Unraveling Regional Inequality: The Heterogeneous Impact of China's Great Western Development Program

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Abstract: This paper studies China's Great Western Development Program, which was designed to promote growth in the backward western provinces. In addition to evaluating its original policy goal, we further investigate its unintended consequences and potential mechanisms. Employing a regression discontinuity design and nightlight series data, we find that the program led to a 1.3-1.7% faster annual output growth in China's western region. Though the financial investment is homogenous, the positive growth effects are limited to localities with better initial endowments. We suggest that the program has widened inequality within the treatment group due to lack of targeting.

Keywords: regional development, economic development, place-based policy, inequality, spatial discontinuity

1 Introduction

Place-based policies are common interventions aimed at enhancing economic development and reducing regional disparity (Neumark and Simpson, 2015) and are widely used in developing countries (Wang, 2013; Shenoy, 2018; Jia et al., 2020). Although many of these place-based policies are motivated by equity concerns, most of them assign relatively uniform treatment to a broad region as a whole and lack targeting within the treated region. The lack of targeting not only induces a waste of public resources (Becker et al. 2013), but also has the unintended consequence of widening the disparity within the treatment group, as labor and capital may unevenly flow away from the less-developed areas to the more developed ones within the treated region. The literature has developed comprehensive discussions on whether and how place-based policies work in general (O'Keefe, 2004; Glaeser and Gottlieb, 2008; Kline and Moretti, 2014a,b, etc.), but less attention has been given to the heterogeneous treatment effects and inequality within the treated region, especially in a developing country setting[1].

This paper studies one of the most prominent place-based policies that aim at reducing regional disparity: the Great Western Development Program in China. Ever since the economic reforms in the 1980s, while the coastal provinces of China have achieved significant economic growth through integration into international trade networks, the rugged terrain and landlocked geography make it difficult for the western region to develop a competitive manufacturing sector. This has resulted in an increasingly uneven distribution of resources across the west and the east, leaving the west persistently underdeveloped. In 2000, the central government of China targeted the backward Western provinces with generous fiscal transfers, substantial infrastructure investments and a variety of industrial policies. The scheme was one of the largest place-based policies in the world at the time, covering approximately 70% of China's area and 30% of its population in 2000 (Goodman, 2004). In the first five years, the central government had invested more than 1.6 trillion RMB yuan in the west[2]. The number climbed up to 6.8 trillion RMB yuan by 2017[3], while by comparison, China's national GDP was 9.9 trillion in 2000 when the scheme began.

The Western Development Program provides a context to understand the impact of place-based policy on regional development, especially the heterogeneity of treatment effects, for two reasons. First, the geographical cutoff in policy eligibility grants us a

1 Devereux et al. (2007), Briant et al. (2015) and Mayer et al. (2017) have identified local factors relevant for the treatment effects of place-based policies in the UK and France in attracting new firms, including the density of existing plants and spatial integration.

2 The State Council of the People's Republic of China 2006, Chinese Government, accessed 5 June 2024, <http://www.gov.cn/jrzg/2006-02/04/content_177478.htm>.

3 National Development and Reform Commission 2017, The State Council Information Office of the PRC, Chinese Government, accessed 5 June 2024, <http://www.scio.gov.cn/xwfb/bwxwfb/gbwfbh/fzggw/202207/t20220715_204536.html>.

natural spatial regression discontinuity design, which largely rules out concerns on program selection. Second, although regression discontinuity (RD) design only estimates local treatment effects, the Western Development program border extends from north to south China and crosses ten provinces, which creates rich variations in the socioeconomic conditions of localities on both sides of the border. Figure 2[4] plots the policy target region and population density on 1 km × 1 km grids in 2000. As the figure shows, the policy border crosses areas with significant variations in population density.

This paper employs a spatial regression discontinuity design in answering the following two questions: (1) Does the Western Development Program promote self-sustained economic growth, especially after the fiscal transfers recede? (2) How do treatment effects differ by initial endowments? This study follows the literature in using nighttime light series to measure economic output (Henderson et al., 2012, Shenoy, 2018). We address the common concerns related to RD design with two approaches. First, we check the balance of various geographical and socioeconomic outcomes across the border. We find all of them vary smoothly at the discontinuity. Second, we complement the RD approach with a difference-in-differences design by estimating how the border discontinuity changes year by year from 1992 to 2019. The relatively long time series not only enables us to check the parallel pre-trends between the treated and control units but also helps trace the mid-to-long-term impacts of the program.

We find that the light intensity on the west side of the border increased significantly shortly after the policy commenced in 2000. There is an approximately 16 to 20% increase in light emissions ten years after the program began. Combined with census data on economic outcomes and demographic data in counties, we find that the change in light emissions can be translated to a 1.36 to 1.7% increase in annual GDP growth (See Appendix 1). Although the West Development Program is still ongoing, the policy intensity, measured by fiscal transfers to western regions, decreased ten years after its inception. Meanwhile, we find that the Program's growth effects dropped substantially after 2012 and became statistically insignificant, revealing a lack of growth momentum.

We then evaluate the heterogeneity in treatment effects. We categorize the treated units into two groups based on their initial conditions in population density, industrialization and infrastructure access. The results suggest that the treatment effect of Western Development Program is more profound in areas with better initial endowments, suggesting that the effect of external aid is highly correlated with recipients' characteristics. The divergence in growth, however, is not driven by differential policy intensity, because neither fiscal transfers nor bank credit offerings differ across areas with different initial endowments. In addition, we find that Western

4 WorldPop (www.worldpop.org - School of Geography and Environmental Science, University of Southampton; Department of Geography and Geosciences, University of Louisville; Departement de Geographie, Universite de Namur) and Center for International Earth Science Information Network (CIESIN), Columbia University (2018). Global High-Resolution Population Denominators Project - Funded by The Bill and Melinda Gates Foundation (OPP1134076). https://dx.doi.org/10.5258/SOTON/WP00675

Development leads to a reduction in the number of new manufacturing firms, particularly in initially less-developed areas. The treatment effect of Western Development on population density is also negative in less-developed areas. Taken together, the evidence seems to suggest that the policy goal of promoting growth through industrialization in the backward areas within the treated region failed, as the market logic would direct capital and population flow toward places with better endowments, especially with the help of improved transportation infrastructure.

We further examine the impact of Western Development on several household welfare outcomes. We find that Western Development has positive impacts on the number of hospital beds and average living space per capita but not on student enrolment and the literacy rate. Although the policy impacts on household welfare are mixed, they appear homogenous across areas. It suggests that the Western Development Program has a more direct impact on promoting productions and attracting businesses instead of improving welfare indicators. On a positive note, direct spending on improving the quality of public services may be a more reliable way to help the least-developed areas in terms of household welfare improvement.

Our findings highlight crucial considerations for designing place-based policies to reduce regional development gaps in developing countries. Our analysis of the Western Development Program underscores the need for tailored policy approaches (Barca et al., 2012; Iammarino et al., 2019). In less developed regions, inherent limitations often impede growth despite substantial investments. Therefore, it is essential for policymakers in developing countries to first identify the main challenges of promoting growth in various places and then design targeted policies accordingly. In better-endowed areas or major cities within the treated region, one possible focus could be attracting businesses and fostering local agglomerations. Conversely, for less developed areas with isolated markets and inadequate infrastructure, it may be valuable to prioritize support for local provision of public services and establish a basic social welfare net.

The remainder of this paper is organized as follows. Section 2 reviews the current state-of-the-art literature related to place-based policies. Section 3 provides the background material of the study and introduces the identification strategy. Section 4 presents the main results. Section 5 discusses the possible mechanisms. Section 6 discusses the policy implications. Section 7 concludes.

2 Literature review

2.1 Effectiveness of place-based policies

Place-based policies (transport improvements, local tax benefits, special economic zones, etc.) are common responses to regional disadvantages. Policymakers aim to reduce national inequality through them by promoting growth in the targeted regions. The efficiency and equity implications of place-based policies have been extensively discussed in the theoretical and empirical economic literature (see Glaeser and Gottlieb, 2008; Kline and Moretti, 2014b; Neumark and Simpson, 2015, for comprehensive reviews). The classic spatial equilibrium model in economics suggests an efficiency-equity tradeoff (Glaeser and Gottlieb, 2008). Redistributing resources from rich regions to poorer ones would likely lead to reductions in aggregate output. However, recent theoretical and quantitative research has explored conditions under which place-based policies could be welfare-improving, such as pre-existing distortions, agglomeration and dispersion in amenities (Fajgelbaum and Gaubert, 2020; Henkel et al. 2021). Meanwhile, in regional science, there are also perspectives that challenge the tradeoffs between efficiency and equity, and call for a more holistic view that integrates considerations of various local factors including institutional dynamics, social capital and governance (Martin, 2008; Davidson, 2009; McCann, 2023).

Empirical studies find mixed conclusions on the efficiency of place-based policies. Notably, research conducted in developed countries has found limited effects on productivity and income growth but more potential to increase employment. Examples of such programs include California's enterprise zone program (O'Keefe, 2004; Elvery, 2009; Neumark and Kolko, 2010), the French Urban Zones program (Gobillon et al., 2012; Briant et al., 2015), the Tennessee Valley Authority program (Kline and Moretti, 2014a), the Regional Selective Assistance Program (Criscuolo et al., 2019), and multiple EU-funded regional policies (Dall'Erba and Fang, 2017; Becker et al., 2010, 2013, 2018; Bailey et al., 2018; Crescenzi and Guia, 2020; Arbolino et al., 2023).

In developing countries, there is a growing body of evidence that presents a more positive outlook. There are mainly two types of place-based policies evaluated: the first type promotes growth in leading regions, exemplified by the success of China's special economic zones (Wang, 2013; Lu et al., 2019). The second targets less-developed areas to reduce regional disparities, with studies by Chaurey (2017), Shenoy (2018), Hasan et al. (2021), and Vasilakos et al. (2023) highlighting their positive effects on economic growth in India. Our study builds on this literature by analyzing a large-scale place-based policy in China, focusing on both efficiency and equity, while particularly examining its heterogeneous effects within the treated region.

This inquiry into heterogeneous treatment effects connects with existing studies in developed economies, notably the evaluation of the European Cohesion Policy. For example, Gagliardi and Percoco (2016) and Percoco (2017) demonstrate that this policy is most effective in urban areas and regions with smaller service sectors in Italy. Similarly, Di Cataldo and Monastiriotis (2018) find that its effectiveness in the UK depends on pre-existing sectoral advantages. Apart from extending this discussion to developing countries, another distinctive feature of our context is that the treatment region is vast—covering 70% of China’s land, and is characterized by close spatial interconnections such as migration and capital flows across units within it. Looking into the movement of labor and firms could partly explain the inequality effect *within* the treatment region.

A closely-related work is Jia et al. (2020), who evaluate the impact of the same Western Development Program with a regression discontinuity design, documenting significant positive effects on GDP growth. Zheng et al. Zhou (2022) and Liu (2023) explore firm outcomes and document the positive impacts of Western Development Program on TFP and sustainability development. Our study extends this by investigating the heterogeneous effects of the policy and their implications for regional inequality, exploiting high-resolution data over an extended period to assess *long-term* impacts.

2.2 Government interventions

This paper also contributes to the literature on government interventions and their effectiveness. While governments are crucial in addressing market failures, studies show that such interventions often lead to inefficiency and corruption in both developing and advanced economies (Lal, 1985; De Soto et al., 1989; Donahue, 1989). Research on common interventions, including industrial policy and government funding, has yielded mixed findings. For example, Criscuolo et al. (2019) find limited impact on local productivity from a region-based industrial policy in the UK, while Cerqua and Pellegrini (2022) observe that the positive effects of EU regional policies on GDP per capita disappear after a significant reduction in funding, highlighting the challenge of sustaining long-term positive effects. Conversely, Bailey et al. (2015) study industrial strategies in British cities and find that the state can complement the market and stimulate private investment. Therefore, it is crucial to understand the conditions under which such policies may succeed and the determining factors involved.

The absorptive capacity of recipients is a particularly noteworthy source of effectiveness in transfer treatment response. The literature has identified human capital (see Mankiw, Romer, and Weil 1992; Benhabib and Spiegel 1994) and institutions (see Mauro 1995; and Acemoglu, Johnson, and Robinson 2005; and Rodríguez-Pose 2013) as important mediators. Becker et al. (2013) evaluate the roles of these two factors in determining the effectiveness of EU transfers. Specific to regional policies, Devereux et al. (2007), Briant et al. (2015) and Mayer et al. (2017) identify that local initial conditions are relevant for the treatment effects of place-based policies in the UK and France in attracting new firms, which include the density of existing plants, spatial integration and attractiveness differentials between treated and control regions. Our paper offers new insight into the distributional impact of one of the world's largest place-based policies aimed at reducing regional disparity, the Western Development Program in China. We find that areas with worse initial conditions benefit very little from such a development initiative, most likely because the local fundamentals are too weak to support agglomeration economies through industrialization.

3 Materials and methods

3.1 Background

In China, economic development is highly uneven across space (Ravallion and Jalan, 1999). The geographical drawbacks in the west, especially the landlocked location and rugged terrain, create obstacles to agglomerate economic activities and thus impediment development. In 1978, China began its "Reform and Opening-up" to transform the country from a planned economy to a market economy. The reform brought substantial growth to eastern coastal regions and thus exacerbated inequality between the east and the west. At the end of last century, the average GDP per capita in western regions was roughly half of that in the east (see Panel A in Figure 1).

The State Council officially started the Western Development Program in January 2000 (Holbig, 2004) to promote growth in 12 provinces in western China (see Panel B of Figure 2).[5] The program has three main components (Jia et al., 2020). First, the central government has granted generous fiscal transfers and massive credit support to western provinces. As shown in Panel B of Figure 1, the ratio of the central government's fiscal transfers to western provinces with respect to local government revenue rose from 104% in 1995 to 180% in 2010, far higher than that in the eastern region (from 53% to 55%). This ratio peaked in 2010 and started to drop afterwards. Second, numerous industrial policies were introduced to promote the industrialization of western cities, including mining, energy, machinery, and deep processing of natural resources.[6] Firms from the promoted sectors[7] received tax incentives and could pay 10 percentage points less corporate income tax than firms in other sectors[8]. Third, the central government initiated a surge in infrastructure investment in western regions, including investment in transportation, hydropower plants, energy, and telecommunications. Various large-scale infrastructure projects have been initiated to expand interprovincial expressways and railways to connect the eastern and western regions and improve market access. According to the data reported by the National Development and Reform Commission (NDRC)[9], by the end of 2019, railway service in the western region reached 56,000 km, including 9,630 km of high-speed railways.

3.2 Data

We compile multiple sources of township-level and county-level datasets, as outlined below.

Nighttime light data. Due to the lack of township-level socioeconomic statistics, we use the nighttime light series to measure township-level economic output and

5 Three ethnic minority autonomous prefectures in the east were additionally included in the program. These prefectures are Yanbian, Enshi, and Xiangxi. Since Yanbian is located away from the western border, we drop its observations from the main analysis.

6 The central government announced a "Western Development Encouraged Industry Catalogue" to indicate industries planned to receive support. These industries were chosen mainly based on the western region's natural resource conditions and industrial foundations.

7 These sectors are listed in the Western Development Encouraged Industry Catalogue. See https://www.ndrc.gov.cn/xxgk/zcfb/fzggwl/202101/t20210126_1265895.html for the updated version (2021).

8 State Taxation Administration, see http://www.chinatax.gov.cn/n810341/n810765/n812156/n812474/c1186395/content.html and Regulations of the People's Republic of China on Value-Added Taxes. http://www.chinatax.gov.cn/n810341/n810765/n812171/n812680/c1190937/content.html. Accessed 5 June, 2024.

9 National Development and Reform Commission 2020, Chinese Government, accessed 5 June 2024, <https://www.ndrc.gov.cn/xxgk/jd/jd/202005/t20200521_1228547.html>.

economic activity. There are two main sources of nightlight data, the Defense Meteorological Satellite Program (DMSP) and the National Polar-orbiting Operational Environmental Satellite System Preparatory Project (NPP). The DMSP series [10] includes 34 images obtained by multiple satellite sensors from 1992 to 2013, which makes it the longest continuous time series of nighttime light remote sensing data. The series divides the earth into many small cells. Each cell covers a 30 arc seconds × 30 arc seconds square area. It provides a digital value (ranging from 0 to 63) of the average intensity of nighttime light for each cell every year. NPP is a new generation of earth observation satellites launched in 2011 that carries the Visible Infrared Imaging Radiometer Suite (VIIRS), allowing it to acquire new night light remote sensing images (Day/Night Band, DNB Band) with further improved spatial resolution from 2012 to 2019.

Figure 3 shows the raw nighttime light data from DMSP in 2000 and 2010. The blue curve stands for the policy boundary between the west, the targeted area, and the east, the control. To translate the digital value into a measurable variable, this paper measures light intensity with log(0.1 + Digital Value). The average intensity of light emissions is calculated for each town annually from 1992 to 2012. To measure the longer-term effects of the policy, we turn to NPP data in measuring the border effects from 2012 to 2019.

Geographic data. We identify and compute geographic coordinates for each township/county centroid and calculate relevant geographical characteristics using ArcGIS. The average elevation and slope are measured using Shuttle Radar Topography Mission (SRTM) data. The data include radar imagery of more than 119 million square kilometers between latitudes 60◦ north and 60◦ south, covering more than 80% of the Earth’s land surface.

Economic and demographic data. The county-level economic indicators are collected from the China County Statistical Yearbook. The indicators include yearly GDP, agricultural GDP, industrial GDP, budgetary fiscal revenue and expenditure, student enrollment, and the number of hospital beds. The panel covers the period from 1999 to 2018. We use the consumer price index collected from the China National Bureau of Statistics to adjust time-variant indicators to the constant price in 1978. County-level demographic variables are obtained from China’s Population Census, which documents information on population, employment, education, living condition, and other household welfare indicators in 2000 and 2010.

Population density data. We obtain data on township-level population density from WorldPop[11]. The dataset uses satellite remote sensing images, land use type data, demographic data, elevation, landform, and other spatial data to estimate the population size at 1 km × 1 km grid. We further aggregate it to townships.

Infrastructure data. We focus primarily on two types of infrastructure: railways and roads. Data on railways and roads are derived from the Geographic Data Sharing

10 Earth Observation Group, National Centers for Environmental Information. https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html

11 WorldPop (www.worldpop.org)

Infrastructure[12] and the Global Roads Open Access Data Set[13], respectively. These datasets also contain basic geographical information of these infrastructures.

3.3 Empirical strategy

We exploit the discontinuity in treatment status across the geographic boundary of the Western Development Program for causal identification. As noted in many geographic regression discontinuity studies (Keele and Titiunik, 2015; Dell, 2010; Shenoy, 2018), spatial boundaries create multidimensional discontinuities in latitude-longitude space, and there is generally no well-accepted form of an optimal RD polynomial. Hence, we follow Dell (2010) and Shenoy (2018) to estimate the baseline model with flexible specifications:

$$y_{is} = \alpha + \beta West_i + X'\gamma + f(geographic\ location_i) + \delta_s + \epsilon_{is} \quad (1)$$

where y_{is} is the change in log light intensity for township i along segment s from 2000 to 2010. $[West]_i$ is a dummy variable for whether the town is located in the western region. X_i is a vector of covariates[14] including the average elevation and slope of township i. $f\ (geographic\ location_i)$ is the function that controls for smooth variation in geographic locations. In addition, to control for geographical heterogeneity, we follow Dell (2010) and divide the policy boundary into ten equal-length segments. δ_s controls for the segment fixed effect, where s denotes the closest segment to the township's centroid. β is the coefficient that measures the causal effect at the border.

The geographic function takes several forms. The first controls for the cubic polynomial[15] in the spatial coordinates of the centroid of each town. The second one, similarly, controls for the cube of the shortest distance from the centroid to the policy boundary. This specification is most similar to a typical one-dimensional RD design, where we treat the distance as the running variable. In the last specification, we remove the geographical controls and simply compare the means of differences in growth between western and eastern townships, which is equivalent to a difference-in-differences estimator on a restricted sample of townships around the border. Since there are no well-accepted criteria for the optimal bandwidth in multidimensional RD design (Dell, 2010; Dell and Olken, 2020), we control for 50- and 100-kilometer bandwidths in each specification in our main regressions.

The RD approach is based on the assumption that except for the treatment and outcome, no discontinuity exists in all potential omitted factors at the border. An obvious challenge is that the Western Development border largely coincides with provincial boundaries. Two concerns might arise from this issue. First, the Western

12 College of Urban and Environmental Science, Peking University, http://geodata.pku.edu.cn

13 SEDAC, https://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1

14 The controls are included in all regressions in this paper unless mentioned otherwise.

15 Letting x and y denote longitude and latitude, the function is $x + y + x^2 + y^2 + xy + x^3y^3 + x^2y + xy^2$.

Development treatment might be confounded with a variety of other provincial-level institutions. We argue that this is less of a concern in the Chinese setting, as political, economic and legal institutions, such as tax rates and de facto regulations, are consistent across provinces in a centralized system. Second, some provincial boundaries in China are defined by natural mountains and rivers. A rough examination of the Panel A of Figure 2 reveals that population density differs sharply across the northern part of the border. This is largely driven by the fact that this segment of the border follows natural geographical division: the western part of the northern boundary is eastern Inner Mongolia, largely occupied by a sparsely populated grassland, while the eastern part is the more densely populated provinces (Jilin, Heilongjiang, and Liaoning). Therefore, we limit our main sample to the central-western regions (see Figure 4). The northern part of the border and its neighboring provinces (Inner Mongolia, Jilin, Heilongjiang, and Liaoning) are excluded from our main sample.

To offer a more direct test of the continuity assumptions, we examine the continuity of the following potential characteristics within the 100km bandwidth on each side of the boundary: elevation, terrain ruggedness, population density, and other county-level indicators. Panel A of Table 1 shows that the differences in light intensity, population density, elevation, and slope in 2000 are insignificant across the boundary. Panel B shows no significant differences in aggregate production, population structure and local government finances across the Western Development boundary. Figure A 2 plots the results of the McCrary density test. It suggests that the observations are continuously distributed across the policy border.

4 Results

4.1 Cross-sectional results

Figure 5 shows the graphical result from Equation 1 controlling for the polynomial of townships' distances to the border, which offers an intuitive illustration of the RD estimator. In the graph, the towns are grouped into bins according to their distances to the boundary. We plot the average difference in light intensity from 2000 to 2010 (left panel) and from 2012 to 2019 (right panel)[16] of each bin and the fitted curves. The graph implies a discontinuity in economic output growth between western and eastern border areas, where western townships were growing much faster than their counterparts in the east in the first decade of Western Development Program. In comparison, the discontinuity in growth in the second decade (2012-2019) is much less obvious in magnitude.

Table 2 reports the baseline results across a variety of spatial controls and bandwidths using change in log light intensity as the dependent variable. Columns (1) - (2) present estimates from the specification that controls for a cubic polynomial of longitude and latitude. The light intensity of western towns grew significantly faster

16 Results before and after 2012 are reported separately. Nighttime light data before and after 2012 were taken from different satellite projects, making the results from the two time periods generally incomparable.

(17.4% to 19.2%) than that of the east controls in the first ten years of the program. Columns (3) - (4) control for a cubic polynomial of the distance from the township to the policy boundary. The estimates remain statistically significant in all specifications at 95% confidence level, which implies that Western Development Program steadily brought a 16% to 20% long-term increase, or a 1.6% to 2% annual increase, in light intensity between 2000 and 2010. Column (5) - (8) present the RD estimates on nightlight intensity growth from 2012-2019, a period when the intensity of Western Development Program substantially diminished. The estimates become smaller in magnitude and insignificant in some specifications which suggests that the gap between treated and control townships first enlarges as the treated units outgrow the rest, and stabilizes after 2012. We show that the results are robust in different settings in the appendix.[17]

4.2 Event study analysis

We then conduct an event study analysis to check for the existence of pre-trends and dynamic treatment effects spanning two decades post treatment. This analysis relies on a long time series of nightlight data. As outlined in Section 3.1, we use satellite data from two sources: the DMSP series (1992 to 2013) and the NPP product (2012 to 2019). To evaluate data consistency between the two satellite sets, we first analyze the correlation between the two sources during overlapping years of 2012 and 2013. Figure 6 demonstrates a strong positive correlation in light intensity measurements from both satellites during these years, along with a similar trend over time.

We then combine the two light series and examine the evolution of year-by-year RD estimates from 1992 to 2012 and from 1992 to 2019 in two separate sets of regressions. For the first part, we have

$$y_{ist} = \sum_{k=1992, k\neq 2000}^{2012} \alpha_k [Year\ Dummy]_k + \sum_{k=1992, k\neq 2000}^{2012} \beta_k [West]_i \times [Year\ Dummy]_k + \sum_{k=1992, k\neq 2000}^{2012} [Year\ Dummy]_k \times f(geographic\ location_i) + \delta_i + \delta_{st} + \epsilon_{it} \quad (2)$$

In Equation 2, y_{ist} is the log light intensity obtained from DMSP satellites for township i along segment s. $[West]_i$ is a dummy variable indicating whether the town is located in the western region. $[Year\ Dummy]_k$ equals 1 if t equals k. $f\ (geographic\ location_i)$ is the function that controls for smooth variation in geographic locations. δ_i controls for the township-invariant characteristics. δ_{st} is segment by year fixed effect. β_k is the coefficient that measures the border effect in year k.

The left two panels of Figure 7 present the estimated coefficients from Equation 2. The lower left panel shows that the majority of the pre-treatment coefficients are

17 The border effect is robust in different bandwidth lengths and geographical control specifications. We also find that the policy effect is not driven by regional heterogeneities by testing for different hypothetical borders.

statistically insignificant with the border distance polynomial controls. In the upper left panel, when we control for the polynomials of latitude longitude, the parallel pre-trend generally holds after 1997. There is a visible gap in growth between 1996 and 1997. One explanation is that the gap reflects the adjustment in fiscal allocation following the Ninth Five-year Plan announced in 1996. It is important to note that the central government gradually started to support the western region by allocating poverty alleviation funds and bank loans in the Ninth Five-year Plan. The one-off jump in growth from 1996 to 1997 suggests that the Ninth Five-year Plan might have had some impact on the western region, but the growth impact was not persistent, as the estimators remained flat and insignificant until 2000. Therefore, the effect observed in section 5.1 was more likely to be the result of the Western Development Program since no other large-scale development schemes took place before 2000.

We turn to the combined DMSP and NPP light series from 1992 to 2019 for the long-run analysis, with the following specification:

$$y_{ist} = \sum_{k=1992,k\neq 2000}^{2019} \alpha_k [Year\ Dummy]_k + \sum_{k=1992,k\neq 2000}^{2019} \beta_k [West]_i \times [Year\ Dummy]_k + \sum_{k=1992,k\neq 2000}^{2019} [Year\ Dummy]_k \times f(geographic\ location_i) + \delta_i + \delta_{st} + \epsilon_{it} \quad (2)$$

It should be noted that Western Development Program is still ongoing as of 2019, with all the tax incentives remained the same. But as shown in Figure 1, the size of fiscal transfers to western provinces has dropped significantly after a decade. Therefore, the estimated βs in the long run, plotted in the right two panels of Figure 7, should reflect not only the persistent effects of the more intensive treatment before 2012 but also the contemporary responses to treatment after 2012. As the urban literature on persistence emphasizes the role of increasing return to scale: the density drawn by initial temporary shocks increases local productivity or amenities, which helps to retain the firms and residents attracted by the initial shocks and keeps attracting new businesses. In the right two panels of Figure 7, we plot the long-term RD estimate. Though the distance to border specification finds more optimistic results (Panel B) compared with the longitude and latitude specification (Panel A), it is however consistent that estimates after 2012 are largely constant, suggesting that the economic growth rates between Western townships and the controls have been quite similar in the long run. On one hand, it seems that the economic masses accumulated in Western township through the earlier phase of Western Development Program have not quickly dissipated after the scaling down of treatment intensity, indicating some persistence. On the other hand, the lack of growth momentum after 2012 suggests against the existence of strong agglomeration economies in Western townships that may help to self-sustain their economic growth. In addition, as the Western Development Program is still ongoing as of 2019 despite a reduction in investment amount, the closing gap in growth rates between the Western townships and the controls from 2012 to 2019 reveals little marginal return to new program investments in the long-term.

4.3 Heterogeneous treatment effects by initial endowment

Although our RD estimates suggest that Western Development Program brought output growth and relieved the inequality between the east and the west, the aggregate estimate might conceal great heterogeneity in policy responses across localities. Understanding this could help policymakers refine policy targeting and adjust the types of treatment to places with different initial endowments. It also remains to be investigated whether uniform transfers to the whole western region would widen inequality within the treated areas through the reallocation of labor and capital.

We proceed with our analysis by estimating the heterogeneous treatment effects of the Program. To obtain a comprehensive measure of the initial endowments in 2000 (the year the Program started), we combine different dimensions of infrastructure, industrialization level and population density into a single definition. A township is identified as one with less favorable initial endowments if either its distance to the nearest railway, county industrial GDP share, or population density is below the median. As a result, 56% of all 3,860 western townships are identified as favorable places, showing strong correlation in these three indicators.

Table 3 presents the results. We include a dummy "developed" for the 56% of townships meeting the criteria and introduce its interaction with treatment variables into the baseline model[18]. In Columns (2) and (4), we find that the coefficient estimate of the interaction term is significant for both specifications, while that of the treatment indicator decreases and even becomes insignificant, suggesting that those more developed areas are the main beneficiaries of the Western Development Program. It seems that the place-based policy may fail to provide as much aid to the most needed. In addition, Columns (5) – (8) present the heterogeneity in the treatment effect after 2012. Compared to the results from the first four columns, although the treatment effect is smaller in magnitude, the coefficient estimate of the interaction term remains significant and positive. However, the treatment effects of the Western Development Program on less-developed areas become small or even insignificant. Taken together, western townships with better initial endowment in 2000 have continued to develop faster than the less-developed western townships since the Program started[19]. In the appendix, we find that these findings are robust when we replace the initial endowment measure with the initial per capita GDP.

5 Mechanisms and discussion

5.1 The sources of heterogeneity

A possibility of the source of heterogeneity is that the allocation of program resources across regions depends on initial conditions. For instance, the placement of roads and railways would prioritize larger and more central towns. A significant

18 In this case, we estimate the following equation: $y_{is} = \alpha + \beta West_i + \delta West_i \times Developed_i + X'\gamma + f(geographic\ location_i) + \delta_s + \epsilon_{is}$, where y_{is} indicates the log change in distance to the nearest railway or light intensity.

19 For our tests to be valid, we also conduct an additional test on the heterogeneity among urban and rural areas. See Appendix Table A 4.

proportion of fiscal transfers in China are allocated as earmarked grants. These grants are project-based with funds directed toward specific purposes, such as infrastructure, social housing, agriculture and energy conservation. It is likely that the allocation of such grants takes account of the capacity of local governments in supporting these projects, which arguably correlates positively with the initial development of local areas. Political connections are also shown to have positive impacts on the allocation of fiscal resources and bank credit (Jiang and Zhang, 2020). It is likely that the less-developed areas are also less connected politically.

We first estimated the border effect on county government's per capita budgetary fiscal expenditure and per capita amount of local loans[20]. Columns (5) to (10) in Table 4 show no visible differences between developed and underdeveloped counties on fiscal expenditure, amount of local loans, and government infrastructure investments[21] as the coefficient estimates of the interaction terms are insignificant. The results suggest that the distribution of government infrastructure investment, fiscal and financial resources under the Western Development Program appears even across places. The less-developed areas were not unfavorably treated; of course, they also did not receive additional help to compensate for their initial disadvantages.

Further tests are conducted to investigate the heterogeneity in firm activities, and population density. In column (4) of Table 5, we find that the Western Development policy led to a reduction in the number of new manufacturing firms, especially in initially less-developed regions, while simultaneously increasing new firm establishment in more prosperous treated areas. These outcomes imply capital flows from less developed areas to more developed regions within the treated region. A possible explanation is that Western-development-induced investments and business promotion policies accentuate the locational advantages in the developed areas, which helps them further attract businesses and investment. The concentration of industry clusters and established business networks in the more prosperous areas could create a favorable environment for new firms to thrive and expand.

Finally, we evaluate the impact of Western Development on population density. In the urban studies literature, density has been an important indicator of agglomeration economies. It has been argued that densely populated, diverse areas can promote innovation and facilitate the spread of new ideas, especially with the concentration of more educated workforce (Glaeser and Gottlieb, 2008; Moretti, 2004; Shapiro, 2006; Saiz, 2010). However, in our context, we find that the Western Development Program had a negative impact on population density for both developed and underdeveloped areas and had no effect on the literacy rate (see Table 4). The reduction in population density might be the result of easier transport access. The construction of new transportation infrastructure lowered the cost of migration, making western residents easier to migrate to the coastal regions. The coefficients on the treatment indicator and

20 In this section, our main sample observations are county governments, which are in charge of distributing fiscal resources downward to townships.

21 Infrastructure investment data is collected from China County Statistic Yearbook.

interaction terms are significant but opposite in direction, meaning that townships with better initial endowment experienced less population outflow, while the less-developed townships suffered great population loss.

5.2 Household welfare outcomes

We next turn to the policy impact on household welfare. In addition to GDP growth, do we observe an improvement in living standards in the treated areas, especially those with worse initial endowment? Various welfare indicators are collected from the statistical yearbooks. Unlike the satellite data, they are observed only in the census years. Consistent with the previous analysis, we evaluate the RD estimate only on the growth of key outcomes from 2000 to 2010. The policy effect is estimated from a model similar to Equation 1, and the unit of observation is a county.

The socioeconomic indicators were collected from the China Population Census and county yearbooks. Columns (1) - (3) in Panel A of Table 6 report policy effects on social welfare indicators related to healthcare and education. The effects, however, are mixed. Due to the Program, the number of hospital beds per capita increased by 16.7% during the first decade of its implementation, suggesting that the government does improve the provision of public goods. However, the Program does not have a positive effect on the number of primary and secondary school students enrolled or the literacy rate.

For household welfare, Columns (4) - (7) in Panel A of Table 6 show that Western Development had a positive effect only on average housing area per household. The impacts on access to tap water and wire telephones were also positive, although not precisely estimated. Western Development Program had limited impact on savings, which means that the gap still existed after the scheme had been implemented for 10 years. Although the overall effects on household welfare appear mixed, Panel B of Table 6 shows that they are largely homogenous across initial development levels, or even slightly larger for the least-developed areas. On a positive note, in terms of reducing the disparity in public service provisions, fiscal transfer appears to be a more effective strategy for less-developed areas compared to subsidies and tax incentives, which are often intended for creating business agglomerates.

6 Policy implications

The findings of this study provide several important implications for place-based policies in reducing regional disparities. First, we find that though usually designed to reduce regional disparity, place-based policies may on the contrary exacerbate inequality within the targeted region since they favor industries and areas with initial advantages (Gagliardi & Percoco, 2016; Percoco, 2017; Di Cataldo & Monastiriotis, 2018; Bailey et al., 2023). Building upon empirical analysis on the impact of China's Western Development Program, we suggest that policymakers should not view the targeted region as a homogenous part when designing a place-based policy. In a large geographically disadvantaged region, such as western China, we should not expect state-led industrialization to work equally well in all subregions, as the locational fundamentals in some areas might be too poor to support agglomeration economies. The positive growth effects in other areas would further attract labor and capital from those initially disadvantaged areas, exacerbating regional inequality. A fine-tuned policy that balances equity with efficiency should set different policy goals for areas that differ in their initial endowments, and take into consideration the mobility in factors from the disadvantaged areas.

Second, our findings indicate the importance of customizing the assistance provided in place-based policy packages based on the unique characteristics and resources of different areas within the policy-targeted region. In better endowed areas or larger cities with favorable location advantages and infrastructure, the focus should be on attracting businesses and fostering local agglomerations. This can be achieved through measures such as tax incentives, improved access to credit, and enhanced transportation and energy infrastructure. Conversely, in economically disadvantaged areas, greater emphasis should be placed on supporting the provision of essential public goods like education and healthcare, along with basic infrastructure through fiscal transfers. These findings align with the recommendation put forth in the literature (Barca et al., 2012; Iammarino et al., 2019; Flanagan et al., 2022), emphasizing the need for regional policies that not only prioritize technological capabilities and opportunities but also address regionally based societal and collective challenges through a participatory approach.

Finally, our paper also calls into attention the persistence effects of place-based policies in achieving long-term economic improvements in disadvantaged areas, even after the subsidies have ended. We have documented mixed evidence: the growth rate of treated western regions have stayed higher than the control region during the subsidies period, but the growth rate gap diminished after the gradual phasing out of initial investments. These growth effects, however, are limited to townships with better initial endowment. These heterogeneous persistence effects provide valuable insights for policymakers in designing effective and sustainable interventions and determining an optimal treatment regime or sequence (Kim, 2023).

7 Conclusion

This paper investigates the effects of place-based policies on regional economic development via analyzing China's Western Development Program started in 2000. Since the adjacent western and eastern townships in border areas have similar initial features, the geographic discontinuity at the policy boundary allows us to apply a spatial RD approach to estimate the policy impact. By measuring the change in the intensity of light emissions from 2000 to 2010, we find a substantial increase in economic output growth in western townships after the start of the Program. Western Development Program has increased the light intensity of western townships by approximately 16% to 20% in ten years with respect to eastern townships near the border, which can be translated to an increase of 1.36 to 1.7 percentage points in the average annual GDP growth rate. Our main contribution is to evaluate the heterogeneity in the treatment effects of the program and investigate the potential channels. We find, despite the initial goal of reducing regional inequality, the policy unintentionally enlarges inequality within the policy-targeted region, as the treatment benefits are reaped by the relatively well-off areas, leaving the poor and underdeveloped areas further lagging behind.

There are two potential caveats related to the current study. First, our study focuses on the heterogenous treatment effects of the place-based policy and its welfare effects. Although we show that the West Development Program does not seem to damage control areas closer to the border, we cannot rule out negative spillover effects that are not distance-dependent (e.g., fiscal redistributions from appointed provinces). Second, although we found the policy effects dropped significantly as the fiscal transfers reduced from 2012 to 2019, we could not rule out the treatment effects over a longer time horizon since the scheme is still ongoing. More in-depth studies on the interaction of Western Development and the fiscal and political system in China over a longer period of time are left to future research.

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Tables

Table 1 Summary Statistics in 2000

	West	East	Mean difference (s.e.)
	(1)	(2)	(3)
Panel A. Township-level observations			
light intensity in 2000	1.69	2.5	−0.81
			(0.78)
population density in 2000 (people per square kilometer)	199.87	221.73	−21.85
			(38.65)
elevation (meter)	671.36	566.17	105.18
			(84.95)
slope (%)	4.22	3.64	0.58
			(0.62)
number of urban townships	732	658	
number of rural townships	276	530	
Observations	1,008	1,188	
Panel B. County-level observations			
GDP (ten thousand, in log)	11.30	11.60	-0.30
			(0.26)
GDP in agricultural sector (ten thousand, in log)	8.86	8.96	−0.10
			(0.28)
GDP in industrial sector (ten thousand, in log)	8.51	9.02	−0.51*
			(0.30)
fiscal revenue (ten thousand, in log)	6.79	6.94	−0.15
			(0.23)
fiscal expenditure (ten thousand, in log)	7.75	7.88	−0.13
			(0.13)
infrastructure expenditure (ten thousand, in log)	7.58	7.47	0.11
			(0.21)
population (ten thousand)	38.95	43.88	−4.93
			(7.68)
urbanization rate	0.12	0.15	-0.03
			(0.02)
migrant rate	0.029	0.033	−0.004
			(0.005)
employment proportion	0.054	0.053	−0.001
			(0.001)
literacy rate (%)	89.07	91.58	−2.51*
			(1.32)
Observations	63	61	

Note: The sample includes observations located within a bandwidth of 2×50 km from the Western Development boundary. Panel A documents township-level variables. Panel B presents county-level variables with data collected from different sources, including the China County Statistic Yearbook and Population Census. “Urbanization rate”, “Migrant rate”, and “Employment proportion” are the urban population, newly moved-in migrants and employed workers divided by total population. *p<0.1; **p<0.05; ***p<0.01. The reported standard errors are clustered by boundary segments.

Table 2 Border effect in the baseline RD regression

	log light intensity growth, from 2000 to 2010				log light intensity growth, from 2012 to 2019			
	Geographical controls							
	longitude and latitude		distance to border		longitude and latitude		distance to border	
	<50km	<100km	<50km	<100km	<50km	<100km	<50km	<100km
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
west	0.174***	0.192***	0.205**	0.166**	0.008	0.019	0.079**	0.054*
	(0.054)	(0.046)	(0.099)	(0.069)	(0.022)	(0.019)	(0.040)	(0.028)
Observations	2,193	4,178	2,193	4,178	2,194	4,184	2,194	4,184
R^2	0.085	0.066	0.081	0.062	0.173	0.186	0.157	0.167

Note: The table reports the results from the baseline regression model. The dependent variable is ln(LightIntensity2010 + 0.1) -ln(LightIntensity2000 + 0.1) and ln(LightIntensity2019 + 0.1) -ln(LightIntensity2012 + 0.1). All regressions control for segment fixed effect and include time-invariant controls. *p<0.1; **p<0.05; ***p<0.01.

Table 3 The heterogeneity in treatment effects[22]

	Dependent variable: change in log light intensity from 2000 to 2010				Dependent variable: change in log light intensity from 2012 to 2019			
	Geographical controls							
	longitude and latitude		distance to border		longitude and latitude		distance to border	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
west	0.264***	0.122**	0.241***	0.098	0.049**	0.0007	0.103***	0.068**
	(0.052)	(0.059)	(0.076)	(0.082)	(0.020)	(0.022)	(0.029)	(0.031)
west×developed		0.270***		0.265***		0.088***		0.064***
		(0.052)		(0.051)		(0.020)		(0.019)
Observations	3,358	3,348	3,358	3,348	3,342	3,342	3,342	3,342
R^2	0.075	0.083	0.071	0.078	0.18	0.18	0.16	0.16

Note: The table reports the results from the baseline regression model. The dependent variable is the log change in light intensity. "developed" is an indicator that equals 1 if the township is identified as a more developed place in 2000. All regressions control for segment fixed effect and include time-invariant controls. The bandwidths are set at 100 km. *p<0.1; **p<0.05; ***p<0.01.

22 The sample is restricted to townships with available records in infrastructure, industrial production and population in 2000, which are used to define the initial development status.

Table 4 Test for the source of heterogeneities

	light intensity	light intensity	population density	population density	per capita fiscal expenditure	per capita fiscal expenditure
	(1)	(2)	(3)	(4)	(5)	(6)
west	0.022	-0.000	-0.024	-0.079***	0.218***	0.229***
	(0.013)	(0.017)	(0.017)	(0.021)	(0.043)	(0.046)
west×Developed		0.039***		0.096***		-0.043
		(0.019)		(0.023)		(0.048)
Observations	207	207	201	201	207	207
R^2	0.460	0.473	0.408	0.461	0.559	0.561
	per capita local loans	per capita local loans	per capita infrastructure investment	per capita infrastructure investment		
	(7)	(8)	(9)	(10)		
west	0.229***	0.269***	-0.045	0.057		
	(0.068)	(0.075)	(0.149)	(0.164)		
west×Developed		-0.147		-0.350		
		(0.114)		(0.245)		
Observations	203	203	197	197		
R^2	0.209	0.216	0.142	0.151		

Note: The table reports the results from the baseline regression model with additional interactions. All Dependent variables measure change from 2000 to 2010 and take log form so the coefficients measure change in percent. All regressions control for segment fixed effect and include time-invariant controls at the bandwidth of 100 km. “Developed” is an indicator that equals 1 if the township or county is identified as a more developed place in 2000. *p<0.1; **p<0.05; ***p<0.01.

Table 5 Western Development Effect on Firm Entry

	Log(#Firm Entry)		Log(#Mfg. Firm Entry)		Log(#Agr. Firm Entry)		Log(#Service Firm Entry)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
west	-0.529	-0.883	-0.749	-1.173**	-0.528	-0.740	-0.472	-0.891
	(0.505)	(0.538)	(0.481)	(0.514)	(0.459)	(0.492)	(0.516)	(0.552)
west×dev		0.633*		0.745**		0.376		0.739**
		(0.345)		(0.341)		(0.317)		(0.366)
Observations	198	198	213	213	199	199	212	212
R^2	0.434	0.444	0.404	0.418	0.451	0.455	0.442	0.454

Note: The table reports the results from the baseline regression model at county level. The dependent variable is log number of new entry firms. All regressions control for segment fixed effect and include time-invariant controls. Bandwidth is selected as 500 km. *p<0.1; **p<0.05; ***p<0.01.

Table 6 Changes in welfare outcomes in counties

	Social Welfare			Household Welfare			
	hospital bed	student	literacy	housing area	tap water	telephone	saving
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. Average Treatment Effect							
west	0.167**	-0.049	-0.0001	0.098***	0.098	0.135	0.017
	(0.068)	(0.041)	(0.007)	(0.029)	(0.117)	(0.090)	(0.065)

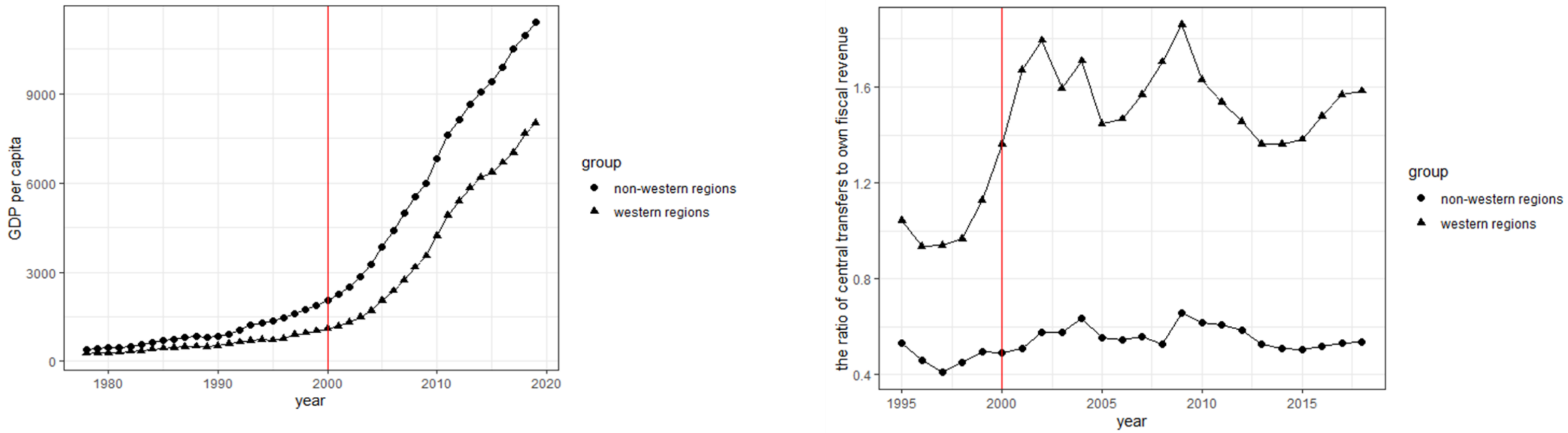
Observations	214	214	210	210	210	214	208
R^2	0.174	0.418	0.419	0.414	0.381	0.333	0.433
Panel B. Heterogeneity							
west	0.146*	-0.043	0.006	0.125***	0.231	0.195	0.063
	(0.088)	(0.054)	(0.009)	(0.039)	(0.157)	(0.120)	(0.084)
west×Developed	0.048	-0.031	-0.011	-0.024	-0.253	-0.129	-0.065
	(0.097)	(0.060)	(0.010)	(0.043)	(0.173)	(0.132)	(0.094)
Observations	205	205	201	201	201	205	201
R^2	0.19	0.44	0.43	0.43	0.38	0.32	0.45

Note: These regressions measure the change in welfare outcomes from 2000 to 2010. "Hospital bed" is the number of hospital beds per 10 thousand people. "Student" is the number of primary and secondary school students per 10 thousand people. "Literacy" is the percentage of literate population to the total population. "Housing area" is the per household housing area. "Water" and "telephone" is the fraction of households that have access to tap water and wire telephones. "Saving" is the average savings per household (in 10,000). "Mean difference" reports the mean difference of each indicator between the treatment group and the control group in 2000. "Developed" is an indicator that equals 1 if the county is identified as a more developed place in 2000. All dependent variables take log form, so the coefficients measure change in percent. Regression control for polynomial of latitude and longitude. The bandwidth is 100 km. All standard errors of mean difference are clustered in segments. *p<0.1; **p<0.05; ***p<0.01.

Figures

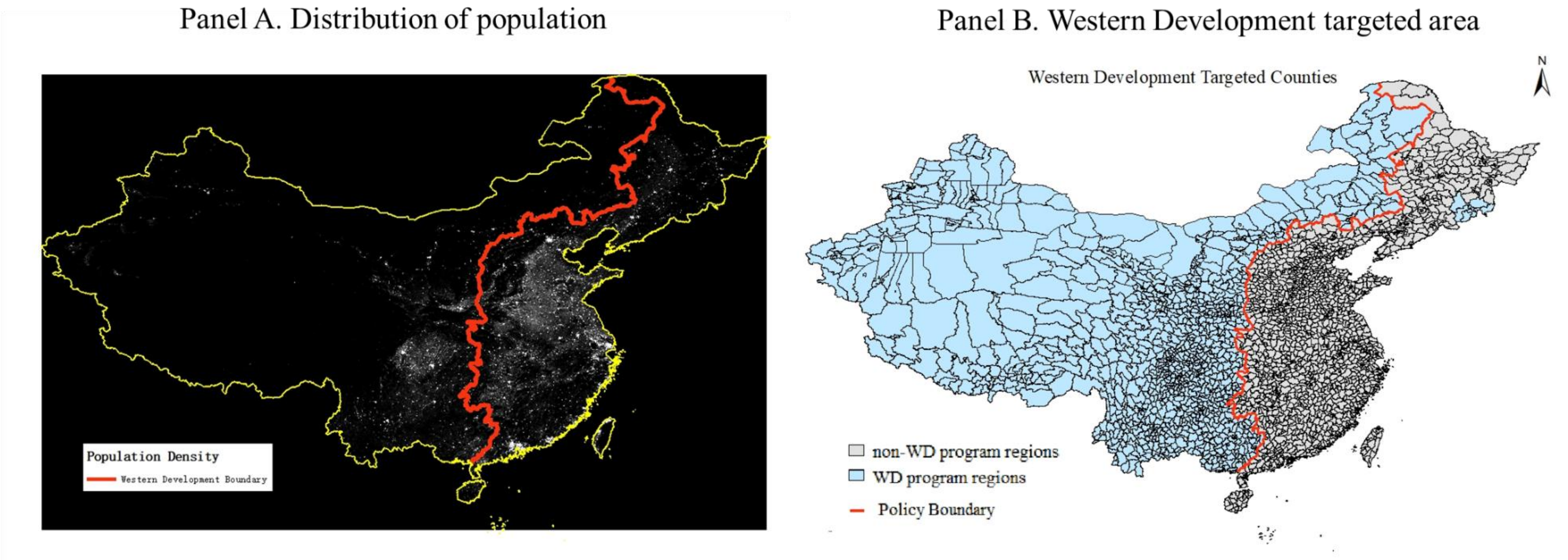
Panel A. GDP per capita

Panel B. Public finance



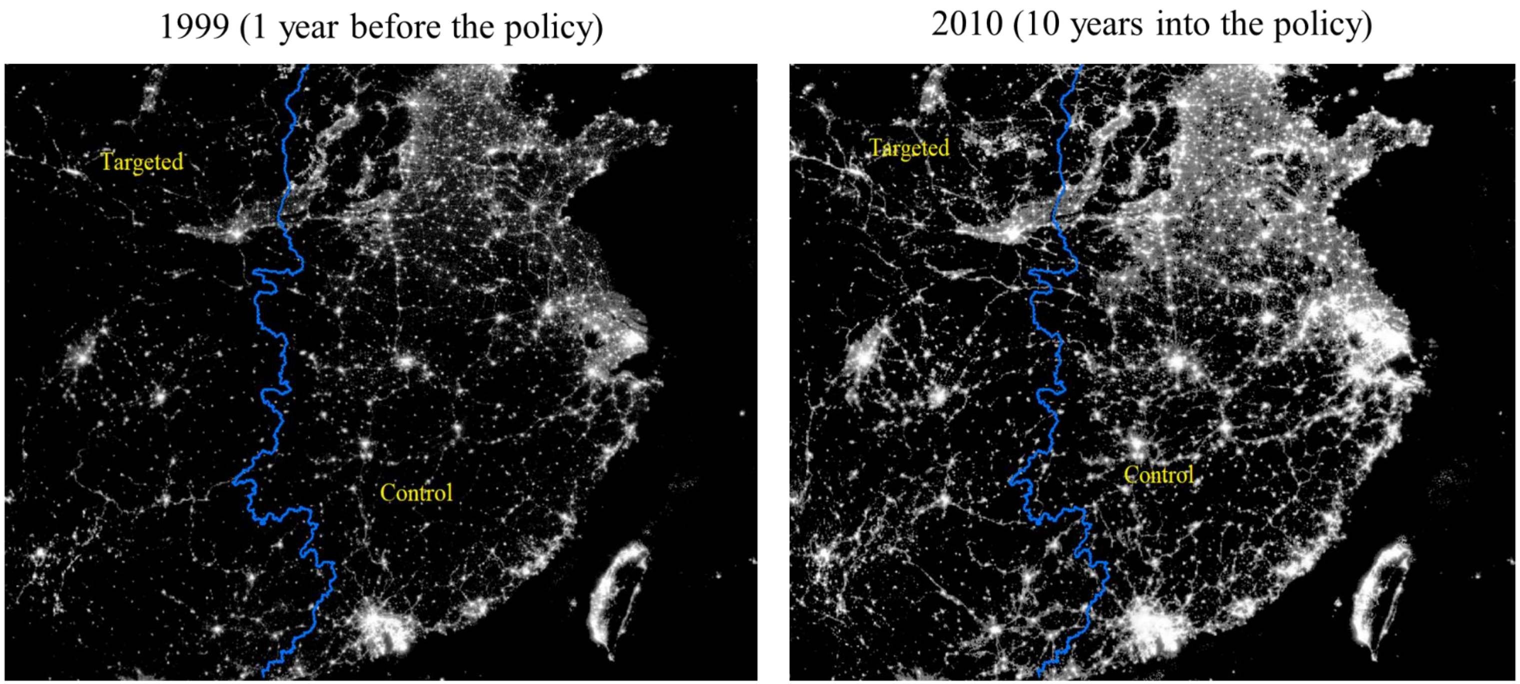
Note: Panel A shows the changes of GDP per capita for western region and non-western region (adjusted to the constant price in 1978) from 1978 to 2020. The unit is RMB Yuan. Panel B shows ratio of central transfers to local governments' own fiscal revenue for western and non-western regions. The red line indicates the start year of the Western Development.

Figure 1 GDP and public finance for the western and eastern regions



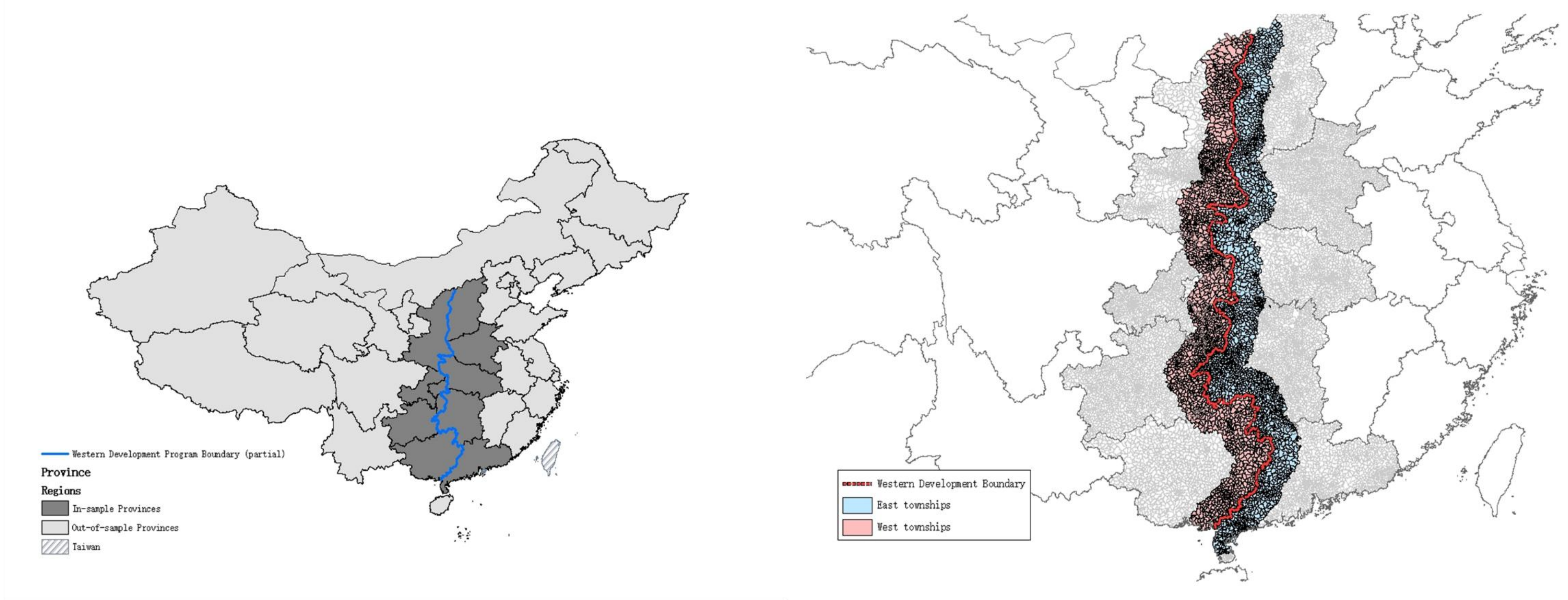
Note: Panel A shows the population density in 2000. The brighter area suggests higher population density in the 1*km*× *1km* grid. The red curve is the boundary of the Western Development Strategy. Panel B shows the spatial distribution of the Western Development program (in counties). The solid red curve is the main boundary of the policy. Regions painted in blue (grey) are (not) covered. To control for spatial continuity, the observations in Yanbian are omitted in the main regressions.

Figure 2 Western Development Targeted Areas



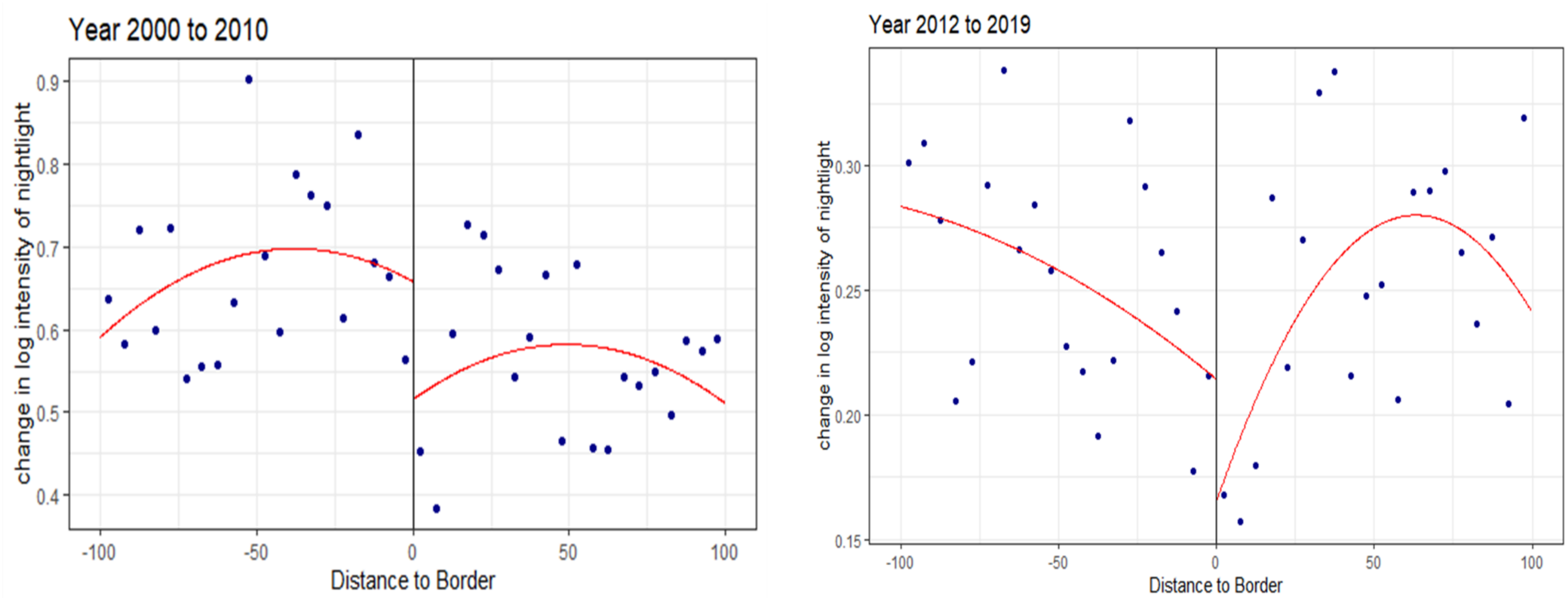
Note: Raw satellite imagery of nighttime light emissions from DMSP/OLS The thick blue curve is the policy boundary.

Figure 3 Nighttime light emissions pre and post-Western Development



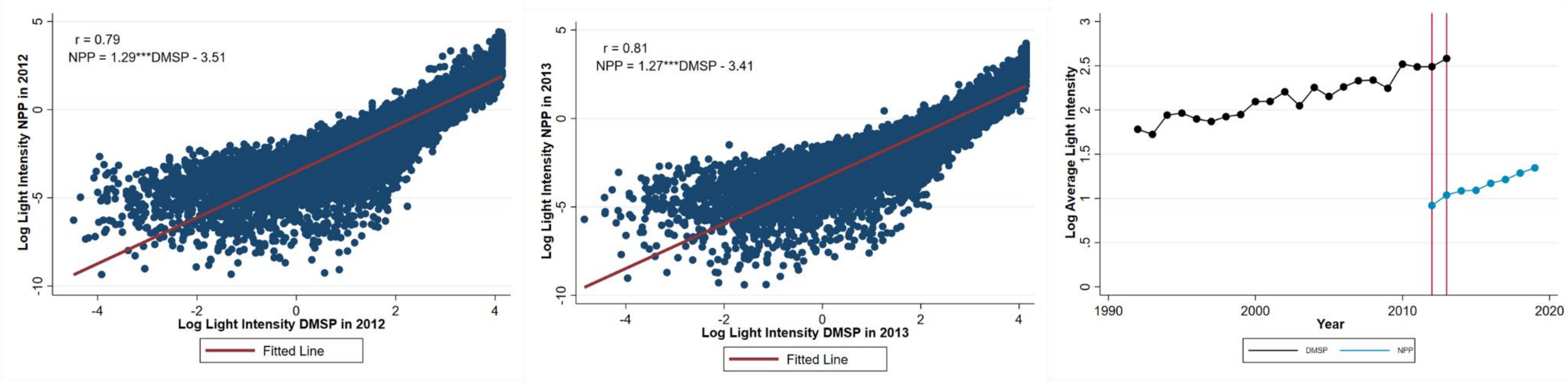
Note: In the left panel, the blue curve is the partial boundary of the policy. Regions painted in thicker (lighter) gray are (not) included the adjacent provinces at the border. The right panel shows the townships within 2×100-km bandwidth, which are included in the main regression.

Figure 4 Map of the sample used in the main regression model



Note: These figure shows the discontinuity in growth of light emission intensity from 2000 to 2010 and from 2012 to 2019. The red curve fit RD regression using within a bandwidth of 100km on both side of the boundary. The x-axis denotes the distance from a town centroid to the Western Development border. Each dot represents the average of log light intensity within a 5 km bin. Bins that corresponded to negative distance values are the ones treated by Western Development.

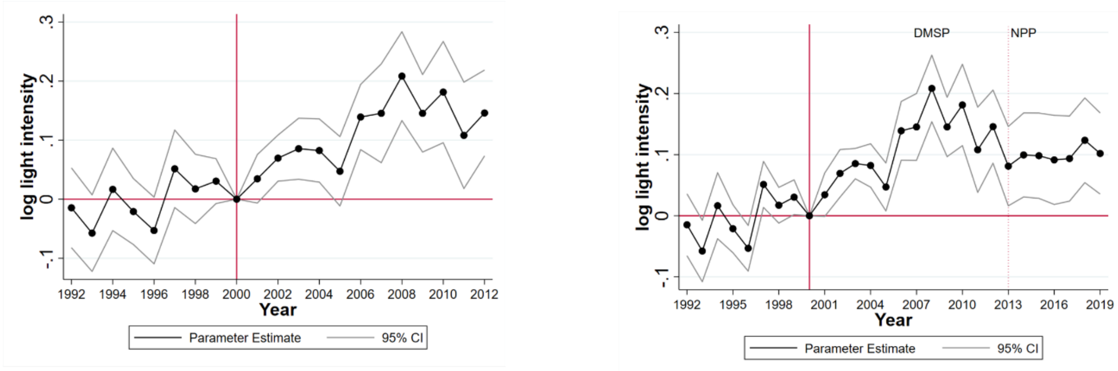
Figure 5 Discontinuity in the growth of light intensity



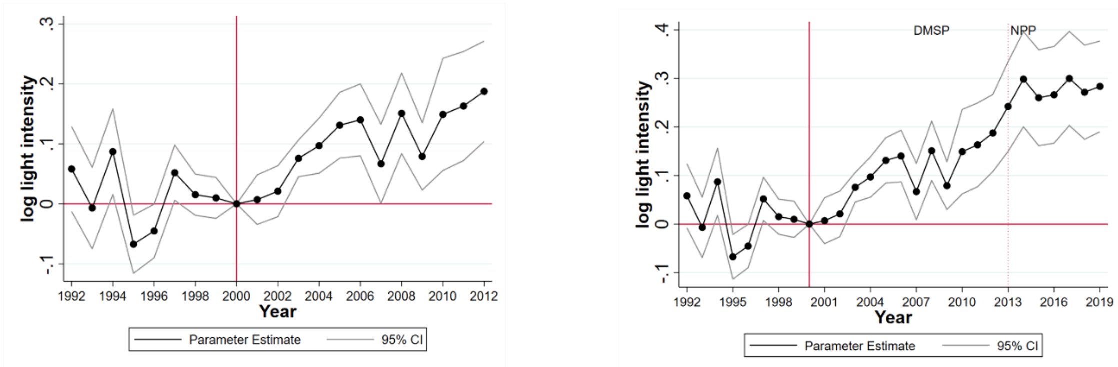
Note: This figure shows the correlation between DMSP night light series (1992-2012) and NPP night light series (2012-2019).

Figure 6 Correlation between DMSP and NPP light intensity

A. Cubic polynomial of longitude and latitude



B. Cubic polynomial of distance to the border



Note: This figure shows the dynamic of the policy effects and 95 percent confidence intervals estimated from Equation 2 and Equation 3. In the first column, the red vertical line shows the start year of the program (Year 2000). In the second column, the dotted vertical line shows the start year of NPP light series. See section 5 for details.

Figure 7 The dynamic effects across policy boundaries

Appendix

1. The relationship between night light and economic output in China. Though studies have shown that nighttime light emission is a plausible proxy for economic output, one may be concerned about the external validity of such conclusions. Given the specific context of Chinese counties, do light intensities work as well to predict economic output and welfare as they do in other contexts? We use the county panel of light series data and socio-economic indicators to examine their correlation in Western Development's context. Figure A 2 shows scatter plots of output, industrialization rate, and urbanization rate against light intensity. Similar to Henderson et al. (2012)'s estimation, we find that if light intensity increases by 1 percent, there will be a 0.85 percent point increase in GDP, a 0.13 percent point increase in industrialization rate, and a 0.04 percent point increase in urbanization rate. The R2 suggests that nighttime lights explain roughly two-fifth of the variation in output. Hence our estimation suggests that Western Development had led to a 1.36% to 1.7% annual increase in GDP, which is economically large since the average GDP growth rate of the western areas in 2000 is around 8%.

2. Effects on Regional Inequality. Due to data constraint, we don't have granular level measure of income distribution. Therefore, we detour to construct several alternative measures to study the direct effect on regional inequality.

First, we use the GDP per capita of the county in 2000 as a measure of initial endowment and revisit the heterogeneity analysis. Table A 1 presents the heterogeneities in the treatment effect. We interact the treatment dummy "west" with the log value of per capita GDP in 2010. Our findings indicate that places with 1 percent higher initial per capita GDP experience approximately 0.13-0.14% faster growth in the first decade of Western Development. This suggests that the program may have the stronger positive effect on output in places with higher per capita GDP initially, and may reduce output in places with lower per capita GDP. Combine together the results suggest an enlarging gap in income between these two types of regions.

Second, we construct Gini index at the county level as the dependent variable to measure the impact of west development program on inequality directly. To construct the county-level Gini index, we first use light intensity to proxy for per capita income in each township within the county. We obtain township-level population information from WorldPop, which estimates population density using high-resolution satellite images. Combining the population and income proxy, we construct a distribution of income $H_i(Y)$ for each county i, where:

$$H_i(I) = Pr\ (Share\ of\ Population\ with\ income\ lower\ than\ I\ in\ county\ i).$$

Let $h_i(Y)$ be the corresponding pdf function of income. The Gini index in county i is therefore given by:

$$G_i = \frac{2\int_0^{\overline{Y}}[1 - h_i(Y)]dY}{\overline{Y}}$$

In Table A 2, we have observed a positive effect of the Western Development program on the inequality levels in the treated counties. The coefficients become more significant as we increase the sample size by increasing the length of the bandwidth. This finding aligns with our main conclusion that the program potentially contributes to an increase in inequality in the treated regions.

3. Bandwidth Robustness Check. Figure A 3 presents the RD estimates obtained under different specifications. They are robust to a wide range of bandwidths and to different geographical control functions. Panel A plots the point estimates and 95% confidence intervals from Equation 1 with a cubic polynomial of latitude and longitude at different bandwidths. All estimators are significant at the conventional level at bandwidths from 50 km to150 km in 10 km increments. Panel B plots the results from the Equation (1) where the geographical function takes the form of a cubic polynomial of the distance from the town centroid to the boundary. Panel C and Panel D shows the results from linear geographical controls. These functions can be explicitly expressed by

$$f(\text{polynomial of latitude and longitude}_{\text{i}}) = \sum_{k=0}^{p} w_k \, Lat_i^k \times Lon_i^{3-k}$$

$$f(\text{polynomial of distance to boundary}_{\text{i}}) = \sum_{k=1}^{p} b_k \, Dist_i^k$$

where $p = 3$ for the cubic controls and $p = 1$ for the linear controls. In all panels, the estimated β is positively significant. Although there is a certain variation when the bandwidth is relatively small, it indicates that the Western Development does bring an impact to the western towns near the boundary.

4. Border effect across western provinces. There is a potential threat of endogeneity in our empirical setup since the boundary of Western Development overlaps with the boundary of administrative divisions. The discontinuity exists not only in the treatment of Western Development for townships on each side of the boundary, but also in the treatment of local policies. Therefore, it may be the provincial and municipal level local policies that have brought about this difference in growth rate, rather than the state-led Western Development. Even if the policy effect of the Western Development does exist, these local policies may also lead to biased estimators in our baseline model. To address the problem of endogeneity, we first equally divide the policy boundary into 10 different segments and control the segment fixed effect in our basic regression, allowing the heterogeneity of policy effects in different segments. The segment effect controls for the variations in outcome variables linked to different local policies at different provincial boundaries. A placebo test is also conducted to test whether there is heterogeneity in the development trend across western provinces. The assumption is that if a province-level policy has created a significant impact during 1992-2012, there should also be a significant border effect at the province boundary (north-south instead of west-east). We replace the boundary in the basic model with three boundaries between four western provinces and replace the treatment variable with the provincial dummy (See Figure A 4). Figure A 5 compares the development pattern in three adjacent province groups: Guangxi vs Guizhou, Guizhou vs Chongqing, and Chongqing vs Shaanxi, where townships located within 50 km to the province boundaries are included in our sample. As shown in the figure, no significant border effect exists in any of the three provincial discontinuities in 20 years, which means the impact of local policy on our estimated effect of Western Development is minimal.

5. Geographic spillovers. Another factor that would affect our interpretation of the welfare effects of Western Development is the spatial spillovers to adjacent areas. The control areas might be negatively affected by the treatment if companies and workers shifted their production to the west side of the border to reap the tax benefits. Similarly, the program may also have positive spatial spillovers. The construction of water, energy, and transport facilities in the west may also benefit the surrounding areas. In either way, the RD estimate would be subject to a violation of the stable unit treatment value assumption (SUTVA).

To test the spillover effects, we follow prior studies to conduct a spatial exclusion approach (Ehrlich and Seidel, 2018). This approach assumes that the magnitude of the spillovers is greater in areas closer to the treatment border, since the relocation cost of eastern enterprises and workers increases as the distance increases. The radiation effect of western public goods in the east decreases, as well. Therefore, removing the observations closest to the border will exclude the areas most affected by the spillover effects. We should observe a significant difference in RD estimates between the results based on the full sample and those based on the observations further away from the border, which indicated by the red and blue area in Figure A 6. In addition, we can examine the spillover effect by pushing the boundary inward and outward. If we place an imaginary boundary 50 km east or west of the original boundary, then the border effect estimated on this imaginary boundary will reflect the existence of distance-based spillovers.

For the spatial exclusion approach, we rely on the means comparison estimator that excludes the polynomials of geographical controls because these controls could capture the spillover effects and leave the estimate less sensitive to potential spatial spillovers. Table A 3 reports the results of this approach. The Wald test shows that the border effect estimates for both samples (Columns 2 and 3) are not significantly different from the baseline estimate (Column 1), giving little evidence of the existence of spillovers. Columns (4) - (6) report the border effect estimates based on the imaginary boundary approach. Similarly, the Wald test suggests that the border effect exists only at the real boundary. These results suggest that our findings from the above sections are unlikely to be disrupted by geographical spillovers at the border.

6. Heterogeneity in urban and rural divisions. We distinguish the urban and rural areas basing on the definition of China's administrative divisions. In China’s government system, “Townships” are the fundamental division to distinguish urban and rural area. There are several types of townships, including "subdistricts (Jiedao)", "towns (Zhen)", and "townships (Xiang)". "Subdistricts" and "towns" are identified as urban divisions, which are usually areas with a higher level of concentration of industry and commerce or a higher proportion of the non-agricultural population, while "township (Xiang)" refers to rural areas. In other words, urban divisions are usually developed areas with better initial endowments, which might lead to difference in treatment effects. Similar results are found that less-developed rural areas are benefiting less from Western Development (Table A 4).

7. Preliminary Cost-Effectiveness Assessment.

Next, we endeavor to conduct a rough cost-benefit analysis of the policy. It should be interpreted with great caution as the analysis is based on rather strong assumptions. Table A 5 reports the estimated monetary benefit, i.e., GDP growth. The first column represents three different estimation models. The second column shows the impact of Western Development on the light intensity from 2000 to 2010, which increased by 16.6% - 19.2%. We estimated the correlation between China's GDP and light intensity and found that if light intensity increases by 1 percent, there will be a 0.85 percent point increase in GDP. Hence our estimation suggests that Western Development had led to a 13.6% to 17% increase in GDP since 2000 (Henderson et al., 2012). The total GDP of the West in 2000 was converted into the constant price in 1978, which was about 48.1 billion US dollars. Assuming that the economic growth effect near the border is applicable to all western regions (relatively conservative), the GDP growth brought by the western development will be about 7.3-7.8 billion US dollars in ten years. According to the data released by the National Development and Reform Commission, the central investment in the western development was about 2882.2 billion yuan from 2000 to 2010, which was about 79.4 billion US dollars after adjusting to the 1978 price. Therefore, the benefit-cost ratio is between 8.5% - 9.9%.

Note that we only get a rough understanding of cost efficiency from this table, as we are basing on LATE estimates. Under a rather strong assumption that the border effect is representative of the treatment effects over the whole region, we can compare Western Development's yield with other place-based policies. For example, Kline and Moretti (2014a) found that the yield of the Tennessee Valley Authority program in the U.S. was about 138%. Shenoy (2018) found that the benefit-cost ratio of fiscal subsidies to Uttarakhand was between 65% and 155%. However, this does not mean that Western Development is a failure. On the one hand, Western Development has a massive scale and covers a much longer time period, such a rate of return is considerable economically.

Appendix Table

Table A 1 The heterogeneity in treatment effect: Measured by per capita GDP

	Log change in light intensity from 2000 to 2010	
	longitude and latitude	distance to border
	(1)	(2)
west	-0.626*	-0.577*
	(0.365)	(0.350)
west×log(per capita GDP 2000)	0.139**	0.129**
	(0.056)	(0.054)
Observations	3,370	3,370
R^2	0.08	0.07

Note: The table reports the results from the baseline regression model with additional interactions. The dependent variable is ln(LightIntensity2010 + 0.1)- ln(LightIntensity2000 + 0.1). All regressions control for segment fixed effect and include time-invariant controls at the bandwidth of 100 km. "log(per capita GDP 2000)" is the log value of per capita GDP in 2000. *p<0.1; **p<0.05; ***p<0.01.

Table A 2 Effect on county-level Gini index

	Dependent variable: change in Gini index from 2000 to 2010	
	Geographical controls	
	longitude and latitude	distance to border

	(1)	(2)	(3)	(4)	(5)	(6)
west	0.0385	0.0750*	0.0795**	0.0551	0.0878	0.0888**
	(0.0561)	(0.044)	(0.0344)	(0.0931)	(0.0559)	(0.035)
Observations	276	552	968	276	552	968
Sample	< 100 km	< 200 km	Full Sample	< 100 km	< 200 km	Full Sample
R^2	0.154	0.094	0.083	0.125	0.079	0.069

Note: The table reports the results from the baseline regression model at county level. The dependent variable is estimated Gini-index. We use light night intensity to proxy for township level income to estimate county level Gini-index. All regressions control for segment fixed effect and include time-invariant controls. *p<0.1; **p<0.05; ***p<0.01.

Table A 3 Test on geographical spillovers

	Dependent variable: change in log light intensity from 2000 to 2010					
	Spatial Exclusion Approach			Imaginary Boundary Approach		
	<100 km			<100 km		
	Baseline	Excluding observations within 2×30-km bandwidth	Excluding observations within 2×50-km bandwidth	Original boundary	Pushing the boundary 50-km east	Pushing the boundary 50-km west
	(1)	(2)	(3)	(4)	(5)	(6)
Border effect	0.178***	0.210***	0.211***	0.166**	0.025	−0.117
	(0.029)	(0.035)	(0.043)	(0.069)	(0.070)	(0.082)
Observations	4,178	2,782	1,985	4,178	4,447	3,873
Test on the equality with the baseline		*p=0.43*	*0=0.45*	*p=0.016*	*p=0.73*	*p=0.15*

Note: Columns 1–3 report diff-in-diff estimators. Columns 4–6 use distance to boundary specification. Bandwidth is set at 2×100 km. The last row of Columns 2-3 reports the results of the Wald test on whether the estimates are equal to the baseline estimate. The last row of Columns 4-6 reports the results of the Wald test on whether the estimates equal to 0. *p<0.1; **p<0.05; ***p<0.01.

Table A 4 Heterogeneity in treatment effects in urban/rural area

	Dependent variable: change in log light intensity from 2000 to 2010					
	Geographical controls					
	longitude and latitude		distance to border		DID estimates	
	(1)	(2)	(3)	(4)	(5)	(6)
west	0.192***	0.113*	0.166**	0.086	0.178***	0.038
	(0.046)	(0.065)	(0.069)	(0.087)	(0.029)	(0.053)
west×Urban		0.215***		0.209***		0.213***
		(0.057)		(0.056)		(0.056)
Observations	4,178	3,358	4,178	3,348	4,178	3,348
R^2	0.066	0.079	0.062	0.075	0.062	0.074

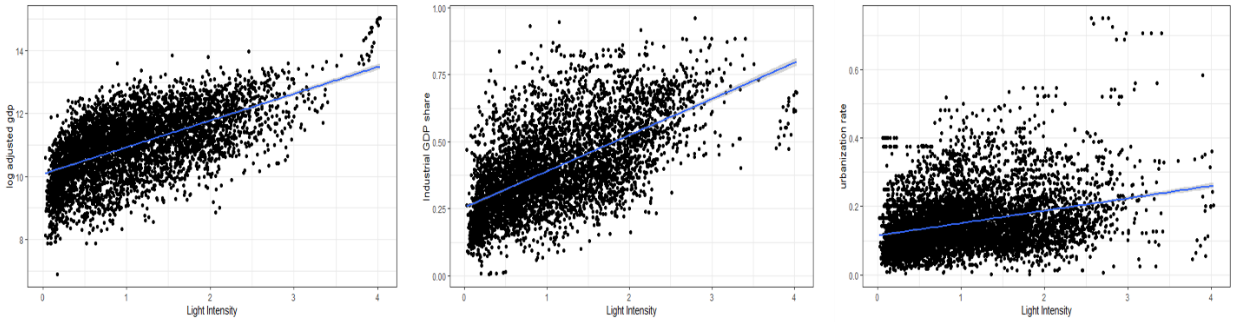
Note: The table reports the results from the baseline regression model. The dependent variable is ln(LightIntensity2010 + 0.1) ln(LightIntensity2000 + 0.1). "Urban" is an indicator that equals 1 when the observation is an urban township. All regressions control for segment fixed effect and include time-invariant controls. The bandwidths are set at 100 km. *p<0.1; **p<0.05; ***p<0.01.

Table A 5 Cost-benefit analysis (2000-2010)

Monetary Value			
Benefit	light intensity	GDP growth rate	added GDP
Geographical function			
Longitude and latitude	19.20%	16.30%	7.84 billion
Distance to boundary	16.60%	14.10%	6.78 billion
DID estimates	17.80%	15.10%	7.31 billion
Cost			79.4 billion
Benefit/Cost			8.5% - 9.9%

Note: All monetary values are adjusted to 1978 price in US dollar. The figures are computed using the exchange rate and price index for consumption reported by the National Bureau of Statistics in China.

Appendix Figure



Note: The figure plots the log overall GDP (adjusted to the constant price in 1978), share of industrial GDP, and urbanization rate against light intensity. The estimated regression models take linear form using pooled county observations. The R-square of the estimated regressions are 0.36, 0.37, and 0.09.

Figure A 1 Light predicts output and development

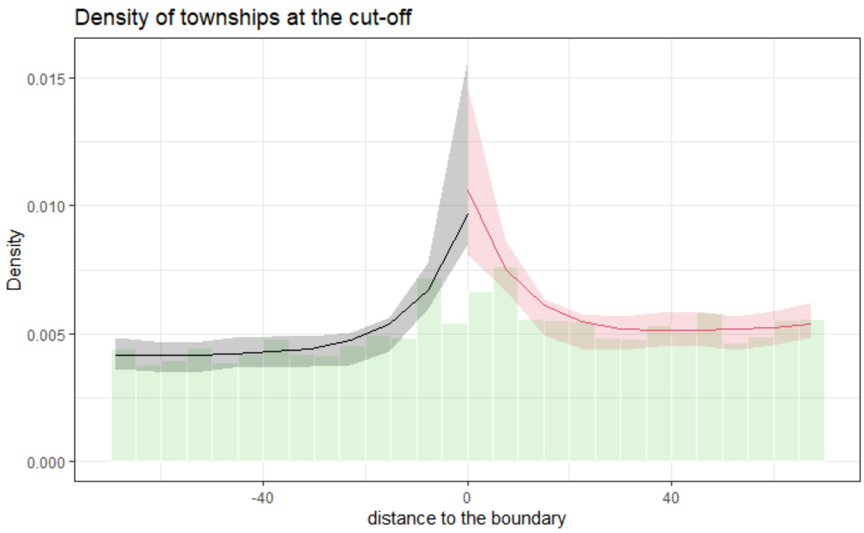
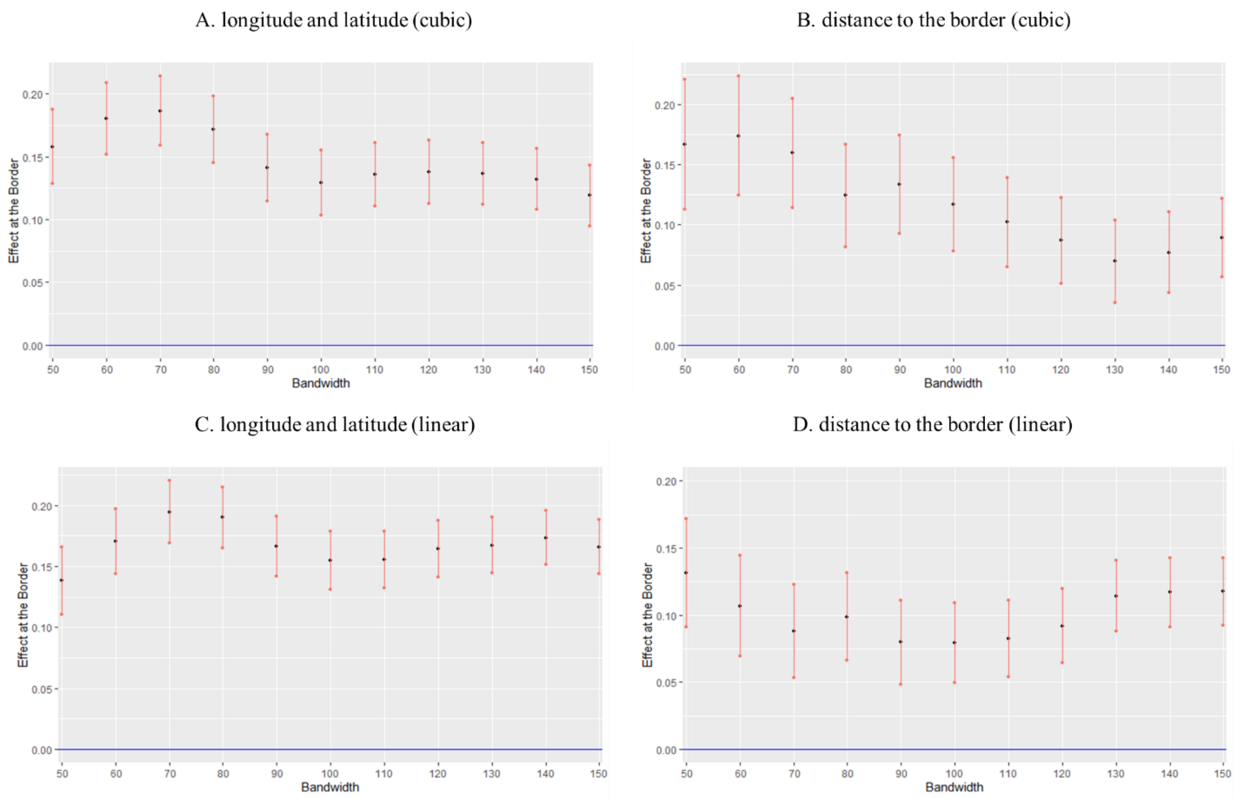
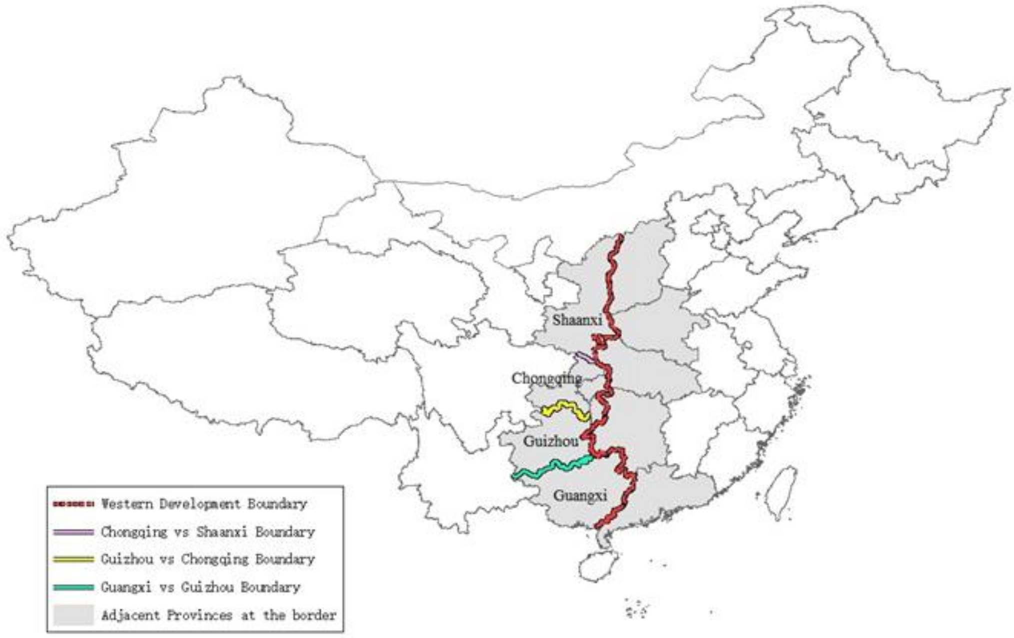


Figure A 2 Continuity at the border



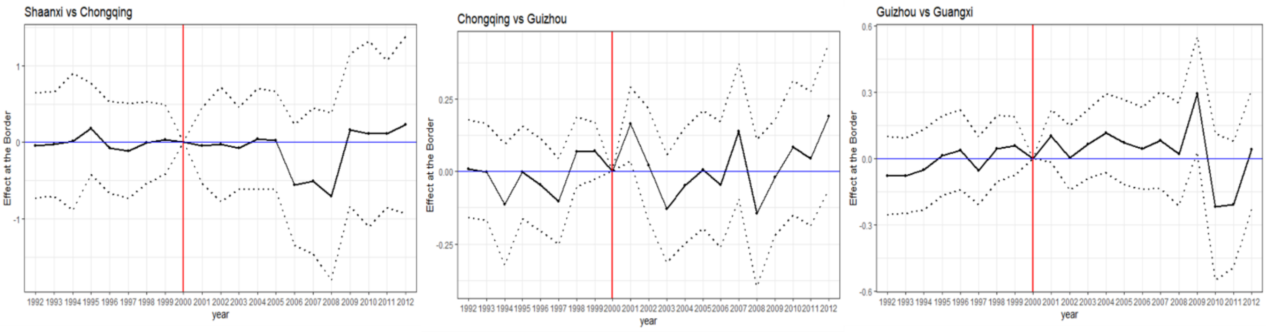
Note: This figure shows separate border effects and 95 percent confidence intervals estimated from Equation 1 using different window of bandwidths, ranging from 50-km to 150-km. Panel A plots estimates using cubic polynomial of longitude and latitude as geographic function. Panel B plots results controlling for cubic polynomial of distance to the border. Panel C and Panel D control for the linear function accordingly. All regressions control for time-invariant variables and segment fixed effect. See section 4 for details.

Figure A 3 Robustness to different bandwidths and geographical functions



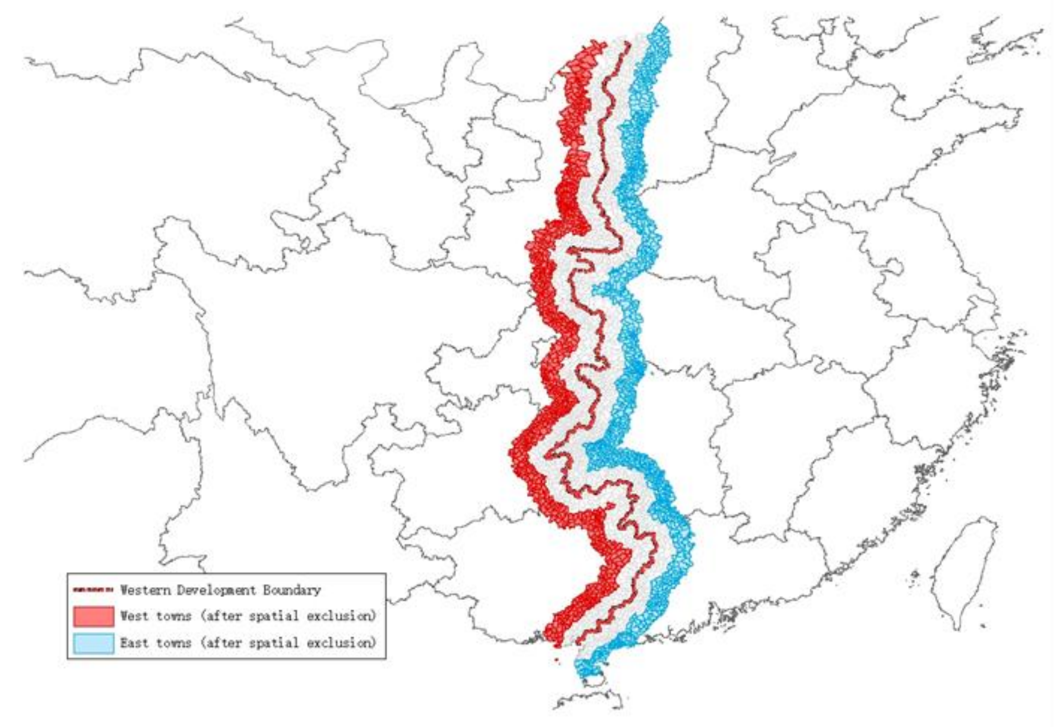
Note: This figure shows three province borders between four west provinces. The provinces filled in gray are adjacent ones at the Western Development boundary.

Figure A 4 Map of adjacent west provinces



Note: This figure shows the dynamic of border effects and 95 percent confidence intervals between targeted provinces. The solid black curves show point estimates of β in Equation 1 using different time comparisons (Treatment variable is changed to new dummies that indicate which province the town is located in.). Each group controls for a cubic of township's distance to the province border. See section 4 for details. The red vertical line shows the start year of the program.

Figure A 5 Test for parallel trends across west provinces



Note: The solid red curve is the Western Development boundary. The red and blue shaded area are towns located in targeted and non-targeted provinces within 100 km from the boundary on each side. We exclude towns within 50 km from the boundary, which are indicated by the gray area.

Figure A 6 Map of spatial exclusion