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A Blessing or a Curse? Highway Connection and the Entry of Polluting Firms in China

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Abstract: We investigate how highway connections influenced the entry of polluting firms based on panel data from 257 Chinese prefectures from 1998 to 2012. We also investigate the heterogeneity and influencing channels. We use the generalized difference-in-difference method as a tool in the empirical analysis. We have three main findings. First, highway connections increased the entry of polluting firms by 54.5 percent. Second, the heterogeneity analysis shows that this effect is mainly caused by prefectures on provincial borders, prefectures in central China, and prefectures with more than 1 million residents in urban districts. Third, highway connections reduced the concern about environmental protection by local governments of prefectures on provincial boundaries but increased concern about local governments of prefectures in interior regions. The concern about employment increased regardless of a prefecture's location in a province. These results indicate that less developed regions, i.e., those on provincial boundaries, valued the benefit of job creation for welfare improvement more than the harm of pollution. Hence, they intentionally reduced environmental regulation to induce polluting firms' entry. Our results provide new and insightful insights into the transition of economic development to a sustainable path, especially in developing countries.

Keywords: highway; entry of polluting firms; environmental protection; employment; China

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1. Introduction

Economic development has long been regarded as the primary goal in China. As an important measure to stimulate economic growth and balance economic development across regions, transportation infrastructure has been extensively constructed by central and local governments in China. In particular, since 1998 (1998 was the first year of massive construction of transportation infrastructure in China), construction on the national highway network has grown rapidly, including national projects like the "five vertical and seven horizontal" national highway trunk lines and the "7918" national highway network, consisting of 7 capital radial lines, 9 north–south vertical lines, and 18 east–west horizontal lines.

However, this rapid economic growth also triggered several noticeable problems, among which pollution received much attention. In 2003, the central government of China made an official statement that economic development should consider the cost to the environment and the efficient usage of energy resources. This point was emphasized again in 2006 when the eleventh five-year plan was announced. To align local governments' incentives with those of the central government on the issue of environmental protection, in 2007, the state council of China proposed a one-vote veto environmental pollution assessment of local leaders' performance. According to Chen et al. (2018) [1], this proposal induced Chinese local leaders to slow down economic growth as serious pollution would jeopardize their careers.

As concern for environmental protection grew, local leaders had an incentive to regulate the entry of polluting firms to balance the benefits of economic development

against the cost to the environment. With this conflicting incentive, local governments' decisions would be very complex when their local region was connected to a highway network. On the one hand, according to new economic geography, transportation factors have an impact on the spatial distribution of economic activities. And since transportation cost is one of the most important concerns of a firm when choosing its location [2] and highway connections can reduce the transportation cost in a region, ceteris paribus, this region should be more attractive for firms. This positive effect can promote local economic development. At the same time, changes in economic and geographical patterns can have an impact on pollution-intensive industries and the spatial distribution of environmental pollution [3]. On the other hand, without government intervention, polluting firms would be attracted as well, which would not only harm the environment but also jeopardize local leaders' careers. Hence, highway connections can be a blessing or a curse for a region.

In this paper, we investigate the impact of highway construction on the entry of polluting firms, heterogeneity, and influencing channels. We apply the generalized difference-in-difference (DID) method to panel data consisting of 257 prefectures in China from 1998 to 2012. We have three main findings.

First, compared to prefectures without highways, highway connections increased the entry of polluting firms by 54.5 percent. This result satisfies the parallel trend assumption and passes the placebo test. It is also consistent with the result obtained from the two-stage least-squares approach. Hence, highway connections bring about more investments but also more polluting firms to a prefecture.

Second, highway connections significantly increased the entry of polluting firms in prefectures at provincial boundaries but had no effect on prefectures in the interior of some provinces. Due to the difficulty of identifying the source of pollution at provincial boundaries and the general lack of infrastructure in such regions, these findings fit the pollution haven hypothesis, which posits that polluting firms tend to invest in regions with relatively cheap factor prices, including labor, land, and other resources. This result thereby indicates that highway connections are actually both a blessing and a curse for such regions compared to prefectures on provincial boundaries without highway connections.

The heterogeneity analysis also reveals that this positive impact was more salient in central China than in other regions. Central China has better infrastructure than western China but less environmental regulation than eastern China. In this sense, it is an ideal location for polluting industries for which infrastructure plays an important role in their business operations. The positive impact was less salient in prefectures with more than 1 million residents in urban districts, indicating that urban residents' health was still an important concern to local governments.

Finally, the mechanism analysis reveals that after the implementation of highway connections, the concern of local governments about environmental regulation increased for prefectures in the interior of some provinces but decreased for prefectures at provincial boundaries. The concern for local employment increased regardless of the prefecture's location in a province. The concern for economic development was not affected, which is consistent with the findings of Chen et al. (2018) [4].

This paper is related to three strands of the literature. The first strand considers the economic consequences of improvements in transport infrastructure, which could promote economic development, improve welfare, and increase employment [5–13]. Donaldson (2018) [14] states that transportation facilities increase intra-regional and inter-regional trade volume, reduce transportation costs between regions, and narrow the commodity price gap. However, whether there is a causal effect between the economic impact and highway construction in China is still controversial. For example, Faber (2014) [15] finds that peripheral counties that are connected to the highway system generate negative industrial output growth through local market effects. Jaworski et al. (2020) [9] argue that highways facilitate the concentration of output and exports in remote areas in relatively favorable sectors and can hence improve overall efficiency and social welfare benefits.

Banerjee et al. (2020) [16] argue that due to the lack of factor mobility, the accessibility of transportation infrastructure cannot have an impact on China's economic growth.

The second strand of the literature considers the impact of transportation infrastructure on firms' location selection. Traditional location theory and models of new economic geography believe that industrial location is determined by transportation and factor costs. Transportation infrastructure improvement can change the relative importance of concentration (market size and agglomeration economy) and decentralization (factor cost and competition), as well as the location choice behavior of enterprises [17–23]. Empirically, Boarnet (1997) [24] found a significant negative spatial spillover effect of highway construction among counties competing for production factors. Ghani et al. (2018) [25] used "The Golden Quadrilateral Project" in India to carry out a natural experiment on the upgrading and reconstruction of highways and found that improvements in transportation infrastructure can improve the productivity and efficiency of resource allocation by attracting new enterprises. Holl (2004) [26] showed that new manufacturing firms intend to be located near highways. Kim et al. (2018) [27] found that highway construction along the west coast of Korea significantly increased the entry of manufacturing firms.

The third strand of the literature studies the role of local governments' incentives in determining manufacturing firms' location or regulating their emission behavior. Based on the pollution haven hypothesis [28] and with the incentive of developing the economy for promotion, local governments may reduce environmental regulations, secretly allowing in or even subsidizing polluting firms' emissions. For example, Jia (2012) [29] analyzes the relationship between promotion incentives and pollution emissions and concludes that local governments still have big concerns about economic development, even though their performance evaluation also relies on progress in environmental protection. Kahn and Mansur (2013) [30] point out that environmental regulation negatively affects polluting firms' entry. He et al. (2020) [31] find that highway connections can lower trade costs and increase a poor region's gross domestic product (GDP) at a cost to the environment.

This paper contributes to the extant literature in two ways. First, while there are many studies about the impact of transportation infrastructure on manufacturing firms' location choices, few have separated polluting firms from general manufacturing firms. However, as the importance of sustainable development has become a global consensus, studying how local governments in developing countries balance economic development and environmental protection is important. Second, our paper adds to the pollution haven hypothesis in that polluting firms also have strong preferences for transportation infrastructure. After being connected to a highway network, regions near provincial boundaries would deliberately reduce environmental regulation to attract polluting firms. This finding suggests that the construction of highways has a distributional effect on polluting firms.

The rest of this paper is organized as follows. Section 2 presents the data and the empirical strategy. Section 3 presents the regression results and the robustness check. Sections 4 and 5 explore the heterogeneity and the channels through which highway construction affects the entry of polluting firms. Section 6 concludes.

2. Data and Empirical Strategy

2.1. Data

We combined three datasets from 1998 to 2012. The first is the annual survey of industrial firms (ASIF), which includes comprehensive production and financial information about all state-owned enterprises (SOEs) and above-scale (annual sales above 5 million RMB before 2011 and 20 million RMB after 2011) non-state-owned firms in manufacturing sectors. We followed the approach used by Brandt et al. [32] (2012) to clean the data.

The second dataset is comprehensive city data on China, which are available on the EPS platform. They provide us with the values of the control variables at the prefecture level.

The third dataset is a collection of government reports on the Chinese city government work report net (the data are available on www.zfgzbg.com, but www.macrodatas.cn has a

more complete version (accessed on 16 February 2022)). This collection has been regarded as a reliable data source to proxy local governments' concerns about any social or economic aspect of the local region by calculating the frequencies of related keywords.

We obtained data about highway connections as follows: According to the national standard of China from 2014, highways are defined as multi-lane expressways designed for cars to drive in separate directions and lanes, with all access points and exits being controlled. The designated speed is 80 to 120 km per hour. We referred to the official document "Highway Route Identification Rules and National Highway Numbering" issued by the central government in 2017 to obtain information about the available highway routes in all prefectures. We collected the opening times for each route. When a prefecture had multiple routes, we took the earliest opening time as the year since which this prefecture has had a highway connection. In addition, in order to ensure the robustness of the regression results, we excluded 15 prefectures which had had a highway connection in 1998 (the DID method requires that the change occur during the sample period since otherwise it is impossible to estimate the policy's true impact) (the starting year of the sample period).

The sample time period was limited to 1998–2012, mainly based on the following considerations: First, the main data source is the annual survey of industrial firms (ASIF), but due to the limitations of updating the ASIF, the data only extend to 2014, while the data for 2014 are widely criticized for not being accurate. Second, after the data cleaning process, we discovered that there were many missing data points in the control variables at the prefecture level and city level in 2013.

2.2. Regression Method

We applied the generalized DID model to explore how the construction of highways affects polluting firms' entry:

$$NP_{\mathrm{it}} = \alpha + \beta \times Highway_{it} + \varphi X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

where i and t are subscripts for the prefecture and year, NP_{it} is the log of the number of new polluting firms in prefecture i in year t, which we obtained by aggregating new polluting firms at the prefecture level; $Highway_{it}$ is a dummy variable which equals 1 if prefecture i had a highway connection in year t and equals 0 otherwise; λ and μ_t are the prefecture and year fixed effects; and ε_{it} is the standard error clustered at the prefecture level. α is a constant; the coefficient β captures the effect of highway connections on polluting firms' entry; and φ is the coefficient of the set of control variables whose values can reflect the degree of influence of an independent variable on a dependent variable.

X_{it} is the set of control variables, including (1) capacity, which is the carrying capacity of the city, measured by the freight volume of railways in prefecture i in year t; (2) pgdp, which is the GDP per capita of the city, and GDP stands for the gross domestic product, which can reflect the level of economic development; (3) labor, which indicates the importance of manufacturing firms in local employment, measured by the ratio of employment in manufacturing sectors to the total employment; and (4) slope, which is the average slope of the prefecture, because the natural condition of a prefecture would also affect a firm's location choice. These four variables may affect a manufacturing firm's location choice. Table 1 presents the summary statistics.

Table 1. Summary statistics.

Variable Name	N	Mean	Std.	Min.	Max.
NP	5157	21.30	40.24	0	720
Highway	5157	0.723	0.448	0	1
Capacity	4381	920.4	2119	0	53,170
pgdp	4139	31,327	25,328	99	182,680
Slope	5157	7.425	6.503	0	27.14
Labor	4798	3.668	0.477	0.0770	4.593

3. Regression Results

3.1. Basic Regression

Table 2 presents the regression results of the basic model, which is presented in Equation (1). The first column reports the result when no control variable in Equation (1) is included, and the second column reports the result with all control variables in Equation (1). We used the Stata 16 software to analyze the results in this paper.

Table 2. Basic regression.

Variables	(1)	(2)
	NP	NP
Highway	0.123 *	0.545 ***
	(1.82)	(3.71)
Capacity		−0.000
		(−0.51)
pgdp		0.401 ***
		(2.89)
Labor		0.304 ***
		(2.95)
Slope		−0.047 ***
		(−4.21)
Constant	2.336 ***	−1.804
	(30.88)	(−1.43)
City FE	YES	YES
Year FE	YES	YES
Observations	3262	2339
# of prefectures	257	238
R-squared	0.589	0.679

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The results show that having a highway connection increased the entry of polluting firms by 54.5 percent at a significance level of 1% compared to prefectures without a highway connection. A higher per capita GDP usually means that a region has stronger economic strength and consumption capacity, which may attract polluting firms to enter. The above explanation is also consistent with our regression results: GDP per capita had a positive effect on polluting firms' entry. The reason why the ratio of employment in manufacturing industries had positive effects on polluting firms' entry may be that such regions could provide a stable and relatively technically trained labor resource pool for polluting firms. In addition, the average slope of the city negatively affected polluting firms' entry. The signs of these coefficients are consistent with our prediction.

3.2. Parallel Trend

To guarantee the robustness of the estimates in our model (1), the sample has to satisfy the parallel trend assumption [33] 2005: before being connected to a highway, the entry of polluting firms in cities in the treatment group and the control group should have similar time trends. Based on Beck et al. (2010) [34], we constructed the following regression model (2):

$$NP_{\mathrm{it}} = \sum_{h=-4, h\neq -1}^{4} \beta_h Highway_{it,h} + X_{it}^{'}\beta + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

where $Highway_{it,h}$ is a dummy variable. Define $d(i)$ to be the year in which prefecture i first had a highway connection. Then $Highway_{it,h}$ equals 1 if $t = d(i) = h$, where $h = -4, \ldots, 4$ and $h \neq -1$ When $t = d(i) \leq -5$ (or $t = d(i) \geq 5$), $Highway_{it,-5} = 1$ (and $Highway_{it,5} = 1$). If prefecture i never had a highway connection during the sample period, $Highway_{it,h} = 0$. When $h < 0$, β_h tests the parallel trend assumption; when $h \geq 0$, β_h captures the dynamic effects of a highway connection.

In order to more intuitively test the assumptions of parallel trends and observe the dynamic effect of a highway connection on the entry of polluting firms, we plotted the regression results of model (2) in Figure 1. The horizontal axis in Figure 1 represents the years before and after connection to a highway, while the vertical axis represents the estimated value of the coefficient. According to Figure 1, the prefectures in the treatment group and the control group followed similar time trends at least four years before the highway connection. This pattern indicates that there was no statistical difference between the treatment group and the control group four years before the treatment, which satisfies the requirements of the parallel trend assumption. After a prefecture was connected to the highway network, the entry of polluting firms significantly increased in that year, and this trend lasted for at least four years. Hence, highway connection also had a mid-term to long-term effect on polluting firms' entry.

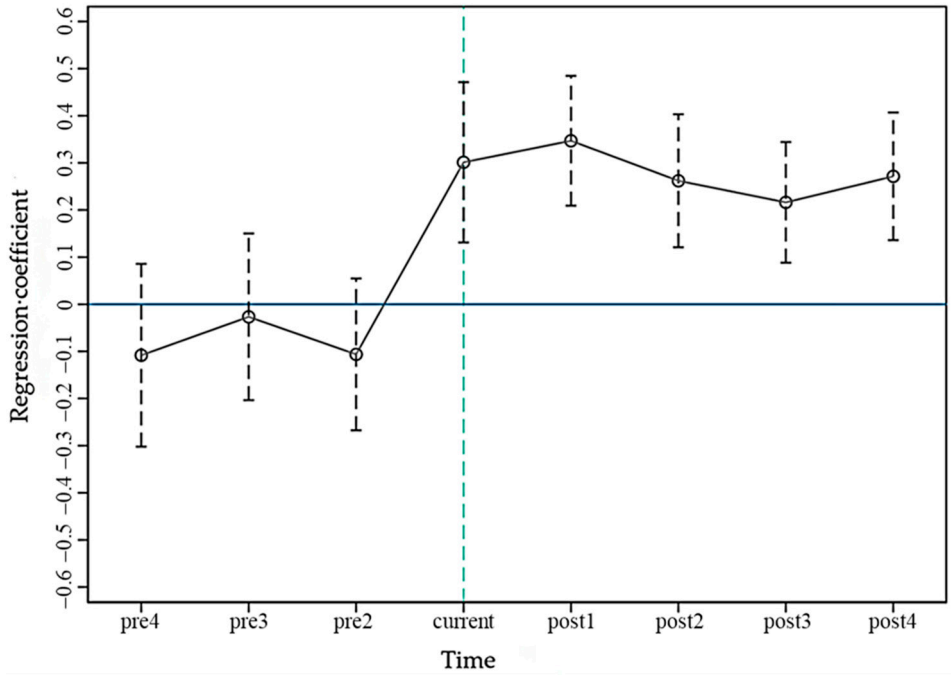

Figure 1. Parallel trend test.

3.3. Placebo Test

Except for highway connection, other policies, events, or random factors may also affect the entry of polluting firms, which may bias the empirical results. In order to investigate the extent to which the results in Table 2 are affected by these factors, we conducted a placebo test using the method used by Ferrara et al. (2012) [35]. We randomly assigned prefectures to the treatment group and randomly picked years during the sample period to be a prefecture's first year of highway connection. The number of prefectures in the constructed treatment group was equal to the number of prefectures in the real treatment group. To guarantee the reliability of the placebo test, we repeated this procedure 500 times. We plot the distribution of the estimated coefficients in Figure 2. The dots represent the estimated coefficients in the 500 regressions, and the vertical line is the coefficient estimate of the benchmark regression in Table 2.

Because the data in this test were randomly generated, the estimated coefficients should be close to zero and insignificant if the result in Table 2 is robust. It can be detected that the estimated coefficients are concentrated around 0. Hence, the randomly constructed highway connection and the treatment group have no effect on the entry of polluting firms. It is also worth noting that the estimated coefficient in Table 2 lies outside the entire distribution. To sum up, the significant and positive effect of the highway connection on polluting firms' entry was not caused by unobserved factors.

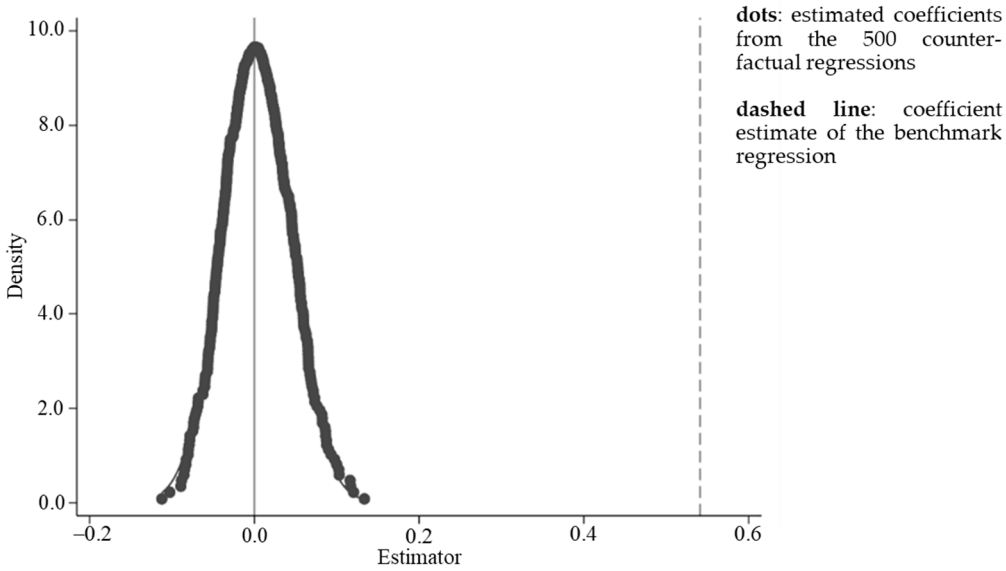

Figure 2. Placebo test.

3.4. Winsorization

We also perform winsorization at the level of 1% on all the continuous variables and regress specification (1) in order to alleviate the possible influence of outlier values and smooth the data in the sample. The results are presented in the second column of Table 3.

Table 3. Winsorization.

Variables	NP
Highway	0.514 ***
	(4.39)
Control variables	YES
City FE	YES
Year FE	YES
Observations	3080
# of prefectures	251
R-squared	0.604

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Obviously, the magnitude of the positive effect of the highway connection on the entry of polluting firms slightly decreased, but it was still positive and significant at a level of 1%, which means that the highway connection increased the entry of polluting firms significantly without being influenced by outliers. Hence, our results in Table 2 are robust to the exclusion of outliers.

3.5. Discussion of Endogeneity

To mitigate possible endogeneity from the omitted variables and selection bias in highway construction, where more developed areas may have obtained the connection earlier and attracted more polluting firms, we next used the instrumental variable (IV) approach to verify the robustness of the results in Table 2. To construct an instrumental variable, we used a dummy variable indicating whether the city had any official courier stations in the Ming dynasty. This construction was inspired by Meng et al. (2021) [36], who used the minimum distance from a prefecture to an official courier station in the Ming dynasty. We then used the intersection of this dummy variable and the year as the instrumental variable. This instrumental variable does not affect polluting firms' location choices but can affect whether a city has a highway connection. The results are presented in Table 4.

Table 4. Two-stage least-squares approach.

Variables	(1)	(2)
	First	Second
	Highway	NP
IV	−0.0139	
	(−3.29)	
Highway		4.076 **
		(2.49)
Capacity	−0.0000	0.000
	(−2.13)	(0.76)
Slope	0.0017	−0.012 ***
	(5.04)	(−3.45)
pgdp	0.0000	0.000
	(−2.65)	(1.29)
Labor	−0.0004	0.003
	(−0.45)	(0.52)
Observations	2336	2336
# of prefectures	236	236
R-squared		0.286
F	10.82	131.8

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The instrumental variable passes the requirements of the first-stage regression, with the F-value being 10.82. In the second-stage regression, compared to Table 2, the coefficient of the main explanatory variable does not change sign or level of significance. Hence, this positive and significant impact of highway connection on the entry of polluting firms is robust.

4. Heterogeneity

4.1. Provincial Boundary

We first explore whether the impact of highway connection on the entry of polluting firms differs between prefectures located in the interior of some provinces and those at a provincial boundary. Heterogeneity may exist because, according to studies including Kahn et al. (2015) [37], Cai et al. (2016) [38], and Chen et al. (2018) [39], local governments tend to place polluting firms on provincial boundaries, where it is difficult to identify the source of pollution. This is a typical problem resulting from China's decentralized governance system, where a province can impose the negative externality of pollution on adjacent provinces. To some extent, provincial boundaries play the role of a pollution haven. In this way, one province can enjoy the benefit of polluting firms' contribution to the local tax and employment, while both the provincial leaders and local residents do not bear the full environmental cost. To some extent, prefectures at provincial boundaries fit the description of a pollution haven.

To check whether this source of heterogeneity existed, we regressed model (1) on subsamples of prefectures in the interior of some provinces and at provincial boundaries. The results are reported in the first and second columns in Table 5.

The results indicate that, compared to prefectures without highway connections at provincial boundaries, the entry of polluting firms in prefectures with highway connections at provincial boundaries increased by 63.9% at a significance level of 1%. In sharp contrast, whether a prefecture located in the interior of a province had a highway connection did not affect polluting firms' entry.

This heterogeneity points to an interesting implication: regions with weak environmental regulations may need to compete to be a pollution haven since polluting firms also prefer prefectures with relatively good transportation infrastructure. Prefectures at provincial boundaries with a highway connection have the advantage of a less strict level of supervision compared to prefectures in the interior of a province, as well as an advantage

in transportation infrastructure compared to prefectures at provincial boundaries without a highway connection. Although it is difficult to compare the benefits of new polluting firms' investment against the environmental costs these firms impose, their entry may be an important opportunity for such regions to develop economically.

Table 5. Location and scale heterogeneity.

Variables	(1)	(2)	(3)
	Interior	Boundary	Scale
Highway	0.221	0.639 ***	0.632 ***
	(0.60)	(3.95)	(5.00)
Highway × lc			−0.280 ***
			(−2.71)
Control variables	YES	YES	YES
City FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	629	1710	2929
# of prefectures	76	169	238
R-squared	0.648	0.699	0.606

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Therefore, these regions may lower their environmental standards in order to attract polluting firms and promote economic development, leading to several possible impacts: first, weak environmental regulations may lead to a decline in the environmental quality of the region; second, a phenomenon called "bottom competition" may occur, where regions compete for investment by lowering environmental standards; and thirdly, the short-term benefits to economic development may have a long-term impact on public health and may lead to subsequent environmental remediation costs. Overall, these results reveal the complex interaction between economic development and environmental protection, requiring policymakers to find a balance between pursuing short-term economic growth and long-term sustainable development.

4.2. Scale Boundary

The scale of a prefecture may also affect the impact of a highway connection because the potential harm from pollution becomes more severe when the population size increases. We followed the official standard set by the State Council of China in 2014 to categorize prefectures into large cities and small cities, depending on whether the number of residents in urban districts is greater than one million. We obtained a list of large cities from the official document and constructed a dummy variable, lc_i, to indicate the scale of prefecture i. lc_i is equal to 1 if city i is categorized as a large city in that document. We added the intersection term of the key explanatory variable, $\frac{Highway_{it}}{lc_i}$, and this dummy variable, lc_i, as a new independent variable in the basic regression model (1) and reported the result in column (3) of Table 5. We did not report the coefficient of lc_i because it does not vary with t.

The results suggest that the positive impact of highway connections on the entry of polluting firms is smaller in large cities. This result is understandable because the benefit of a polluting firm's investment does not increase with the number of urban residents, while the cost to the environment does. In addition, the population density of urban districts is higher than that of rural areas. Hence, local governments in prefectures with larger population sizes in urban districts had more incentive to deter polluting firms' entry.

4.3. Regional Heterogeneity

Local governments have different concerns about environmental protection and different amounts of resources to invest. For example, in 2022, Shanghai spent 3.08% of its GDP on pollution control, while western provinces like Qinghai only spent 0.42%. We conjecture

that local governments in more developed regions pay more attention to environmental issues because their residents have a higher level of wealth and are hence more concerned about environmental protection [40,41]. We ran model (1) on subsamples of eastern, central, western, and northeastern provinces in China. The results are presented in Table 6.

Table 6. Regional heterogeneity.

Variables	(1)	(2)	(3)	(4)
	Eastern	Central	Western	Northeastern
Highway	0.427 *	0.669 ***	0.954	0.621
	(1.81)	(2.76)	(1.46)	(1.14)
Control variables	YES	YES	YES	YES
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	708	887	384	230
# of prefectures	74	85	44	21
R-squared	0.742	0.664	0.587	0.672

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The results indicate that the effect of highway connections on attracting polluting firms is significant in eastern and central China. Moreover, both the magnitude and significance of the effect are greater in central China than eastern China. This result has the same implication as the results in Table 5 because the central provinces of China have less strict environmental regulations than the eastern provinces and better infrastructure than the western provinces. Hence, these provinces have become ideal locations for polluting firms to invest.

5. Mechanism

Since the incentive of local governments is crucial in determining manufacturing firms' locations in China [42,43], we explored in more detail through what channels a highway connection can increase the entry of polluting firms. We considered three possible channels: a decrease in environmental regulation, increasing concerns about economic development, and employment. According to Li and Chen. (2018) [41], employment is a critical concern when local governments allow the entry of polluting firms. In addition, they find that air pollution is an important non-economic factor that can influence polluting firms' compensation to employees through wage increases.

We adopted the methodology used by Chen and Chen (2018) [39] in choosing a set of key words that can capture local governments' concerns about environmental protection. We counted the number of times these environment-related key words appear in government reports, calculated their proportion in the entire government reports, and used this proportion as a proxy for local governments' concerns for environmental protection. In a similar fashion, we calculated the proportion of key words related to economic development and employment in government reports and used them as proxies for the local governments' concerns about economic growth and employment.

We replaced *NP* in model (1) with the three proxies at the city-level and ran the new regressions on the full sample and the two subsamples of prefectures in the interior of some provinces and those at provincial boundaries. The results are reported in Tables 7–9.

In the full sample, highway connections decreased local governments' concerns for environmental protection at a significance level of 5%. However, this effect was mainly caused by the prefectures at provincial boundaries, which had significantly decreased concerns at a significance level of 1%. In sharp contrast, the concerns of the prefectures in the interior of some provinces significantly increased at a level of 10%. The results in Table 7 indicate that not only did the prefectures at provincial boundaries become more attractive for polluting firms after they were connected to the highway network, but local

governments in these regions also intentionally reduced the environmental regulations to further facilitate polluting firms' entry.

Table 7. Mechanism—environmental regulation.

Variables	(1)	(2)	(3)
	Full	Interior	Boundary
Highway	−0.016 **	0.033 *	−0.028 ***
	(−1.99)	(1.75)	(−3.13)
Control variables	YES	YES	YES
City FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	2107	584	1523
# of prefectures	235	67	168
R-squared	0.476	0.500	0.478

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 8. Mechanism—economic development.

Variables	(1)	(2)	(3)
	Full	Interior	Boundary
Highway	0.026	0.018	0.023
	(1.47)	(0.52)	(1.09)
Control variables	YES	YES	YES
City FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	2101	577	1524
# of prefectures	233	68	165
R-squared	0.177	0.208	0.175

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 9. Mechanism—employment.

Variables	(1)	(2)	(3)
	Full	Interior	Boundary
Highway	0.016 **	0.073 ***	0.028 *
	(2.42)	(2.65)	(1.93)
Control variables	YES	YES	YES
City FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	2101	577	1524
# of prefectures	233	68	165
R-squared	0.201	0.213	0.201

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The results in Table 8 show that highway connections did not induce local governments to further economic development, which was possibly due to the central government's warning that economic development should not be achieved at the cost of the environment, especially after 2003. It may also be the case that after the central government's emphasis on the importance of environmental protection, local governments were cautious about revealing their concerns about economic development by using words that were directly related to the local economy.

The results in Table 9 indicate that local governments' concerns for employment increased at a significance level of 5%. Although employment is related to economic development, it is a measure more closely related to social welfare and is usually evaluated separately from economic development in local governments' performance evaluations. The concern for employment grew in both subsamples as a result of the highway connection,

but both the magnitude and significance of the impact were greater for the prefectures in the interior of some provinces.

Combining the results in this section, we can conclude that local governments were aware of the positive effect that highway connections have on polluting firms' entry. This is why, regardless of the location of a prefecture in a province, local governments' concerns about environmental regulation were affected. While local governments' concerns about employment also increased, the results in Tables 5 and 7 indicate that the local governments of the prefectures in the interior of some provinces intended to attract non-polluting manufacturing firms. Polluting firms were hence driven to the prefectures at provincial boundaries by highway connections. The local governments of such prefectures valued the creation of new jobs generated by the entry of polluting firms and subsequently lowered the strength of their environmental regulations to attract them.

6. Conclusions

Since the 1990s, China's highway has been in a relatively fast development stage. In order to evaluate the conflicting effects of the role of highway connections on environmental pollution and economic development, we study the impact of highways on the entry of polluting firms. In this regard, this study enriches the literature on the economic and social impacts of highway construction and yields rich policy implications for sustainable development.

On the one hand, based on the prefecture-level data in China from 1998 to 2012, this paper reveals the positive and significant impact of highway connections on the entry of polluting firms (54.5 percent), and the effect is more salient in prefectures at provincial boundaries, in the central provinces of China, and in prefectures with a larger population size in urban districts. We validated the robustness of the conclusion through the placebo test and winsorization. And we utilized the IV method to alleviate endogeneity issues, enhancing the credibility of the results.

On the other hand, our mechanism results show that highway construction has distributional effects for polluting firms, which also sheds light on the transition of economic growth to a sustainable path. The mechanism analysis suggests that the growing concern for employment after highway connection induced the local governments of the prefectures at provincial boundaries to intentionally pay less attention to environmental protection to attract polluting firms. The highway connections also induced the local governments of prefectures in the interior of some provinces to care more about employment. However, such prefectures also focused their attention more on environmental regulation to deter the entry of polluting firms. Therefore, the following policy implications can be derived: First, highway planning needs to take possible consequences for the environment into consideration, especially for prefectures at provincial boundaries. Hence, a comprehensive assessment of the environmental impact must be carried out during the planning and construction of a highway. Second, the central government should increase its direct supervision of emissions at provincial boundaries because provincial governments do not have the incentive to do so. Such a strategy can mitigate the negative externality from polluting firms' emission. Third, more public health facilities may need to be constructed to accompany highway construction, especially for prefectures at provincial boundaries, as a precautionary act to mitigate the negative effects on local residents' health.

Several future extensions are worth exploiting. For example, the ability of polluting firms investing in prefectures in the interior of some provinces and those investing in prefectures at provincial boundaries to abate emissions may differ, which may further worsen residents' health near provincial boundaries. In Appendix A, we replace the number of new polluting firms with the amount of carbon emissions in a prefecture and find that highway connections significantly increased the amount of carbon emissions in the prefectures at provincial boundaries but had no effect on the prefectures in the interior of some provinces. In addition, a further analysis of the economic benefits and environmental costs of polluting firms may be necessary to better understand the consequences of highway

construction. The extant literature has not reached a consensus on this issue, so it is still ambiguous whether the overall effect of the entry of polluting firms is positive or not. Using data from the United States, Ash and Boyce (2018) [44] point out that facilities that create a higher pollution risk for surrounding communities (that are relatively poor) do not provide more jobs overall.

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Appendix A

Table A1. Carbon emissions.

Variables	(1)	(2)	(3)
	Full	Interior	Boundary
Highway	3.630 ***	−0.009	4.654 ***
	(4.47)	(−0.01)	(4.80)
Capacity	0.002 ***	0.002 ***	0.002 ***
	(8.49)	(5.49)	(7.07)
Slope	−0.471 ***	−0.250	−0.540 ***
	(−7.71)	(−1.56)	(−7.77)
pgdp	−1.648 **	−3.961 **	−1.550 *
	(−2.15)	(−2.53)	(−1.75)
Labor	−5.256 ***	−4.766 ***	−5.598 ***
	(−9.23)	(−5.99)	(−7.43)
Constant	45.807 ***	67.429 ***	45.557 ***
	(6.56)	(4.64)	(5.64)
City FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	2337	627	1710
R-squared	0.635	0.724	0.612
# of prefectures	237	68	169

The t-statistics are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

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