Economic Gains or Political Exchange? Political Incentives and Economic Benefits of Subway Investments in China

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Abstract

Chinese subways move around 23 billion riders annually, but do they deliver more political than economic benefits? Lei and Zhou (2022) propose a political exchange model that reveals subway projects significantly increasing the promotion chances of city mayors. Utilizing GDP data, we adapt their models to investigate the relationship between subway approvals, economic growth, and mayoral promotions. We find that although there is a weak causal relationship between economic growth rates and mayoral promotions, subway project approvals do not lead to higher economic growth rates, undercutting economic justifications for political leader promotions.

1 Introduction

One of the most tangible ways in which governments make impacts on citizens' daily lives is through public goods provision. However, the investments and time that are needed to implement public goods vary widely. On the smaller side, those such as police protection and security can be implemented relatively quickly, but infrastructure such as roads and hospitals may be more capital- and time-intensive.

Today, China is the largest country by population in the world. China's population has grown at an average of 0.5% per year since 1990, with urban

population growth outpacing overall population growth at a rate of 1.5-4.5%. With the share of Chinese people living in urban areas jumping from 25% to 64% in the same period, the need for urban-focused public services has significantly increased.[1]

One method through which local governments have invested in public goods provision has been through transportation infrastructure development. The development of infrastructure such as highways, railways, and subways is vital to inducing urban growth and market integration.[2] China has made massive investments in large-scale, long-term infrastructure projects, both on the national and local levels. Figures 1 and 2 in the appendix illustrate Chinese spending levels above any comparable country on both rail and road infrastructure projects.

Local governments have extensively used local infrastructure investments to support urban development and burgeoning urban populations. Today, China has over 40 metro systems supporting 23 billion rides annually,[3] with all but five of the systems having opened since 2000.[4] While some studies have shown that subway construction leads to economic growth,[5] others have claimed the typical Chinese infrastructure investment fails to actually deliver a positive risk-adjusted return.[6] Subways are incredibly expensive to build, at about 1 billion yuan per kilometer ($157 million USD); their large price tags have now resulted in an effective nationwide moratorium on subway

1. *World Bank Open Data* [in en], accessed December 18, 2023, https://data.worldbank.org.

2. Dave Donaldson, "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure" [in en], *American Economic Review* 108, nos. 4-5 (April 2018): 899–934, ISSN: 0002-8282, accessed December 20, 2023, https://doi.org/10.1257/aer.20101199, https://pubs.aeaweb.org/doi/10.1257/aer.20101199.

3. James Carter, *From state secret to city staple: China opens its first subway* [in en-US], January 2023, accessed December 18, 2023, https://thechinaproject.com/2023/01/18/from-state-secret-to-city-staple-china-open-its-first-subway/.

4. Daizhong Liu, *De-Platformed: China Rethinks Its Subway Addiction*, November 2021, accessed December 20, 2023, https://www.sixthtone.com/news/1008813.

5. Haoran Zhang, "Metro and urban growth: Evidence from China," *Journal of Transport Geography* 85 (May 2020): 102732, ISSN: 0966-6923, accessed December 20, 2023, https://doi.org/10.1016/j.jtrangeo.2020.102732, https://www.sciencedirect.com/science/article/pii/S0966692319306878.

6. Atif Ansar et al., "Does infrastructure investment lead to economic growth or economic fragility? Evidence from China," *Oxford Review of Economic Policy* 32, no. 3 (January 2016): 360–390, ISSN: 0266-903X, accessed December 20, 2023, https://doi.org/10.1093/oxrep/grw022, https://doi.org/10.1093/oxrep/grw022.

construction in cities that do not have an existing system.[7] Thus, there is a question to be asked about the real purpose of subway projects in China: if they accommodate the real needs of urban development, or if they are simply a tool to supposedly boost local competitiveness.[8]

In "Private Returns to Public Investment: Political Career Incentives and Infrastructure Investment in China", Lei and Zhou (2022) explore this question by identifying a mismatch between political and social welfare incentives as shown through subway development. Given the shorter terms of local politicians and the long-term investments required of heavy infrastructure such as subways, their piece aims to understand local politicians' short-term political interests, beyond personal rent-seeking gains, that they could realize from infrastructure projects. They find that there is a 21.3 percentage point increase in the chance that a mayor gets promoted to a higher position if she or he obtains a subway project, demonstrating that increased promotion chances and improved economic performance explain the political motivation for local officials in China to initiate large-scale, long-term infrastructure projects.

Following in the steps of Lei and Zhou, we adopt and extend their methodology to investigate whether approved subway projects lead to improvements in urban economic indicators. We first run a DID regression to understand the influence of both city GDP growth and subway approval on mayoral promotion. We then use an RD specification to understand whether subway approval induces additional economic growth in comparison to others, justifying local mayoral and provincial governor promotions due to increased economic performance.

We find that there is a weak causal relationship between subway approval, GDP growth, and mayoral promotions, and insufficient evidence to determine a causal relationship between subway plan approval and future GDP growth. This lack of confirmation of economic growth through subway projects and the statistically significant causal relationship between subway approval and mayoral promotions suggests that politics-driven infrastructure projects may still be an issue, calling into question the economic growth justifications for China's subway projects.

7. Ibid.

8. Liu Daizhong, 2021

2 Data and Methods

Our data comes from Lei and Zhou's 2022 piece, which combines information from the China Association of Metros, the CCER Official Dataset, the Chinese Political Elite Database, the China City Statistical Yearbook, and the China Urban Construction Yearbook to create a city-level panel data set for 265 prefecture-level cities from 2003 to 2016. The summary statistics for this panel data are presented in Table 1.

Table 1: Summary Statistics

Summary Statistics for Each Variable				
Variable	Mean	Min	Max	N
City GDP growth rate (%)	12.09	-19.38	109.00	3844
City GDP per capita (¥)	32218.63	99.00	467749.00	3845
Mayor age	50.20	33.00	61.00	3804
Mayor connection	0.01	0.00	1.00	3839
City investment in infrastructure per capita (¥)	0.04	0.00	1.00	3861
Mayor promoted within three years	0.41	0.00	1.00	3843
City population	417.42	14.19	1591.76	3571
City GDP (billion ¥)	135.57	3.18	1954.74	3852
Mayor obtaining subway approval	699.33	0.00	13236.19	3848
City land sales revenue per capita (¥)	296.91	0.00	40277.59	3855
City fiscal revenue (Billion ¥)	10.39	0.12	313.65	3856
City fiscal revenue per capita (¥)	2697.62	70.33	81467.34	3855

The baseline model utilizes a difference-in-differences (DID) approach that analyzes the causal influence of subway approvals and GDP growth on city mayoral promotion within three years. We use the following equation:

$$Promotion_{it} = \beta_0 + \beta_1 Approval_{it} + \beta_2 GDPgrowth_{it} \gamma X_{it-1} + \theta_i + \pi_t + \varepsilon_{it} \quad (1)$$

In the baseline model, the outcome variable $Promotion_{it}$ is a dummy variable that indicates whether the mayor of city i is promoted within three years from year t; promotions are defined as a promotion to the party secretary of a prefecture-level city or a vice-province-level position. A lead of

three years is utilized as the average tenure of Chinese mayors is roughly three years. $Approval_{it}$ is a dichotomous variable equal to 1 if the mayor of city i has obtained a subway approval and to 0 otherwise. $GDPgrowth_{it}$ represents GDP growth in city i as a percentage over a three-year moving average centered at year t. γX_{it-1} is a vector of city-level, one-year lagged time-variant control variables, and variables. π_t and ε_{it} are city and year fixed effects respectively. To deal with city-level serial correlation, standard errors are clustered at the city level.

The baseline model is the specification used in column 1 of Table 1. The outcome variable evaluates mayoral promotion in three years. The model in column 1 only includes subway approval and city and year fixed effects. The model in column 2 adds mayoral characteristics onto the baseline model, including but not limited to age, gender, ethnicity, educational background, political connections with the provincial party secretariat, and earlier work experience. These help to correct for selection bias that mayors receiving subway projects may be promoted because they are better connected. Column 3 adds city-level variables such as city population and GDP to correct for any selection bias in which richer, more prosperous, and more populous cities are more likely to gain subway approval than others. Column 4 adds province-year fixed effects to control for extraneous province- and time-specific characteristics, such as provincial leaders' connections to those involved in the subway plan approval process and the central government. Column 5 only includes GDP growth, and Columns 6 thru 9 replicate the forms of specifications 1-4, except with the additional GDP growth variable.

One critical aspect of DID design is the parallel trends assumption. Similar to Lei and Zhou, we test this and demonstrate the effects of subway approval on mayor's promotion through the model specification:

$$Promotion_{it} = \sum_{\gamma \geq -4, \gamma \neq +1}^{\gamma \leq +5} \beta_\gamma Approval_{i(t+\gamma)} + \omega X_{it-1} + \theta_i + \pi_t + \varepsilon_{it} \qquad (2)$$

Where $Approval_{i(t+\gamma)}$ a set of dummy variables indicating whether city i has obtained subway approval at time $t+\gamma$, β_γ indicates the effect of subway approval both before the city has obtained approval and after the city has obtained approval for γ years. The parallel trends assumption requires that all β_γ (when γ ¿ 0) are not significantly different from 0. Figure 3 in the Appendix shows that this design does meet the parallel trends assumption.

The additional models run by Lei and Zhou use a fuzzy regression discontinuity design to identify the effects of subway approvals. To be eligible to build a subway, cities must fulfill four requirements: (1) the city's annual fiscal revenue exceeds ¥10 billion, (2) the city's GDP reaches at least ¥100 billion, (3) the city's population exceeds 3 million people, and (4) more than 30,000 people per hour are expected to use a subway line. While cities satisfying these four requirements are not guaranteed to have subways, those not satisfying them are not eligible to have a subway. Lei and Zhou utilize a parametric, instrumental variable (IV) approach to the fuzzy RD design. We first assume that the promotion of city mayors takes the following functional form:

$$Promotion_{it} = \beta_0 + \beta_1 \widehat{Approval}_{it} + \tau f(Z_{i,t-2}, Pop_{i,t-2}) + \gamma X_{it-1} + \theta_i + \pi_t + \varepsilon_{it} \tag{3}$$

$Z_{i,t-2}$ is the IV, or a dummy variable indicating whether the city has a population of more than 3 million. $f(Z_{i,t-2}, Pop_{i,t-2})$ is therefore a function of the running variable (the population size of the city) and its interaction with $Z_{i,t-2}$. The first stage of this model is specified by the following equation, with subway approval being predicted by the IV (population):

$$Approval_{it} = \alpha_0 + \alpha_1 Z_{i,t-2} + \lambda f(Z_{i,t-2}, Pop_{i,t-2}) + \mu X_{it-1} + \theta_i + \pi_t + \varepsilon_{it} \tag{4}$$

For our purposes of evaluating whether subway approvals result in increased economic growth rates, we adapt Equation 2 to now have GDP growth rates as its dependent variable:

$$GDPgrowth_{it} = \beta_0 + \beta_1 \widehat{Approval}_{it} + \tau f(Z_{i,t-2}, Pop_{i,t-2}) + \gamma X_{it-1} + \theta_i + \pi_t + \varepsilon_{it} \tag{5}$$

In this case, $GDPgrowth_{it}$ is a dichotomous variable equal to 1 if the GDP growth rate of city i in year t+5 outpaces its growth rate in year i, and equal to 0 if it does not. We lead GDP growth rates by five years as this period is roughly the average time for the construction of a new subway line in China.[9]

9. *Beijing's Metro, Beijing Subway Development* [in en-US], accessed December 20, 2023, https://www.railway-technology.com/projects/beijing_subway/.

A potential issue with this design strategy, as described by Lei and Zhou, is that we must assume a functional form of $(Z_{i,t-2}, Pop_{i,t-2})$, which the results are dependent on. This specification includes city fixed effects θ_i and year fixed effects π_t to alleviate potential bias caused by city-level unobserved factors. The bandwidth for our fuzzy RD design is chosen by the method pioneered by Imbens and Kalyanaraman (2012),[10] which resulted in a bandwidth of 1.06 million people. While the bandwidth may seem wide, cities included in this range are medium-sized Chinese cities, given that the median population size for a Chinese city is 3.6 million people.

3 Results

We find some evidence for the importance of GDP growth in relation to city mayoral promotion in three years. While somewhat inconsistent, we do find that this holds across models that both exclude and include the effects of subway plan approval on mayoral promotion.

Table 2: Subway Approval, GDP Growth, and Mayoral Promotions

Mayor Promoted within Three Years

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Subway Plan Approval	0.251	0.270	0.257	0.213		0.238	0.256	0.242	0.201
	(0.095)	(0.096)	(0.098)	(0.097)		(0.103)	(0.108)	(0.106)	(0.103)
GDP Growth Rate					0.008	0.008	0.008	0.008	0.005
					(0.005)	(0.004)	(0.004)	(0.005)	(0.005)
Num.Obs.	3647	3566	3092	3092	2821	2821	2767	2592	2592
FE: City_Code	X	X	X	X	X	X	X	X	X
FE: Year	X	X	X	X	X	X	X	X	X
FE: provinceyear				X					X

Table 2 show the results for each DID model specification. The coefficients for GDP growth rate are positive and statistically significant at the 90% confidence level in four of the specifications (columns 5 through 8). The

10. Guido Imbens and Karthik Kalyanaraman, "Optimal Bandwidth Choice for the Regression Discontinuity Estimator," *The Review of Economic Studies* 79, no. 3 (July 2012): 933–959, ISSN: 0034-6527, accessed December 20, 2023, https://doi.org/10.1093/restud/rdr043, https://doi.org/10.1093/restud/rdr043.

coefficients on GDP growth rate for the statistically significant models are 0.008, indicating that a one-percentage-point increase in average GDP growth rates is associated with a 0.8% percentage-point increase in the chances of city mayoral promotion in the next three years. Similar to the original article, subway plan approval is statistically significant in every model, suggesting a strong, causal relationship between plan approval and the chances of mayoral promotion.

The model in Column 9, which adds all fixed effects and controls into the model, results in subway plan approval being statistically significant but GDP growth becoming statistically insignificant to mayoral promotion. This suggests that subway plans may be more important to mayoral promotion than GDP growth in itself. This provides evidence for the political bargaining conclusion that Lei and Zhou arrive at, given that project approval leading to political promotions suggests that their value is in signaling instead of economic development. Subway plan approvals in China could be more strongly motivated by political factors rather than economic gains.

These findings lead to the question of whether subway plan approvals actually lead to increased economic performance in the future. Adapting Lei and Zhou's fuzzy RD specifications for our use, we use a new dependent variable, $GDPgrowth_{it}$. This replaces city mayoral promotion as the dependent variable as specified in the original regressions (see Equations 2, 4).

Table 3 shows the results of the six RD specifications run; models 1 thru 3 have mayoral promotion within 3 years as the dependent variable, while models 4 thru 6 have $GDPgrowth_{it}$ as the dependent variable. The first-stage regression results can be found in Appendix Figure 4. In all three of our modified specifications (Columns 4-6), subway plan approval is statistically insignificant, with the standard errors outweighing the absolute values of the coefficients. This means that we cannot establish a causal relationship between subway plan approval and increased GDP growth. Although economic growth is a metric against which mayors are likely evaluated and likely influences their promotion track, we cannot say that subway plan approvals lead to increased GDP growth. While subway plans are correlated with mayor promotions according to Lei and Zhou, they do not necessarily translate into economic growth, at least not in a direct or immediate sense detected by the RD model. While not a binary choice, this again points to subway plan approvals potentially having more political value rather than economic growth potential.

Table 3: Subway Approval, GDP Growth, and Mayoral Promotions: Fuzzy Regression Discontinuity Design

	(1)	(2)	(3)	(4)	(5)	(6)
Subway Approval	0.478	0.496	0.411	0.311	0.242	0.235
	(0.536)	(0.529)	(0.524)	(0.440)	(0.490)	(0.531)
Population	0.425	−0.182	−0.415	−0.014	0.717	0.591
	(2.996)	(2.980)	(2.888)	(2.458)	(2.756)	(2.928)
Population x IV	−0.262	1.201	0.976	1.445	−3.643	−3.681
	(3.807)	(4.437)	(4.272)	(3.123)	(4.104)	(4.330)
Num.Obs.	148	143	143	143	138	138

Note that columns 1 thru 3 have mayoral promotion within 3 years as the dependent variable; columns 4 thru 6 have $GDPgrowth_{it}$ as the dependent variable.

4 Conclusion

Our replication and findings support Lei and Zhou's conclusion that subway projects significantly increase the promotion chances of city mayors. The addition of GDP growth to Lei and Zhou's model specifications reveals that, while not conclusive, GDP growth does have a relationship to local mayoral promotions. While the strength of this relationship varies based on the specification of the model, its significance suggests that in addition to subway project approval, there is an additional causal relationship between GDP growth and the probability of a local mayor being promoted within 3 years. This could imply that mayors who secure subway plan approvals are more likely to be promoted due to perceived competence or success, which explains why mayors may have incentives to work on these projects even if they are unlikely to be in office when the project comes to fruition. Given the positive coefficient on GDP growth, we also conclude that mayors are supposedly rewarded for economic performance as well.

However, our fuzzy regression discontinuity design shows that subway project approvals do not result in significantly increased GDP growth rates.

The lack of statistical significance suggests there is not enough evidence to claim a causal impact of subway plan approvals on future GDP growth rates, which provides evidence to Lei and Zhou's claim that political motivations may drive Chinese infrastructure development more than economic concerns. Lei and Zhou also assert that economic returns from infrastructure projects result in increased promotional chances, but due to the lack of a causal relationship that can be evidenced from our fuzzy RD design, we cannot say that outsized economic returns are derived from subway project approvals, and that if there is an economic return argument for the promotion of political leaders, it may come from the development of other sectors of the economy.

There are certain limitations to our findings. Our models' lack of significance could come from insufficient power, or the effect of subway plan approvals on GDP growth being non-linear or delayed beyond the study period of 2003-2016. Further research may explore longer time horizons or different measures of economic performance, such as wages or property prices. Additionally, another critical lens on this issue would be to extend these questions to different levels of government, as well as across different types of infrastructural investments, such as high-speed rail and airports.

As increased economic performance cannot be assumed from the approval of subway projects, this leaves room for the strong political career incentives of its local officials to become a driving force behind infrastructural investments. While the central government's moratorium on subway projects in cities that do not currently possess subway systems indicates increased awareness of this issue as it extends to urban infrastructure, completely shutting down new opportunities for urban mobility may not fully the answer. These findings warrant a re-evaluation of how such projects are proposed, approved, and evaluated, and potentially a re-evaluation of the incentive structures for local political promotions to ensure money is spent where it needs to be spent.

5 Appendix

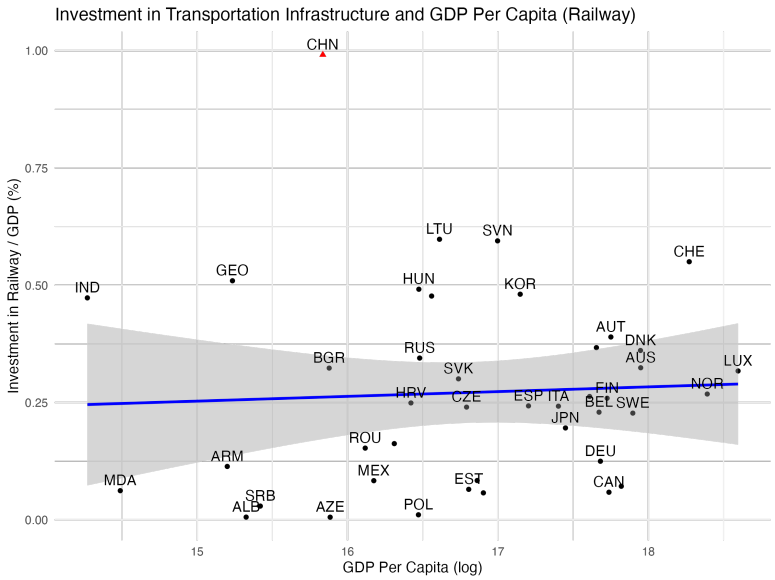

Figure 1: Investment in rail infrastructure versus GDP per capita; the line is a linear fit of the data sample. The shaded area is the 95% confidence interval. Data from OECD and World Bank, via Lei and Zhou (2022).

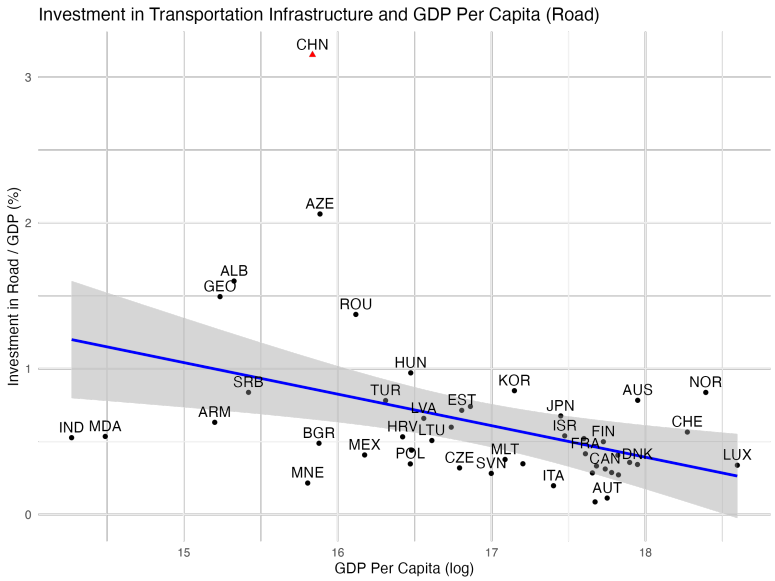

Figure 2: Investment in road infrastructure versus GDP per capita; the line is a linear fit of the data sample. The shaded area is the 95% confidence interval. Data from OECD and World Bank, via Lei and Zhou (2022).

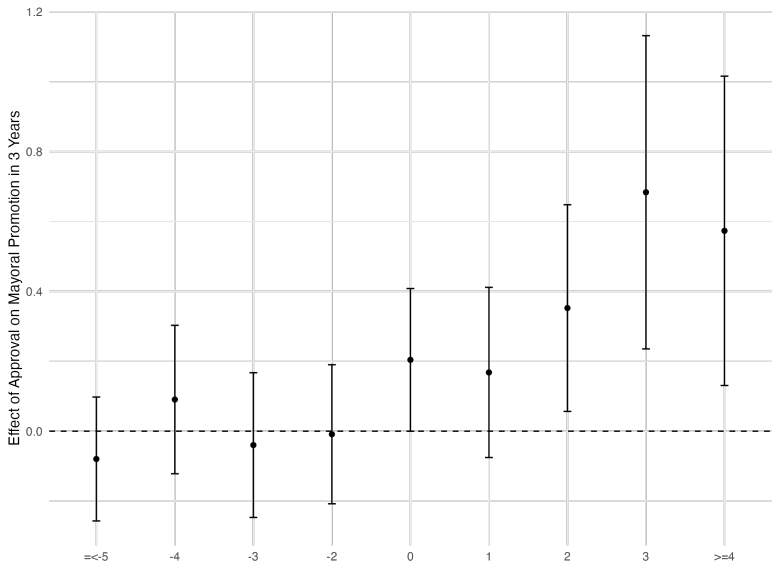

Figure 3: Dynamic effects of subway approvals on mayor promotion. Each circle indicates a point estimate for the effect of subway approval, and the vertical bars represent the 95% confidence interval. Numbers on the horizontal axis refer to the years before (-) or after (+) a city receives subway approval. The year that the city obtains subway approval is the baseline to which all coefficients should be interpreted in comparison.

	(1)	(2)	(3)
IV (Population > 3 million	1.012	1.013	1.012
	(0.138)	(0.173)	(0.187)
Num.Obs.	148	143	143

Figure 4: First Stage Effects for RD Model Regressions 1-3. These are used to evaluate whether the results are susceptible to the weak instrument problem.

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