China. It is important to note in Chinese context since the country is known to suffer from great regional disparities, especially between the coastal area and inland China.

Table 3: Predictor Balance

	Sichuan		China
	Real	Synthetic	
	(1)	(2)	(3)
NTL in 2005	1.12	1.12	5.85
Birth rate	9.28	14.23	11.48
GDP per capita	10116.06	13086.29	17738.12
Schooling	102.50	99.75	98.80
Transport	195.77	211.96	209.94

Notes: The birth rate is the ratio of the number of births to the average population in a year. The GDP per capita is expressed in yuan per person. The proxy for schooling refers to the percentage of graduates of primary schools that actually enter to secondary schools. The transportation system efficiency proxy is the volume of passengers transported by the railway system every year. It is expressed per 100 million passengers per kilometers.

Table 4: Weight associated for each donor pool province

Donor pool	Weight
Anhui	0
Beijing	0
Fujian	0
Guangdong	0
Guangxi	0
Hainan	0
Hebei	0
Heilongjiang	0
Inner Mongolia	0
Jiangsu	0
Jiangxi	0.304
Jilin	0.146
Liaoning	0
Ningxia	0
Qinghai	0
Shandong	0
Shanghai	0
Tianjin	0
Tibet	0
Xinjiang	0.55
Yunnan	0

Source: Author's elaboration on NOAA data.

5.2 Major findings

Looking at Figure 4, Sichuan and its counterfactual matches closely, until 2008, year of the 8.0 magnitude earthquake. Post-disaster, a gap appears between Sichuan and its counterfactual. This gap embodies the impact of the earthquake on Sichuan NTL, namely the treatment effect. In 2009, the NTL in Sichuan has decreased by 14% compared to its counterfactual where no natural disaster occurred[15]. As argued in Section 3.1, this negative impact on Sichuan NTL can be interpreted as migration from rural to urban areas inside the province. Here, the natural disaster materializes the final factor pushing potential migrants toward the poverty trap, preventing them from gathering the monetary funds necessary to out-migrate.

Second remarkable fact looking at Figure 4, the negative impact on Sichuan NTL is short-lasting. Even a large disaster as a 8.0 magnitude earthquake does not seem to have a lasting impact on migration. The treatment effect is back to zero when reaching 2011. Then, natural disasters, regardless on how destructive they are, do not have a permanent impact on monetary constraints, and therefore, on migration patterns. In this case, it takes three years after the event to reach a full recovery and go back to business as usual. This result echoes the literature demonstrating that naturals disasters impact both economic activity and population income in the short run, but not in the long run. As long as natural disasters do not impact the household monetary constraint anymore, they have no effects on migration patterns as well.

Last but not least, the impact of such a devastating event remains quite low in proportion. Since the economic reforms in 1970s, Wenchuan earthquake remains the most destructive natural event, in terms of economic loss. According to a statement from the central government[16], the earthquake left 5 million people homeless. Intuitively, one could expect larger consequences on migration patterns. But looking at the results, the inhabitants still did not leave their township of birth. The institutional constraints regarding internal migration certainly played a major role in mitigating the impact of any natural disaster on migration. It also echoes the paper of Belcher and Bates (1983) which shows that migration does not depend on how great the economic damages

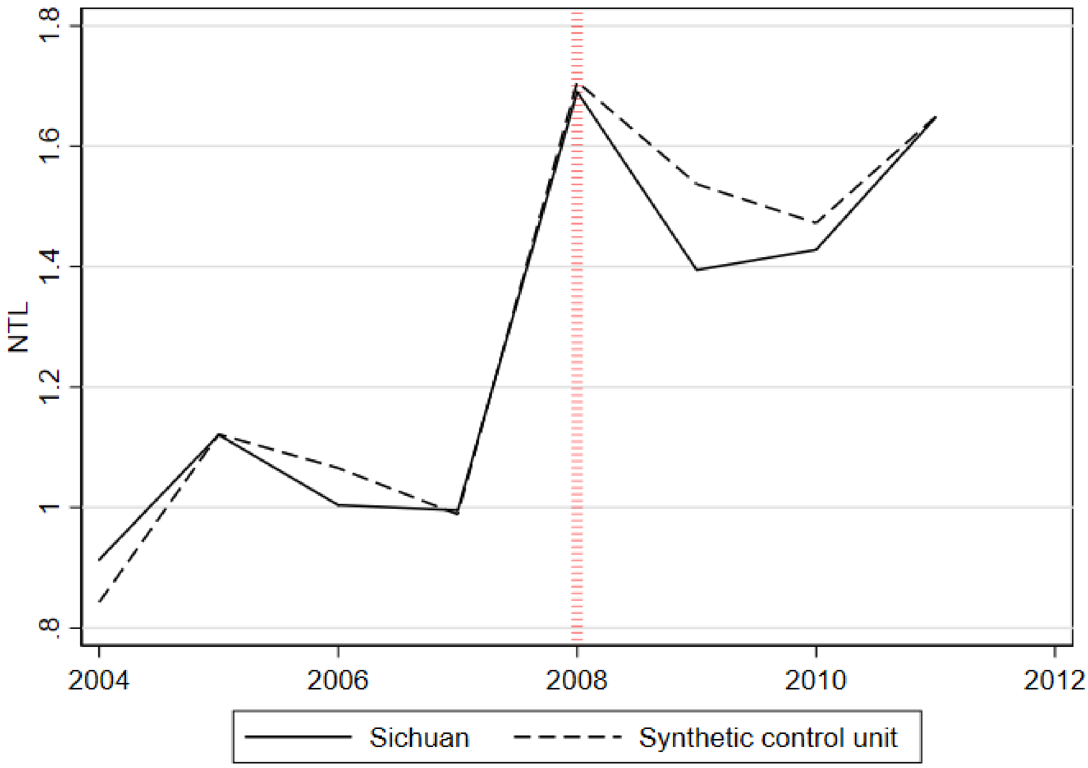
[15] The treatment effect is obtained by subtracting $\boldsymbol{Y_1^*}$ and Y_0 *i.e.* the NTL of the synthetic counterfactual minus the observed NTL of Sichuan.

[16] Reported by the New York Times, in an online article written by Jake Hooker on May 26, 2008: https://www.nytimes.com/2008/05/26/world/asia/26quake.html

are for the community but rather depends on whether the potential migrant lost or not the annual harvest along with the natural disaster.

Both results confirm the literature that considers the natural disasters, as an additional monetary constraint, preventing migration in the short run, to later on have no impact at all in the long run. I further discuss the results in Section 6.

Figure 4: NTL trends for Sichuan and its counterfactual



Source: Author's elaboration on NOAA data.

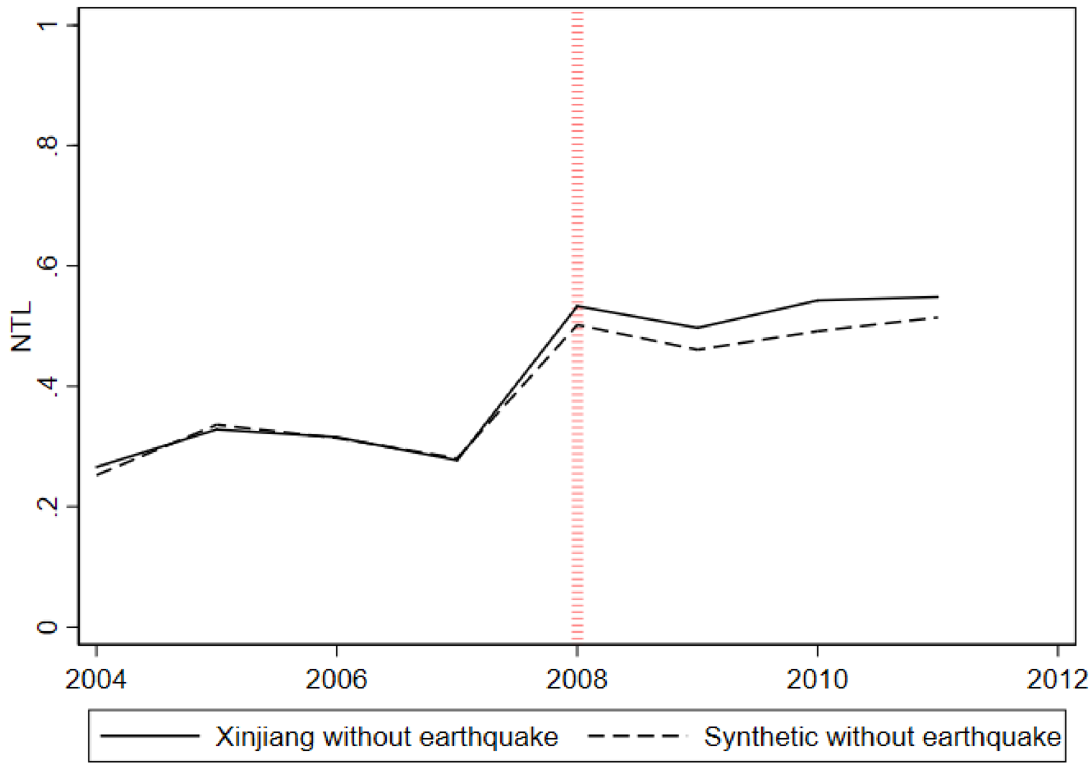
5.3 Robustness check

A question remains concerning whether the gap depicted in Figure 4 reacts to the earthquake or is simply due to the incapacity of this study to reproduce the NTL trend for Sichuan, in absence of an earthquake. Following Abadie and Gardeazabal (2003), I perform a placebo study. In other words, I run the same SCM on a province that did not get treated and check if there is also a gap post-2008. The idea is to compare the NTL variation of a province similar to Sichuan, in which no natural disaster occurred, to the NTL variation of its synthetic counterfactual in which no natural disaster occurred either. Doing so, I evaluate whether the gap observed for Sichuan was initiated by factors other than the earthquake. I chose to run this placebo study using Xinjiang province, the province with the greater weight in the donor pool. Indeed, Xinjiang accounts for 50% of the combination of control provinces in the synthetic Sichuan (see Table 4). Therefore, as explained above, I compute a synthetic Xinjiang *i.e.* a weighted combination of other Chinese provinces, by minimizing the RMSPE [17].

Figure 5 shows the actual NTL trend for Xinjiang and the one computed for its synthetic counterfactual. First, the match between Xinjiang and synthetic Xinjiang is convincing, given that the NTL are overlapping before 2007. Starting from 2007, a small gap develops between Xinjiang and its counterfactual. Starting in 2007, this gap has low chances to be caused by the 2008-eartquake. Also, the NTL trends are exactly parallel, no drop occurs following the 2008-earthquake. Thus, as expected, the earthquake did significantly not affect Xinjiang NTL (listed as unaffected in the EM-DAT database). Results obtained with Sichuan are therefore not due to hazard.

[17]Note that Sichuan is excluded from Xinjiang donor pool.

Figure 5: Placebo test on Xinjiang Province



Source: Author's elaboration.

6 Discussion

Using the synthetic control method to construct Sichuan counterfactual, I find that Wenchuan earthquake in 2008 has a mitigating impact on rural-to-urban migration in the short run. It acts as a supplementary monetary constraint and further inhibits migration out of rural areas. This effect becomes null in the long run, so natural disasters do not seem to impact permanently migration patterns. It means that when facing natural disasters, people in China rather stay put. This small migrating reaction is consistent with the local context. Indeed, by further diminishing people incomes, natural disasters economic damages add to already high migrating costs due to institutional barriers.

Another line of explanation that needs further investigation would be the potential resilience of Chinese citizens facing natural disasters. Indeed, China experiences a high frequency of natural disasters. In total, according to the EM-DAT, 509 natural disasters that either implied 10 or more human fatalities, 100 or more people affected, the declaration of a state of emergency or a call for international assistance occurred between 2000 and 2016[18]. Such frequency can lead to higher resilience to natural hazards among the inhabitants. In this case, the population adjusts their behaviors to natural disasters, integrates the risk in their daily life, and then, their coping strategy when facing a natural event would be to stay put and take sustainable actions to mitigate the risks in the long run (such as self-insurance, diversification of income sources, and so on).

The absence of reliable data keeps posing a problem to seize the effects of natural disasters on migration. A more detailed analysis could be completed using monthly and/or survey data. It would allow to capture more precisely temporary migration. With monthly data, one can also identify the circular migration discussed by Zhao (1999), which is temporary migration that results in going back home. Since temporary and circular migration is the most widespread pattern in China, there could be wide variations in monthly migration, but low rates at year-end. I could not access this type of data.

[18]It includes earthquakes, severe floods and droughts, storms, extreme temperature, landslide.

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7 Appendix

Table 5: Variables used in the Synthetic Control Method

Variable	Definition	Source
Nighttime Light (NTL)	Yearly measure of light intensity at night. It ranges from 0 (desert area) to 63 (dense area). Cloud-free measure made from satellite data.	NOAA National Geophysical Data Center
Birth Rate	(Number of birth/Average Number of Population)$\times$ 100	NBSC
GDP per capita	Indicates the gross domestic product in yuan per person.	NBSC
Schooling	(Number of students Entering in Junior Schools / Number of graduates from primary school) $\times$ 100. When it exceeds 100, it means that some students were transfered from other provinces and/or cities.	NBSC
Transport	Volume of passenger traveling by train. Expressed in terms of 100 million persons. Built as an indicator of the transport development scale.	NBSC

Source: Author's elaboration from NOAA and NBSC data.

Table 6: Variables from the Correlation Table

Variable	Definition	Source
Urban ratio	(Number of people living in a city/Total population)$\times$ 100	NBSC
Urban Population	Urban population ($\times$ 10000 persons) as a mix of administrative and statistical definition. Considers as an urban dweller, a person living in an area under the jurisdiction of a city but also living close to urban construction, densely populated area (more than 1500 people per km2), etc.	NBSC
Rural Population	Total population except urban population.	NBSC
GDP Prim.	GDP of the primary industry referring to agriculture (including farming, forestry, animal husbandry and fishery). Expressed in 100 million yuan.	NBSC
GDP Second.	GDP of the secondary industry referring to the industrial (including mining and quarrying, manufacturing, production and supply of electricity, water and gas) and construction sector. Expressed in 100 million yuan.	NBSC

Source: Author's elaboration from NBSC data.

Figure 6: NTL trends in Gansu province