Mayors' Promotion Incentives and Subnational-level GDP Manipulation in China

Jiangnan Zeng*and Qiyao Zhou†

December 2023

Abstract

What role do local officials' incentives play in regional economic growth? How do local officials behave under promotion pressure? This paper studies the unintended impact of mayors' promotion incentives on regional economic growth and subnational-level GDP manipulation in China. We employ a regression discontinuity design that accounts for age restrictions in deciding promotions for mayors. We find that when GDP performance is prioritized in officials' promotion evaluations (before 2013), mayors' promotion incentives significantly increase the statistical GDP growth rate by 3.4 percentage points. However, their effects on nighttime light and other non-manipulable real economic growth indicators are close to zero. This gap can be attributed to GDP manipulation under our empirical framework. The above pattern no longer persists after 2013, when the role of GDP statistics in mayoral promotions was reduced. Our findings indicate that GDP manipulation makes performance-based competition between mayors devolve into a data manipulation game. Further analyses suggest a dynamic pattern of GDP manipulation, and that GDP manipulation hampers officials' accountability.

Keywords: GDP manipulation; regional economic growth; mayor; promotion incentives

Classification Codes: D73, H11, O43

Declarations of interest: None.

*Department of Economics, Dietrich School of Arts and Sciences, University of Pittsburgh, 4901 Wesley W. Posvar Hall, 230 South Bouquet Street, Pittsburgh, PA, 15260, USA. jiz198@pitt.edu

†Department of Economics, University of Maryland, Tydings Hall, 7343 Preinkert Dr., College Park, MD 20742, USA. qiyaoz@umd.edu

1 Introduction

Understanding the drivers behind the spatial distribution of economic growth is crucial, and among these factors, the role of local officials is particularly significant. The incentives for local officials vary across political regimes. In democratic nations, they are held accountable through elections (Ferreira and Gyourko, 2009). In contrast, in authoritarian regimes such as China, officials are motivated by evaluations of their performance from their superiors (Li and Zhou, 2005; Yao and Zhang, 2015). This paper explores the discretionary effect of local officials' incentives on regional development in China.

The economic reforms that were adopted by China in 1978 led to a substantial increase in the country's economic growth. Directly following these reforms, GDP growth rates increased from an average of roughly 4% per year to an annual average growth rate that exceeded 9%. Much of this growth has been attributed to the performance-based cadre evaluation system that made regional GDP growth the central focus of promotion decisions for local officials. Local officials' promotion incentives directly led to more effective local management of the economy (Maskin, Qian, and Xu, 2000; Blanchard and Shleifer, 2001; Li and Zhou, 2005). Not surprisingly, empirical analysis of the impact of promotion incentives has been based on official reports of localized GDP performance (Li and Zhou, 2005; Chen, Li, and Zhou, 2005; Yao and Zhang, 2015). However, China's subnational governments are notorious for manipulating local GDP growth rates.[1] Recent literature has called into question the veracity of locally reported government statistics in China, particularly when the stakes are high for the relevant local officials (Rawski, 2001; Nakamura, Steinsson, and Liu, 2016; Chen, Qiao, and Zhu, 2021). If official statistics like GDP can be readily manipulated, then these promotion incentives may encourage subnational officials in China to distort these statistics and provide biased information to higher levels of government.(Serrato, Wang, and Zhang, 2019). As a result, the performance-based competition between China's subnational governments may devolve into a GDP manipulation game.

The above discussion raises the following question: will officials prioritize local economic development, or manipulate GDP data under promotion pressure? It is difficult to provide a precise and causal answer to this question due to the challenges in measuring promotion incentives for subnational officials in China and the lack of reliable data on actual economic growth. In this paper, we revisit the above findings on localized economic performance using

[1]GDP manipulation at the subnational level does not necessarily imply that the national level GDP is manipulated, since the national level GDP statistics in China is calculated by the national bureau of statistics independently, and is not a simple summation of subnational level's statistics.

a range of alternative economic growth measures that are immune to manipulation by local politicians [2]. First, we demonstrate the ability of these alternative measures to identify the impact of other substantial economic shocks. Using these alternative measures as well as official GDP statistics, we find strong evidence to suggest that at least some of the localized economic progress that has been attributed to local officials' promotion incentives likely instead reflects manipulation of the localized GDP statistics themselves.

To identify subnational officials' promotion incentives, this study draws from the literature on term limits and electoral accountability (Besley and Case, 1995; Ferraz and Finan, 2011). Age restrictions on promotion eligibility for subnational officials provide a suitable context to identify exogenous variations in promotion incentives in China. Specifically, the promotion ineligible age for mayor-level officials is 57 (Kou and Tsai, 2014; Huang et al., 2020). Empirical data in Figure 1 also suggests the same pattern. The sharp decline in promotion probability at age 57 implies a significant drop in mayors' promotion incentives.[3]

We conduct a regression analysis that exploits the discontinuity in mayors' promotion ineligible age (i.e., 57) to identify the extent to which subnational GDP statistics are manipulated when mayors face promotion pressure. Our findings reveal that when economic growth is prioritized in officials' promotion evaluations (prior to 2013), mayors' promotion incentives significantly boost the statistical GDP growth rate by 3.4 percentage points. However, this effect is not found in non-manipulable economic indicators such as electricity usage, manufacturing firms' employment and total factor productivity. This significant gap can be attributed to GDP manipulation when mayors face promotion pressure. The GDP manipulation extent is around 3 percentage points under our empirical framework. We also find that the above pattern no longer persists after 2013, when the role of GDP statistics in mayoral promotions was reduced. This lends further support to our argument that when a measure is no longer a target, promotion incentives have no effect on it.

Heterogeneous analyses indicate that the GDP manipulation extent is smaller for mayors with high manipulation costs, and it is smaller in the agriculture sector, where the manipulation costs are high. Further analyses indicate that mayors have incentives to strategically adjust the potentially manipulated data. Successors tend to report a lower statistical GDP growth rate the first year when they are in office if their predecessors have strong promotion incentives. Our results also indicate that the substantive extent of GDP manipulation at the subnational level undermines the officials' accountability in China—mayors with higher

[2]The term "immune to manipulation" can be interpreted in two ways. Firstly, it implies that the data is difficult to manipulate. Secondly, it refers to indicators that local officials have no incentive to manipulate.

[3]The definition of promotion is discussed in section 2.2.

GDP growth rates are more likely to be promoted, regardless of their performance in real economic indicators (nighttime light growth rate).

There are several challenges to our empirical strategies. One issue that may arise is omitted variable bias, where high-ability mayors are more likely to get promoted before age 58, which leads to the discontinuity in mayors' unobservable abilities at the age threshold. The structure of the panel data allows us to control for mayor fixed effects and to compare the performance of the same mayor when they are 57 with the performance when they are 58. The results remain robust. In addition, we conduct an event study analysis to check the pre-trend. We find that the effects of promotion incentives on the statistical GDP growth rate are unlikely to be driven by city-specific pre-trends. The second concern is related to the sensitivity of nighttime light: null results of the light around the age cutoff point may be driven by measurement errors. We alleviate this concern by showing how light and GDP respond to two economic shocks - the change in the implementation of two-control zone policy in 2005 and the Great Recession. We find that the estimated effect of economic shocks on light is more precise than on GDP. A 1.5 percent point GDP shocks can be reflected in light. If there is no GDP manipulation, the 3 percent point effect of promotion incentives on statistical GDP growth rate should be easily reflected in light. Furthermore, we check the robustness of our results using other non-manipulable growth indicators—electricity usage, manufacturing firms' employment, and firm-level TFP. The third concern is that career-minded mayors may undertake actions to quickly boost GDP, but these may not be immediately reflected in nighttime lights. (e.g. investment in infrastructures). We rule out this possibility by re-estimating the RD Equation (13) using government expenditures as the outcome variable and finding null results.

Our paper is related to the growing literature that studies the manipulation of official statistics (Klimek et al., 2012; Karplus, Zhang, and Almond, 2018; Serrato, Wang, and Zhang, 2019; Martinez, 2021). In a closely related and parallel work, Chen, Qiao, and Zhu (2021) employ a difference-in-differences strategy that compares county-level officials who began their terms before the political turnover years with those who started after. They find that the latter group is more likely to manipulate GDP statistics, as these officials are more likely to get promoted and therefore have stronger incentives for promotion.

Our paper differs from Chen, Qiao, and Zhu (2021) by investigating the trade-off that mayors face between the manipulation of GDP statistics and real economic growth. We have constructed a theoretical framework that illustrates the mechanisms and have empirically investigated the heterogeneity in the cost of GDP manipulation. We show that widespread GDP manipulation at the subnational level distorts promotion decisions and undermines

official accountability in China.

We offer a more accurate measure of promotion incentives, leading to a clearer empirical design, and propose an empirical framework with fewer functional form assumptions to identify GDP manipulation. Specifically, Chen, Qiao, and Zhu (2021) base their main identification on the assumption that officials starting their terms after the political turnover years have stronger promotion incentives than those who begin after, which may be too strong.[4] Utilizing the promotion age criterion, our regression discontinuity design does not rely on a pre- and post-classification, ensuring a clearer identification of promotion incentives, and consequently, GDP manipulation. Moreover, Chen, Qiao, and Zhu (2021) construct a "real" GDP index as the weighted average of official GDP statistics and other objective indicators. However, this approach does not avoid the bias of GDP manipulation: the manipulation not only directly affects the "real" GDP index through official statistics but also biases the estimated weights. Martinez (2021) demonstrates that the nighttime light elasticity of GDP is higher in authoritarian regimes due to GDP manipulation.

This paper also relates to the literature that studies local officials' incentives in regional economic development. Bartik (2005, 2018) argue that the "top-down" incentives of state and local governments may not align with the best interests of the local areas. In contrast, the "bottom-up" approach is posited to be more effective, as it incorporates more information and allows for the verification of officials' incentives. Buntaine et al. (2022) find the effectiveness of "bottom-up" citizen participation in China's "war against pollution". Our paper contributes to this literature by documenting that without civilian participation and surveillance, local officials' "top-down" incentives in regional economic development can be distorted. The promotion pressures on mayors can transform performance-based competition among mayors into a contest of data manipulation.

Last but not least, we complement a large body of literature that attributes China's rapid economic growth over the past 30 years to decentralization and local government competition (Blanchard and Shleifer, 2001; Li and Zhou, 2005; Xu, 2011). We extend their framework by incorporating GDP manipulation in the existing framework. If China's subnational officials are more incentivized to manipulate the data than to develop the economy due to low manipulation costs, the connection between China's rapid economic growth and officials' meritocratic incentives may be tenuous.

[4]Our study suggests that mayors who have served for several years could have stronger promotion incentives than new mayors due to diminishing prospects for promotion over time. Moreover, the average mayoral term in China is three years—significantly shorter than the five-year political cycle—with over 75% of the mayors in our sample being promoted or rotated in non-turnover years. This suggests that mayors may maintain strong promotion incentives throughout their tenure.

We organize the paper as follows. The following section discusses the institutional background and the age discontinuity. Section 3 introduces a model. Section 4 discusses the empirical strategies. Section 5 introduces the data. Section 6 presents the main regression results. Section 7 presents the heterogeneity results. Section 8 checks the robustness of our results. Section 9 discusses some dynamic patterns in GDP manipulation. This is followed by a conclusion.

2 Institutional Background

2.1 Performance-based cadre evaluation system

Political turnover decisions are usually made by the upper-level governments in China. For instance, the mayor-level officials are managed by the organization department at the provincial level. During the post-reform era (i.e., 1978-), the provinces and cities have played an important role in economic management (Qian and Xu, 1993). They are empowered with more authority in allocating economic resources than before. To a degree, provincial and prefectural leaders are middle-level managers in multi-divisional corporations, each responsible for their division's performance.

By delegating more power to the subnational leaders, the central and provincial governments intend to motivate the subnational officials to promote the local economy by rewarding and punishing them based on their economic performance. Government reports and provincial yearbooks contain details on relative rankings for provincial performance, ranging from the growth of GDP and steel production to miles of constructed roads. In 1993, the Organization Department of the Central Committee of the CPC defined a national policy for civil servant evaluation that stipulated work performance ratings for cadres at all levels. Four criteria were used: political integrity, competence, diligence, and actual work achievements. Among the criteria, work achievements account for more than 60% of the weight and are generally measured by local GDP growth rates (Edin, 2003). These principles were reiterated when the Central Committee of the CPC (CCCPC) published formal guidelines for cadre selection in 2002. In the 2014 version of the CCCPC's guidelines, the role of GDP is weakened, while environmental protection, political loyalty, and government debt were placed higher weights. In our main analysis, we use data from 2003 to 2013, where GDP statistics serve as the primary indicator for promotion. Additionally, we conducted a placebo test using data from 2014 to 2018.

2.2 Promotion

China has five administrative levels. From top to bottom are Central government; provinces & autonomous regions & centrally-administered municipalities; prefectures; counties and districts; and townships. Every Chinese prefecture-level city has two paramount leaders: the mayor and the Party secretary. By law, a mayor is an executive officer employed by the local (prefecture-level city) government. In practice, the Party secretary is mainly in charge of organizational and other political duties, while the mayor oversees daily governmental operations, of which economic growth is the highest priority Zheng et al. (2014); Serrato, Wang, and Zhang (2019). We focus on mayors in this paper.

Promotion decisions for mayors are typically made by provincial-level officials. The most common promotion for a mayor is to become the Party secretary in a city of the same rank (Landry, 2008). Serrato, Wang, and Zhang (2019) provide a more general definition of promotion by including the case where mayors are directly promoted to vice-provincial level positions. Besides these two types of promotions, transitioning to other positions, such as assistant governor, is also generally considered a promotion for mayors.

In this paper, we present a general definition of the promotion of mayors, using data-driven methods. A mayor is considered promoted if she advances to a higher-ranked position or remains at the same rank but moves to a more important position. In this context, higher-ranked positions refer to vice-provincial level positions. The importance of a position is defined by the probability of a mayor-level official being promoted to a vice-provincial level position from their current role *over the course of their career*. Appendix A.6 provides a detailed discussion and presents the calculation results, which are based on the CPED dataset provided by Jiang (2018). For instance, our calculations indicate that a prefecture-level city mayor has a 22% chance of being promoted to a vice-provincial or higher level position during her career. This probability increases to 37.6% for Party Secretaries in prefecture-level cities and 50.8% for Assistant Governors. Therefore, these roles are considered more important than the mayors, despite being at the same rank. To our knowledge, this study provides the most comprehensive and objective analysis of the promotion trajectory for Chinese officials to date.

Based on our calculation, the following mayor-level positions are regarded as more "important" than the mayor in prefecture-level cities: (a) Party secretaries in prefecture-level cities; (b) vice ministers of provincial-level organizational, united front work, propaganda,

and development and reform departments; (c) assistant governors; (d) vice secretary general at the provincial government or the provincial Party committee; (e) vice mayors or Party secretaries in vice-provincial level cities.

2.3 Age restrictions in China's cadre system

Another critical factor influencing mayors' promotion is age. Since 1980s, CCP has emphasized the appointment and promotion of younger cadres, while restricting the promotion of aging officials. In the 2000s and the early 2010s, CCP introduced the upper age limits for different level officials (Kou and Tsai, 2014).

We list age restrictions on Chinese officials at different levels in Table 1 with referring to the Interim Provisions for Party and Government Leading Cadre Tenure and Kou and Tsai (2014). A mayor aged 58 cannot be promoted to vice-provincial level positions. In a parallel work, Huang et al. (2020) uses the same age discontinuity to study mayoral promotion incentives and the privatization of the state-owned enterprises. Narrative evidence also supports the age restrictions in Table 1 directly or indirectly. *Hu Jintao's speech about the general election of the* 17^{th} *CPC Conference* in 2007 clearly states mayor-level officials who are 58 are not eligible to get promoted.[5] An article published in *China Internet*, a state-run web portal of China, mentions that it is hard for mayor-level officials to get promoted when they are 58 or above.[6] The promotion age restrictions in China was relatively consistent during the time periods we investigate.

Table 1: Promotion eligible age

Position rank	Promotion eligible age
Vice mayor level	≤55
Mayor level	≤57
Vice provincial level	≤62

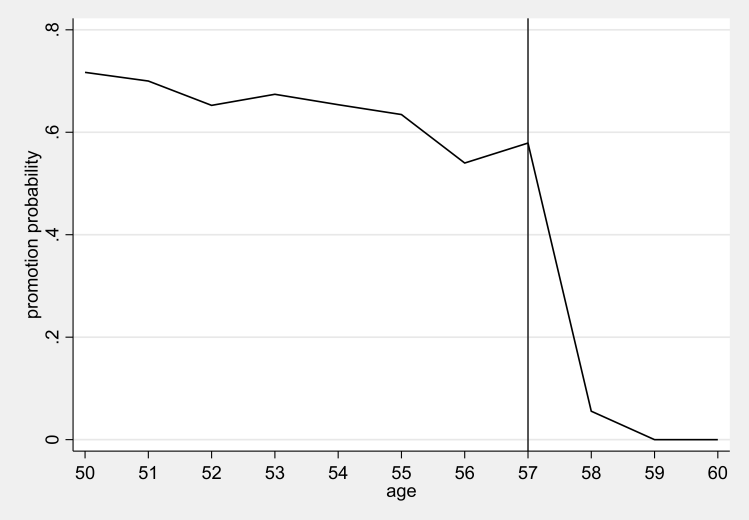
Notes: Source: (1) Kou and Tsai (2014); (2) Kou (2005) p.272; (3) Hu Jintao's speech about the general election of the 17^{th} CPC Conference https://news.ifeng.com/mainland/200702/0210_17_75079_1.shtml, retrieved on October, 10, 2022.

Figure 1 plots the promotion probability for mayors at different ages. The promotion is a dummy variable, switching on if a mayor is placed to either higher ranked or to the

[5]https://news.ifeng.com/mainland/200702/0210_17_75079_1.shtml

[6]http://news.china.com.cn/txt/2010-10/21/content_21171519.html

Figure 1: Promotion probability of mayors



Notes: The definition of promotion is discussed in section 2.2, and calculated in appendix A.4. "Promotion" is a dummy variable, which equals one if a mayor is placed to either higher ranked positions or to the same rank but more "important" positions after she *leaves the office*, and equals zero otherwise.

same rank but more "important" position after she leaves the office. The sharp decline in promotion probability at age 57 for mayors echoes the rule of the promotion ineligible ages for the mayors. Mayors who are just below the age threshold (i.e., 57 years) have strong promotion incentives (i.e., it is their last chance of getting promoted), while the promotion incentives for the mayors who are just above the threshold decline dramatically. The decline in promotion incentives among mayors above the age threshold is similar to the retirement shirk phenomenon in the US, where members of Congress in their final term report reduced efforts, or shirk responsibilities (Smart and Sturm, 2013; Besley and Case, 2003).

2.4 Measurement of local GDP statistics and anecdotal evidence of GDP manipulation in China

China's national GDP and regional GDP are calculated independently. Specifically, the National Bureau of Statistics is responsible for calculating the national GDP, while the local Bureau of Statistics handles the GDP calculations for their respective regions.[7] Consequently,

[7]Source: Website of National Bureau of Statistics, https://www.gov.cn/jrzg/2009-08/12/content_1389409.htm, retrieved on October 23, 2023.

the sum of local GDP statistics does not necessarily equate to the national GDP statistics.[8]

The directors of city statistical bureaus, commonly belong to the "municipally managed cadres (Shi Guan Gan Bu)", have their promotions determined by city-level officials, including mayors, city secretaries, and the heads of the cities' organizational departments. This hierarchical structure enables the mayors to manipulate local GDP statistics.[9]

Manipulating GDP comes with costs. Whenever the city's Statistics Department announces its yearly GDP growth rate, it should also disclose sector-specific GDP numbers, such as those for agriculture, manufacturing, and services. Other data, including employment, investment, and the Consumer Price Index (CPI), should also be shared and cross-referenced. GDP manipulation requires cooperation among various officials, including the directors of the local bureau of statistics, vice mayors, and county-level officials. Local officials and heads of statistical departments will face penalties if data manipulation is discovered.[10]

Anecdotal evidence suggests that GDP manipulation is common in China. In 2017, the governor of Liaoning province confessed to inflating fiscal revenue and GDP figures by at least 20% between 2011 and 2014. An article in the prominent state-run media, Xinhua Net, quoted local officials, stating, "Local officials revealed the unspoken rule: They can achieve as many targets as set by the higher authorities, and any target set will definitely be met."[11]. Official statistics in Tianjin, Weihai, Baotou, Ordos, Tongliao, Tieling, and Yinchuan have been found to be manipulated.

The accuracy of China's official data has also been widely questioned in scholarly works. Rawski (2001) argues that contrary to the 7.1% growth reported in official statistical data from 1997–2001, the Chinese economy might have grown at just around 2% annually. Using Engel curves to derive alternative estimates for inflation and economic growth, Nakamura, Steinsson, and Liu (2016) demonstrate that China's official statistics offer a more smoothed depiction of the actual scenario. The manipulation isn't confined solely to GDP statistics. Kung and Chen (2011) and Meng, Qian, and Yared (2015) highlight how officials, motivated

[8] As illustrated in Figure 3, the weighted average of city-level GDP growth rates was almost always higher than the national GDP growth rate between 2003 and 2013.

[9] For instance, according to Renmin Net, a mainstream media source, a director of the local bureau of statistics was removed from their position for refusing to collaborate with mayors in manipulating the data. Source: Renmin Net, http://politics.people.com.cn/n1/2017/0120/c1001-29037119.html, retrieved on October 23, 2023.

[10] Several mayors were punished due to data manipulation. For instance, Sutao Sun, the mayor of Weihai, and the mayor of Jinan were jailed for manipulating the data. Yuqiang Liu, the mayor of Linfen, was criticized by the Ministry of Environmental Protection for manipulating air pollution data, and he did not get promoted afterwards.

[11] http://politics.people.com.cn/n1/2017/0120/c1001-29037119.html, retrieved on October 23, 2023

by career incentives, exaggerated food production figures, leading to significant fatalities during the Great Leap Forward (1958-1961). Comparing satellite data with officially reported figures, Karplus, Zhang, and Almond (2018) scertain that China's SO2 data has been altered, especially in regions with stringent emission standards. Serrato, Wang, and Zhang (2019) discovered widespread misreporting related to the "one-child-policy" performance during the 1990s, which seemingly correlated with the promotion prospects of mayors in China.

3 Conceptual Framework

In this section, we provide a simple theoretical framework to illustrate what incentivizes mayors to manipulate the data, and the heterogeneity in GDP manipulation cost. The model predictions also provide guidance for our empirical exercises.

3.1 Model Setup

We consider a single-period environment with *two* strategic mayors competing in GDP statistics to get promoted.

Mayor i is career-minded. She can exert costly effort, denoted by $m_i \geq 0$, to manipulate GDP statistics, and $g_i \geq 0$ to promote real economic growth. Mayor i competes with another mayor for promotion. If mayor i is promoted, she will be awarded a fixed prize of $R \geq 0$. Mayor i's utility function can be written as:

$$u_i = \begin{cases} R - \alpha_i m_i^2 - g_i^2, \text{if promoted} \\ -\alpha_i m_i^2 - g_i^2, \text{if not} \end{cases} \tag{1}$$

Where, α_i is the mayor-specific cost of GDP manipulation, $\alpha_i > 0$. The official GDP statistics can be written as the sum of GDP manipulation m_i, city-specific economic growth rate v_i, and growth shocks ϵ_i. GDP statistics are realized after mayors exert their costly efforts:

$$GDP_i = m_i + g_i + v_i + \epsilon_i \tag{2}$$

ϵ_i follows a normal distribution with mean 0 and standard e=deviation σ. Following Li et al. (2019), we assume that in this tournament, the mayor with higher GDP statistics will be promoted. However, it should also be noted that in reality, a mayor's likelihood of promotion will also be affected by other factors such as political loyalty, experience, and political connections. Another interpretation of Equation (2) is that v_i also captures these

factors in addition to the growth shocks. And the mayor with the highest score function $s_i = m_i + g_i + v_i + \epsilon_i$ will get promoted. Mayor i's promotion probability is:

$$Pr_i = \left(1 - \Phi(\frac{g_j + m_j + v_j - g_i - m_i - v_i}{\sigma})\right) \tag{3}$$

3.2 Analysis

Mayor i's expected payoff function $f(g_i, m_i|g_j, m_j)$ can be written as:

$$f(g_i, m_i|g_j, m_j) = -g_i^2 - \alpha m_i^2 + \left(1 - \Phi(\frac{g_j + m_j + v_j - g_i - m_i - v_i}{\sigma})\right) \cdot R \tag{4}$$

First order conditions in terms of g_i and m_i can be written as:

$$[m_i] : -2\alpha m_i + \frac{R}{\sigma}\phi(\frac{g_j + m_j + v_j - g_i - m_i - v_i}{\sigma}) = 0 \tag{5}$$

$$[g_i] : -2g_i + \frac{R}{\sigma}\phi(\frac{g_j + m_j + v_j - g_i - m_i - v_i}{\sigma}) = 0 \tag{6}$$

Equation (5) and (6) determine the "optimal" level of GDP manipulation m_i^* and growth rate g_i^* for mayor i. We obtain the following theoretical predictions:

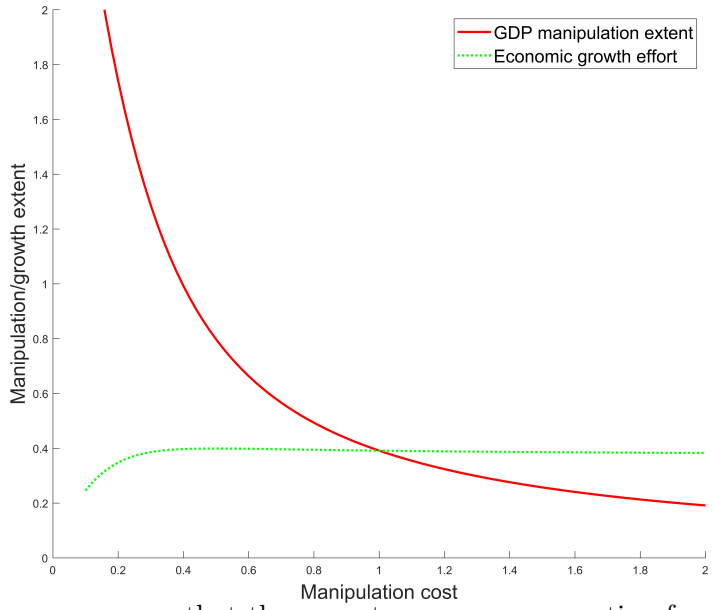
Prediction 1: Mayors will manipulate GDP statistics as long as the reward for winning the competition remains positive. The extent of GDP manipulation becomes zero when mayors are no longer eligible for promotion. Formally, $m_i^* > 0$ if $R > 0$, $m_i^* = 0$ if $R = 0$.

We conduct comparative statics to examine the heterogeneity in GDP manipulation cost α_i. Given the potential non-monotonicity, we use numerical exercises to show the results. The results are reported in Figure 2. In this exercise, we assume that there are two mayors (mayor 1 and mayor 2) competing for promotion. We assume Mayor 2's parameters are fixed and focus on Mayor 1. We plot the relationship between manipulation cost and the efforts in GDP manipulation and economic growth for mayor 1. The x-axis is the manipulation cost for mayor 1, i.e., α_1. The red solid line in Figure 2 illustrates the influence of GDP manipulation cost on the extent of GDP manipulation, while the green dotted line represents the effect of GDP manipulation cost on the mayor's efforts towards economic growth.

Prediction 2: Mayor i's GDP manipulation extent decreases with the manipulation cost α_i. Mayor i's efforts in economic growth increase with the manipulation cost when it is low, and slightly decrease when the manipulation cost exceeds a certain threshold.

When the cost of GDP manipulation is low, Mayor i's probability of winning the com-

Figure 2: Heterogenity in GDP manipulation cost



Notes: In this exercise, we assume that there are two mayors competing for promotion. $v_1 = v_2 = 0.5$, $R = 3$, $\alpha_2 = 0.5$, and the x-axis is the manipulation cost for mayor 1, i.e., α_1. The results remain robust when we use different sets of parameters.

petition is high. Mayor i's efforts in GDP manipulation and in promoting economic growth act as substitutes. The increase in GDP manipulation cost leads to an increase in the real economic growth rate. However, when α_i exceeds a certain threshold, this relationship disappears. Since the high cost of GDP manipulation correlates to a low probability of winning. Consequently, the benefits derived from increased efforts to promote growth are offset by the associated costs, leading Mayor i to cease increasing efforts in promoting real economic growth.[12]

[12]Note that Mayor i's effort in real economic growth will not decrease to zero as the manipulation cost α_i goes to infinity. This is because her opponent, mayor j's positive manipulation cost α_j making GDP_j a finite number. As long as mayor i has a good draw in ϵ_i, she still has non-negligible chances of winning the competition. Due to the convex cost function, Mayor i has incentives to spend some of her efforts on promoting real economic growth, even when facing high manipulation costs.

4 Empirical Strategies

4.1 Data generation process

According to the model, the official GDP growth rate contains two parts: real economic growth and GDP manipulation:

$$GDP_s = GDP_r + GDP_m \tag{7}$$

Where GDP_s, GDP_r, and GDP_m denote statistical GDP growth rate, real GDP growth rate, and the manipulation part of GDP growth rate, respectively. Nighttime light growth, denoted by light_g, is a function of real economic growth (GDP_r):

$$\text{light}_g = h\left(GDP_r\right) + \varepsilon_{\text{light}} \tag{8}$$

We assume that mayoral promotion incentives affect the nighttime light growth rate only through the channel of GDP_r. Differentiating (7) and (8) in terms of mayoral promotion incentives (PI):

$$\frac{\partial GDP_s}{\partial PI} = \frac{\partial GDP_r}{\partial PI} + \frac{\partial GDP_m}{\partial PI} \tag{9}$$

$$\frac{\partial light_g}{\partial PI} = \frac{\partial GDP_r}{\partial PI}\frac{\partial h}{\partial GDP_r} \tag{10}$$

Define $\gamma = \frac{\partial GDP_S}{\partial light_g}$ to normalize the nighttime light growth rate, making it comparable to the statistical GDP growth rate.[13] We then combine Equation (9) and (10) to estimate the impact of mayoral promotion incentives on GDP manipulation:

$$\frac{\partial GDP_m}{\partial PI} = \frac{\partial GDP_s}{\partial PI} - \frac{\partial light_g}{\partial PI} * \gamma \tag{11}$$

Equation (11) provides guidance for our empirical design. We need to identify three key parameters to quantify the impact of mayoral promotion incentives on GDP manipulation. These are: first, the impact of mayoral promotion incentives on the statistical GDP growth rate ($\frac{\partial GDP_s}{\partial PI}$); second, the impact of mayoral promotion incentives on the nighttime light growth rate ($\frac{\partial light_g}{\partial PI}$); and third, a normalizing constant γ that makes the GDP growth rate and nighttime light growth rate comparable.

[13] γ can be interpreted as the impact of nighttime light growth rate on statistical GDP growth rate.

4.2 RD framework to identify GDP manipulation

We use the regression discontinuity design to identify the effect of mayoral promotion incentives on statistical GDP growth rate, nighttime light, and other non-manipulable economic growth indicators. The discontinuity lies in mayors' promotion ineligible age (i.e., 58). Mayors who are younger than 57 are still eligible for promotion, and they have stronger promotion incentives than mayors who are older than 58. The following local linear regressions were estimated (Imbens and Lemieux, 2008; Lee and Card, 2008):

$$GDP_{s,it} = \alpha + \beta_{gdp} PI_{it} + \tau age_{it} + \rho \left(PI_{it} * age_{it} \right) + \delta X_{it} + v_t + \mu_i + \varepsilon_{it} \tag{12}$$

$$growth_{nm,it} = \alpha' + \beta_{nm} PI_{it} + \tau' age_{it} + \rho' \left(PI_{it} * age_{it} \right) + \delta' X_{it} + v'_t + \mu'_i + \varepsilon'_{it} \tag{13}$$

Subscript i denotes prefecture-level city i, t denotes year. PI_{it}, a dummy indicating promotion incentives for the mayor of the prefecture-level city i at year t, is the variable of interest. PI_{it} equals 1 if mayors are 57 or younger and 0 if they are 58 or older. age_{it} is a normalized mayor's age at year t.[14] X_{it} is a set of control variables, including mayors' educational background, gender, and how long they serve in office. $GDP_{s,it}$ and $growth_{nm,it}$ represent the statistical GDP growth rate and the non-manipulable economic growth indicators, respectively. City fixed effects μ_i and year fixed effects v_t are included in all specifications. β_{gdp} in (12) identifies the impact of mayoral promotion incentives on statistical GDP growth rate at the age cutoff point. β_{nm} in (13) identifies the impact of mayoral promotion incentives on non-manipulable growth indicators at the age cutoff point.[15] Note that we checked the robustness of our results by adding higher polynomials in Appendix A.1.2.

If mayoral promotion incentives lead to GDP manipulation rather than real economic growth, we would expect β_{gdp} to be positive and significant, while the coefficients for non-manipulable growth indicators β_{nm} would be close to zero.

4.3 Potential threats to identification

4.3.1 Selection on unobservables at the age cutoff point

One potential concern of our empirical framework is the manipulation of the running variable at the age cutoff point. A possible scenario is that high-ability mayors are more likely to be promoted before they arrive at their promotion ineligible age. The panel structure of our

[14] age_{it}=real age-58

[15] Note that since age_{it} is normalized, the interaction term equals zero at the age cutoff point.

data allows us to control for mayor fixed effects to absorb mayors' unobserved abilities. The intuition here is to compare the same mayors' performance on both sides of the age cutoff point (i.e., 57). The local linear regressions are estimated as follows:

$$GDP_{s,jt} = \alpha + \beta_{gdp} PI_{jt} + \tau age_{jt} + \rho\left(PI_{jt} * age_{jt}\right) + v_t + \mu_i + \eta_j + \varepsilon_{ijt} \tag{14}$$

$$\text{growth}_{\text{nm},jt} = \alpha' + \beta_{\text{nm}} PI_{jt} + \tau' \text{age}_{jt} + \rho'\left(PI_{jt} * age_{jt}\right) + v'_t + \mu'_i + \eta'_j + \varepsilon'_{ijt} \tag{15}$$

Where all notation remains identical to that of the Equation (12) and (13), except that the subscript j denotes mayor j, and η_j denotes the mayor fixed effects.

In addition to incorporating mayor-fixed effects, we also conduct several tests to make sure our results are not driven by confounding factors. First, we examine whether cities with mayors older than 57 differ in observable characteristics from those with younger mayors. As shown in Figure A5. We find no significant differences. Second, the Panel structure of our data enables us to conduct an event study analysis and check the parallel trend. The results reported in Figure A6 suggest that the effects of promotion incentives on statistical GDP growth rates are unlikely to be driven by city-specific pre-trends.

4.3.2 Sensitivity of nighttime light

Although nighttime light is exogenous to artificial manipulation in GDP statistics, there might still be concerns related to the "insensitive" lights.

One concern is that career-minded mayors may engage in activities that aim to boost GDP quickly but may not be reflected in nighttime lights immediately (e.g. investment in infrastructures). We rule out this possibility by re-estimating the RD Equation (13) using government expenditures as the outcome variable. Government expenditures are necessary to financing government activities to influence GDP, and generally will not affect promotion.

Another concern is that growth in lights is more irreversible than GDP growth. For instance, in the event of negative economic shocks, GDP statistics will drop, while nighttime light growth might remain relatively stable in the short term. Measurement errors in light may also lead to the imprecise estimation of β_{nm}. To mitigate these concerns, in section 8.2 we test the response of city-level nighttime light and statistical GDP to two economic shocks—the Two Control Zone policy (TCZ) and the Great Recession. We find that the nighttime light growth rate is as responsive, if not more, to the two economic shocks than the GDP growth rate. Furthermore, in Figure 3, we compare the nighttime light growth

rate, the weighted average of city-level GDP growth rate [16], and the national-level GDP growth rate during the Great Recession. The national-level GDP statistics is calculated by the national bureau of statistics independently using the production approach, which is *not* a simple summation of the city-level GDP statistics.[17] We find some converse results: the nighttime light growth rate is more responsive to economic shocks than the national-level GDP growth rate. The weighted average of city-level GDP growth rate, however, remains unchanged during the recession. The discrepancy between the weighted average of the city-level GDP growth rate and the national-level GDP growth rate also provides some evidence of subnational-level GDP manipulation in China.

We also use alternative non-manipulable growth indicators–electricity, manufacturing firms' employment, and firm-level TFP to examine the robustness of our nighttime light results. We find mayoral promotion incentives have little impact on these indicators. The results are reported in sections 6.3 and 6.4.

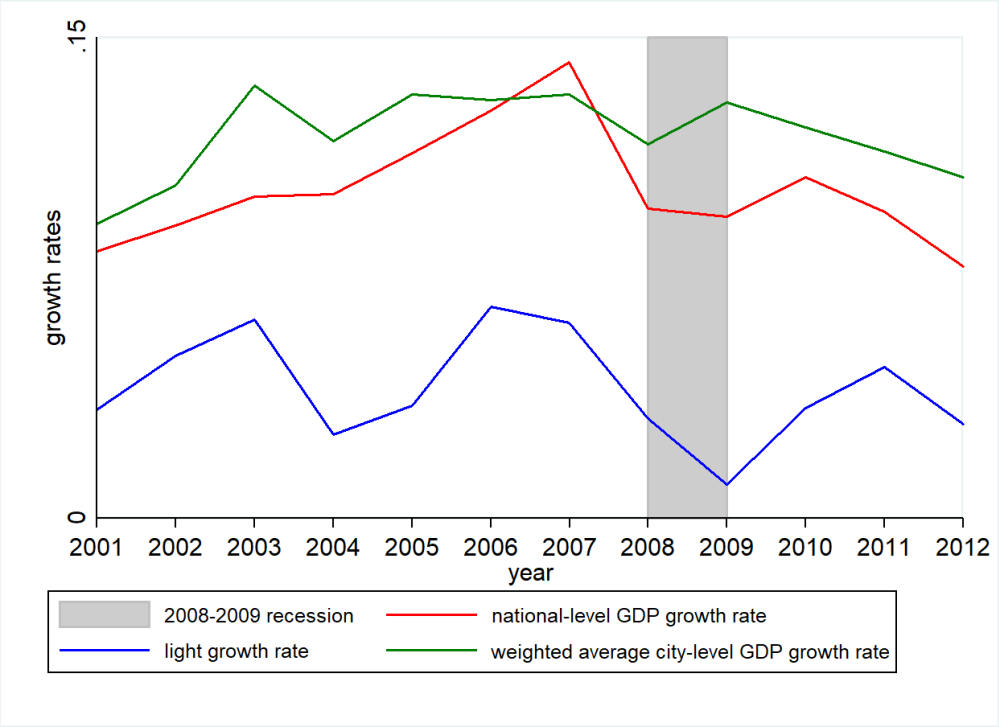
To rule out the possibility that light may be a lagged indicator of economic growth, we explore the relationship between promotion incentives and the lead term of nighttime lights in Appendix A.3 under the same RD framework.

The literature also provides consistent evidence that nighttime light is responsive to economic shocks immediately and highly correlates with economic growth both at the national and subnational levels. Henderson, Storeygard, and Weil (2012) document a strong and robust relationship between nighttime light and GDP at the national level. Hodler and Raschky (2014) use the light data at the subnational level and provide strong evidence that light is sensitive to shocks at the subnational level. They find that political leaders strongly affect their home region's light in the first year when they assume office, and the effect disappears when they leave the office. Tang and Hewings (2017) and Liu, Zeng, and Zhou (2019) find that annexing counties into cities as districts in China significantly increases the original county's nighttime light intensity almost immediately. World-Bank (2017) and Huang, Hsiang, and Gonzalez-Navarro (2021) use nighttime light as the dependent variable in evaluating local policy effects.

[16] The weight is the city's GDP statistics.

[17] See the following website for a detailed explanation of the national-level GDP calculation process http://www.stats.gov.cn/tjsj/zxfb/201401/t20140108_496941.html

Figure 3: Comparing different growth measures



5 Data

We collected data from several sources. The prefecture-level city mayor data is manually collected by the authors. We obtained data on 892 mayors in 255 cities from 2003 to 2013.[18] The dataset includes mayor's demographic characteristics such as age, gender, and education level. The observations are at the city-year-mayor level.

GDP data and other official statistics, such as the share of the agriculture, manufacturing, and service industries, come from the statistical yearbook. GDP statistics are adjusted to the prices in 2000 using the provincial-level price deflator.

We use non-manipulable economic growth indicators to study the effects of mayoral promotion incentives on real economic growth. The term "non-manipulable" can be interpreted in two dimensions. First, it implies that the data is difficult to manipulate. Second, it also refers to the indicators for which local officials lack incentives to manipulate.

The most preferred measure for real economic growth is nighttime light. Nighttime light data are processed and published by the NOAA's National Geophysical Data Center

[18]We don't include the prefecture-level cities in Xinjiang and Tibet, and the autonomous prefectures in our analysis.

Table 2: Summary statistics

Variable	Obs	Mean	Std. Dev.
GDP growth rate	2,429	0.109	0.065
Nighttime light growth	2,429	0.049	0.044
Share in agriculture industry	2,186	15.18	9.11
Share in manufacturing industry	2,185	49.75	10.72
Share in service industry	2,186	35.1	7.62
ln(employment)	2,158	11.65	1.22
Elctricity growth rate	2,363	0.106	0.118
ln(TFP)	2,158	1.72	0.54
Term	892	3.91	1.38
Female=1	892	0.067	0.251
Age	892	50.6	3.76

Notes: (1) Time period is 2003 to 2013. (2) The first eight rows report the summary statistics for the data at the city-by-year level, while the last three rows (term, female, and age) report the summary statistics for the mayor-level variables. For the last three rows, we refer to the statistics of the mayors' last year in office. Due to data availability in earlier years, our sample includes mayors who began their terms in 2002 or later. (3) All output and revenue measures have been adjusted to 2000 constant prices using the provincial-level price deflator. (4) "Term" denotes how long an individual has served as the mayor in a given city.

(NGDC). It is well-established that light is exogenous to artificial manipulation, strongly correlates with measures of real economic growth, and is sensitive to economic shocks (Henderson, Storeygard, and Weil, 2012; Hodler and Raschky, 2014; Clark, Pinkovskiy, and Sala-i Martin, 2017; Martinez, 2021; Hu and Yao, 2021). The original data has a resolution of around 1km, and we aggregate the nighttime light intensity at the city level. Notably, nighttime light data fits both criteria of being "non-manipulable": mayors neither possess the means nor the incentives to manipulate it.

Data on electricity consumption is sourced from the city's statistical yearbook. The manufacturing firms' employment and total factor productivity (TFP) data come from the Chinese Industrial Enterprise Dataset. This dataset contains all manufacturing firms with annual sales greater than 5 million CNY (around 700 thousand USD).[19] In section 8.3, we discuss the calculation method.

Table 2 presents the summary statistics for the variables used in the main analysis of

[19]This criterion becomes 20 million CNY in 2012.

this paper, covering the period from 2003 to 2013.

6 Results

6.1 Promotion incentives, official GDP statistics, and nighttime light

Panel A of table 3 presents the effects of mayoral promotion incentives on official GDP growth rate (Equation (12) and 14). The variable of interest (PI) is a dummy that denotes the mayors' promotion incentives, which equals 1 if she is 57 or younger and 0 if she is 58 or older. The first four columns only include city and year fixed effects. We add mayor fixed effects in columns (5) and (6) to deal with the concerns that high-ability mayors are more likely to get promoted before they arrive at their promotion ineligible age.

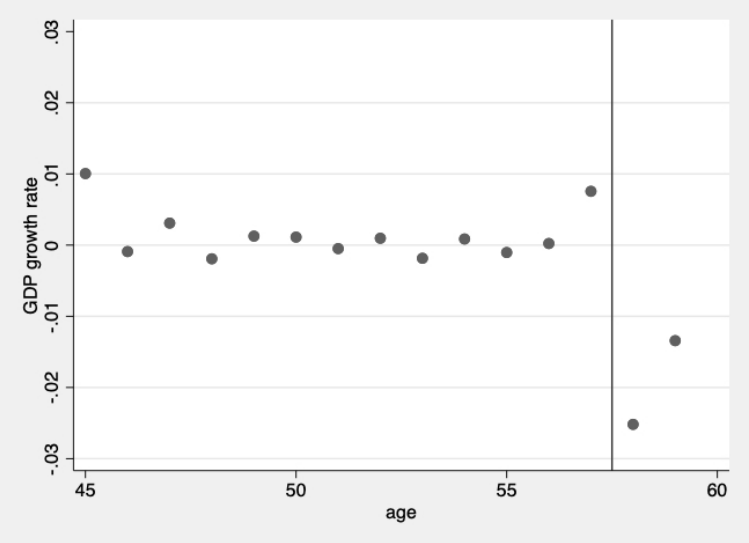
Table 3: Mayoral promotion incentives, official GDP statistics, and nighttime light

	(1)	(2)	(3)	(4)	(5)	(6)
		City FE			City FE + Mayor FE	
Panel A: Official GDP growth rate						
PI=1 (age$\leq$ 57)	0.0358**	0.0326**	0.0249*	0.0257*	0.0343*	0.0308**
	(0.0156)	(0.0157)	(0.0134)	(0.0133)	(0.0176)	(0.0154)
Obs	295	294	1105	1100	295	1105
R^2	0.125	0.157	0.100	0.106	0.280	0.326
Panel B: Nighttime light growth rate						
PI=1 (age$\leq$ 57)	0.00512	0.00422	0.00129	0.00211	0.00418	0.00411
	(0.00693)	(0.00710)	(0.00563)	(0.00567)	(0.00734)	(0.00617)
Obs	295	294	1105	1100	295	1105
R^2	0.398	0.416	0.271	0.283	0.585	0.571
Demographic controls		X		X		
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Mayor fixed effect					X	X
# of cities	115	115	237	237	115	237
Age coverage	55-60	55-60	51-60	51-60	51-60	51-60

Notes: (1) Demographic controls include the gender of the mayor, their education level, and how long the individual served as mayor in the city, and are absorbed in the last two columns. (2) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 3 shows strong and robust evidence of the positive impact of mayors' promotion

Figure 4: Mayoral promotion incentives and GDP growth rate



Notes: Data is aggregated by age bins and is plotted following a three-way transformation. The variable on the y-axis is a demeaned GDP. We subtract GDP statistics for city i ($\overline{GDP_{ijt}}$) by the mayor fixed effect ($\overline{GDP_j}$), city fixed effect ($\overline{GDP_i}$), and year fixed effect ($\overline{GDP_t}$): $\text{GDP}_{ijt} - \overline{GDP_i} - \overline{GDP_j} - \overline{GDP_t} + 3 \cdot \overline{GDP}$. The x-axis denotes mayors' age.

incentives on official GDP growth rate. Compared to the cities whose mayors are 57 years old or younger with strong promotion incentives, cities with mayors older than 57 have approximately 3 percentage points lower official GDP growth rate.

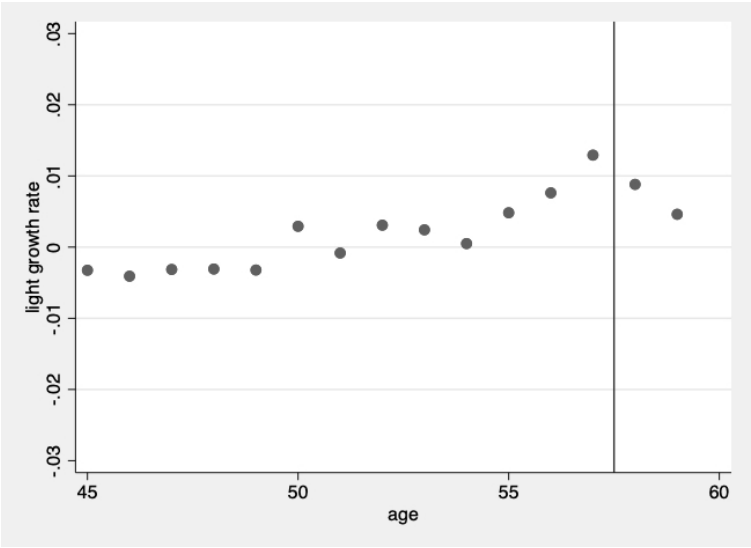
Figure 4 plots the bivariate relationship between age and normalized statistical GDP growth rate after extracting the mayor-level fixed effect. The figure suggests a clear "jump" in statistical GDP growth rate at the age cutoff points, echoing the results in Table 3.

We also investigate the influence of mayoral promotion incentives on cities' nighttime light growth, which is a reliable indicator of real economic growth and is immune to manipulation. The literature has shown the strong predictive power of nighttime light on economic growth, and it is sensible to economic shocks. In section 6.2, we demonstrate the ability of these alternative measures to identify the impact of other substantial economic shocks.

Panel B of table 3 reports the estimation results for Equation (13) and (15) using nighttime light growth rate as the outcome variable. The results in Paenl B of Table 3 show that the effects of mayoral promotion incentives on nighttime light are insignificant and are much smaller than those on official GDP growth rate in all specifications. Figure 5 plots the bivariate relationship between mayoral promotion incentives and nighttime light growth, indicating that nighttime light growth rates are continuous at the age cutoff.

The results presented in Section 6.1 offer evidence that mayoral promotion incentives

Figure 5: Mayoral promotion incentives and nighttime city light



Notes: Data is aggregated by age bins and is plotted following a three-way transformation. The variable on the y-axis is a demeaned nighttime light growth rate. We subtract light growth for city i ($light_{ijt}$) by mayor fixed effect ($\overline{light_j}$), city fixed effect ($\overline{light_i}$), and year fixed effect ($\overline{light_t}$): $light_{ijt} - \overline{light_j} - \overline{light_i} - \overline{light_t} + 3 \cdot \overline{light}$. The x-axis denotes mayors' age.

significantly increase cities' statistical GDP growth rate by around 3 percentage points, while having no significant impact on nighttime light. We attribute the gap between these two estimators to GDP manipulation.

6.2 Estimation of the GDP manipulation extent

Section 6.1 offers evidence that mayoral promotion incentives increase cities' statistical GDP growth rate, while their effect on nighttime light growth is relatively small and statistically insignificant. This section aims to combine these two estimators to estimate the extent of GDP manipulation when mayors face promotion pressure based on Equation (11).

Note that the results in Table 3 identify the impact of promotion incentives on statistical GDP growth rate ($\frac{\partial GDP_s}{\partial PI}$), and on nighttime light growth rate ($\frac{\partial light_s}{\partial PI}$). We employ Equation (16) to obtain the normalizing constant γ:

$$lngdp_{s,it} = \alpha'' + \gamma lnlight_{it} + \varepsilon''_{it} \tag{16}$$

The magnitude of the point estimate of γ reported in Table 4 is similar to that found in Henderson, Storeygard, and Weil (2012). It is worthwhile to note that the estimate of γ has little impact on the consistency of the estimated GDP manipulation extent, since the discontinuity in nighttime light (β_{light}) is close to zero. We use various γs to check the

robustness of the results.

Table 4: Estimation of γ

Outcome Variable	ln(GDP)
ln(light)	0.369***
	(0.069)
Year fixed effects	X
City fixed effects	X
Obs	2428
R^2	0.99

Notes: All standard errors are clustered at the city level, *** p<0.01, ** p<0.05, * p<0.1.

Based on Equation (11), we calculate the GDP manipulation extent using the following formula: $manipulation = \hat{\beta_{gdp}} - \hat{\beta_{light}} \cdot \hat{\gamma}$. We bootstrap 500 times to calculate the point estimates and the standard errors. The extent of GDP manipulation is reported in Table 5.

Table 5: GDP manipulation extent

Age coverage		γ=0.2	γ=0.369	γ=0.6
55-60	Manipulation	0.0305*	0.0296*	0.0290*
	std.	(0.0166)	(0.0170)	(0.0173)
51-60	Manipulation	0.0315**	0.0308**	0.0302*
	std.	(0.0152)	(0.0157)	(0.0160)

Notes: (1) City fixed effects, mayor fixed effects, and year fixed effects are controlled in all specifications. (2)Standard errors in parentheses are obtained based on 500 bootstrapped resamples clustered at the prefecture-level city level.

The results in Table 5 indicate that mayoral promotion incentives have a significant impact on GDP manipulation. Mayors with high promotion incentives tend to manipulate the statistical GDP growth rate by around 3 percentage points, and this effect is statistically significant. Various values of γ have a limited impact on the estimates of GDP manipulation extent.

6.3 What happened after 2013?

Environmental protection (Greenstone et al., 2021) and political loyalty (Ji, 2020) have become increasingly crucial for officials' promotion after 2013. Meanwhile, the role of GDP statistics in mayors' promotion is weakened. Many policy documents and President Xi's public speeches strengthened that GDP statistics should no longer become the main indicator to evaluate local officials' performance.[20] We expect to see GDP and being below 58 are less complementary after 2013. We re-estimate the RD equation using the data from 2014 to 2018.[21].

The results are reported in Table 6. Columns (1), (2), and (3) use the statistical GDP growth rate as the outcome variable. The last three columns use the nighttime light growth rate as the outcome variable. As expected, mayoral promotion incentives no longer have a sizeable impact on both the official GDP growth rate and the nighttime light growth rate after 2013. It is worthwhile to mention that the discontinuity in promotion probability at age 57 still persists from 2014 to 2018. The probability for the mayors aged 57 to get promoted is 53 %, and this number decreases to 11 % for the mayors who are 58. The change in the coefficients of promotion incentives after 2013 mainly comes from the changes in evaluation targets rather than the promotion age criterion. The results corroborate our main argument from an opposite direction— when a measure ceases to be a target, promotion incentives play no role in it.

Using the same method as outlined in Section 6.2, in Section A.4, we report the GDP manipulation extent after 2013. The estimates are not statistically distinguishable from zero.

7 Heterogeneity

We explore the heterogeneity in GDP manipulation in this section. Unraveling these heterogeneous effects can help us better understand the mechanisms behind GDP manipulation and lend support to the main results. Based on the model prediction, the extent of GDP manipulation decreases as manipulation costs increase. However, the impact of manipulation costs on mayors' efforts towards economic growth is ambiguous. In this section, we test

[20] http://cpc.people.com.cn/pinglun/n/2013/1107/c241220-23466862.html; http://renshi.people.com.cn/n/2013/1210/c139617-23801847.html

[21] The nighttime light data after 2013 comes from Visible Infrared Imaging Radiometer Suite (VIIRS) data, and its magnitude and measurement may be slightly different from the Defense Meteorological Satellite Program (DMSP) data before 2013. Figure A9 suggests a strong correlation between nighttime light and GDP both before and after 2013.

Table 6: After 2013

	(1)	(2)	(3)	(4)	(5)	(6)
	Official GFP growth rate			Nighttime light growth rate		
PI=1 ($age \leq 57$)	-0.00861	-0.00977	0.00200	0.0116	-0.00995	-0.00202
	(0.0177)	(0.0173)	(0.0196)	(0.0305)	(0.0312)	(0.0362)
Obs	284	260	284	278	256	278
R^2	0.053	0.086	0.425	0.239	0.320	0.361
Demographic controls		X			X	
Mayor fixed effect			X			X
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
# of cities	145	132	145	144	132	144
Age coverage	55-60	55-60	55-60	55-60	55-60	55-60

Notes: (1) Demographic controls include the gender of the mayor, their education level, and how long the individual served as mayor in the city. (2) The results using the other bandwidths remain robust. (3) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

the heterogeneity in GDP manipulation costs from two perspectives. First, we construct an indicator that captures the mayor-level heterogeneity in GDP manipulation cost and examine how this indicator affects the treatment effects. Second, we analyze the heterogeneity in GDP manipulation across sectors.

7.1 Mayor-level heterogeneity in manipulation cost

To construct an indicator that reflects mayor-level heterogeneity in manipulation cost, we draw insights from the corporate finance literature. Khanna, Kim, and Lu (2015) find that a CEO's connectedness with other officials in a company is linked to corporate fraud. This paper uses a similar indicator based on whether an official has served in vice-mayor-level positions within the same city for more than two years. Mayors with such experience are likely to have lower GDP manipulation costs, due to their established connections with directors of the local bureau of statistics, other vice-mayors, and county-level officials. These connections are crucial, as effective GDP manipulation requires the cooperation of these key officials.[22]

[22]Our results remain consistent when we adjust the threshold from two years to one, three, or four. We chose two years as the threshold because the CPC's formal guidelines for cadre selection mandate that officials stay in same-level positions for at least three years before being considered for a promotion to the next rank.

Based on our model predictions, we expect that mayors in the low manipulation cost group will exhibit a larger jump in GDP statistics at the age cutoff point. Conversely, mayors with high manipulation costs are likely to have a smaller discontinuity in GDP at the age cutoff.

The heterogeneity results presented in Table 7 are consistent with our model predictions. For mayors with low manipulation costs (i.e., those with more than 2 years of local experiences), the impact of the mayors' promotion incentives on cities' statistical GDP growth rate nearly doubles, as seen in the first three columns of Panel A. The influence of mayors' promotion incentives on nighttime light is close to zero and statistically insignificant, as indicated in the first three columns of Panel B. Conversely, for mayors with high manipulation costs, the impact of promotion incentives on GDP statistics diminishes and becomes statistically indistinguishable from zero, as shown in the last three columns of Panel A. The impact of mayoral promotion incentives on nighttime light remains insignificant.

Table 7: Heterogeneity in GDP manipulation cost

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A			GDP growth rate			
	Low manipulation cost			High manipulation cost		
PI=1 ($age \leq 57$)	0.0671**	0.0677**	0.0677**	0.0198	0.0202	0.0187
	(0.0265)	(0.0273)	(0.0273)	(0.0212)	(0.0209)	(0.0221)
Obs	86	86	86	209	208	209
R^2	0.467	0.476	0.476	0.102	0.153	0.205
Panel B			Light growth rate			
	Low manipulation cost			High manipulation cost		
PI=1 ($age \leq 57$)	-0.00999	-0.00982	-0.00982	0.00989	0.00988	0.0114
	(0.0168)	(0.0168)	(0.0168)	(0.00808)	(0.00810)	(0.00841)
R^2	0.548	0.550	0.550	0.411	0.421	0.658
Obs	86	86	86	209	208	209
Demographic controls		X			X	
Mayor fixed effect			X			X
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
# of cities	38	38	38	86	86	86
Age coverage	55-60	55-60	55-60	55-60	55-60	55-60

Notes: (1) Demographic controls include the gender of the mayor, their education level, and how long the individual served as mayor in the city. (2) The results using the other bandwidths remain robust. (3) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

7.2 Heterogeneity by sectors

To explore heterogeneity in GDP manipulation across sectors, we re-estimate the Equation (12) using the statistical GDP growth rate in agriculture, manufacturing, and the service sector as dependent variables. The RD estimation results are presented in Table 8. Columns (1) and (2) suggest that mayoral promotion incentives have a negligible impact on the statistical GDP growth rate within the agriculture sector. In contrast, mayoral promotion incentives significantly influence the statistical GDP growth rate in both manufacturing and service sectors. Although we cannot decompose the nighttime light growth data by sector, our main results suggest that GDP manipulation is primarily driven by the discontinuity in GDP statistics.

There are two potential explanations for the sectoral variation in GDP manipulation. First, the cost of manipulation is high in the agriculture sector due to the Ministry of Agriculture's reliance on remote sensing techniques for estimating and monitoring crop yields. Secondly, the agriculture sector contributes to around 15% of the GDP, the benefit of manipulating the agriculture data may not be as high as manipulating the data in manufacturing and service sectors.

Table 8: Heterogeneity of manipulation

	(1)	(2)	(3)	(4)	(5)	(6)
	Agriculture		Manufacture		Service	
PI=1 ($age \leq 57$)	0.00214	0.00426	0.0403*	0.0317**	0.0392*	0.0343*
	(0.0247)	(0.0229)	(0.0210)	(0.0156)	(0.0204)	(0.0195)
Obs	262	984	262	984	262	984
R^2	0.158	0.138	0.232	0.152	0.183	0.143
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
# of cities	104	223	104	223	104	223
Age coverage	55-60	50-60	55-60	50-60	55-60	50-60

Notes: (1) The time period is 2003 to 2013. (2) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

8 Robustness checks: "insensitive" lights?

Section 4.3.2 discusses concerns related to the sensitivity of nighttime lights. This section provides empirical evidence to alleviate these concerns by demonstrating the robustness of our results to other non-manipulable economic growth indicators.

8.1 Government expenditures

As aforementioned, career-minded mayors may invest government spending in infrastructure projects to boost GDP statistics when they are approaching the age threshold. These activities may not be captured by nighttime light growth. To rule out this concern, we directly examine the effect of promotion pressure on government expenditures, which are used to finance infrastructure projects. The results reported in Table 9 indicate no significant impact of promotion pressure at the age cut-off point on government expenditure growth. We interpret this as evidence that career-minded mayors are unlikely to boost GDP statistics through government activities when nearing the age threshold.

Table 9: Government expenditures

	(1)	(2)	(3)	(4)	(5)	(6)
	Local government expenditure growth rate					
	City FE				City FE + Mayor FE	
PI=1 (age$\leq$ 57)	0.00391	0.00199	0.00107	0.00118	0.00517	0.00576
	(0.0206)	(0.0213)	(0.0163)	(0.0169)	(0.0201)	(0.0228)
Obs	295	294	1104	1099	1104	295
R^2	0.172	0.179	0.201	0.213	0.414	0.246
Demographic controls		X		X		
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Mayor fixed effect					X	X
# of cities	115	115	237	237	115	237
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60

Notes: (1) Demographic controls include the gender of the mayor, their education level, and how long the individual served as mayor in the city. (2) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

8.2 Sensitivity of light and GDP to economic shocks

In this section, we use two economic shocks: The Two Control Zone Policy (TCZ) and the Great Recession, to test the responsiveness of city-level nighttime light and statistical GDP to economic shocks.

The Two control zone Policy is an environmental protection policy that aims to reduce SO2 emissions, which have long been a major contributor to China's ambient air pollution. In 1998, the central government established control zones in regions with the highest sulfur emissions or acid rain levels. However, the effect of TCZ on SO2 emission reduction has been small, as its implementation did not initially affect officials' promotions, as noted in Chen, Li, and Lu (2018). In 2005, new regulations were imposed, and the implementation of the TCZ was included in the performance evaluation for city secretaries and mayors. Under a difference-in-difference framework, Chen, Li, and Lu (2018) find that the revision of TCZ policy in 2005 significantly reduced the GDP growth rate by around one percentage point.In this section, we replicate and extend Chen, Li, and Lu (2018)'s findings, examining whether both GDP and light growth rates are sensitive to the TCZ shock since 2005

Another economic shock we examine is the Great Recession. As an imported economic crisis, we expect the Great Recession to have more negative effects on cities that rely more on FDI and international trade.

We test the sensitivity of nighttime light and GDP on economic shocks under a difference-in-difference framework:

$$y_{it} = \beta_1 * (post_{it} * treatment_{it}) + \beta_2 * X_{it} + \mu_i + v_t + \epsilon_{it} \tag{17}$$

Where y_{it} represents the nighttime light growth rate or the statistical GDP growth rate in city i year t. $post_{it}$ is a dummy that equals 1 for the treatment periods (i.e., after 2005 for the Two Control Zone policy, and from 2008 to 2010 for the Great Recession regressions), and equals zero otherwise.In the TCZ regressions, $treatment_{it}$ is a dummy variable that equals 1 for cities in the two control zones and zero otherwise. For the Great Recession regressions, $treatment_{it}$ is a continuous variable measuring the share of FDI in GDP (in 10%). City fixed effects μ_i and year fixed effects v_t are controlled in all specifications. We also include mayors' promotion incentive controls in X_{it}. The results are reported in Table 10.

Column (1) in Table 10 suggests that the TCZ policy significantly reduces cities' GDP growth rate by 1.5 percent point, which is consistent with the findings in Chen, Li, and Lu (2018). The results for nighttime light in Column (2) reveal a similar relationship, with a smaller standard error. The results in Column (3) and (4) suggest that cities with a higher

Table 10: Sensitivity of light and GDP to economic shocks

	Two-control zone policy		The great recession	
	(1)	(2)	(3)	(4)
	GDP	light	GDP	light
TCZ=1	-0.0150**	-0.0123***		
	(0.00752)	(0.00435)		
FDI*Recession			-0.112	-0.178***
			(0.0933)	(0.0582)
Obs	2186	2186	2122	2122
R^2	0.202	0.485	0.211	0.494
City fixed effect	X	X	X	X
Year fixed effect	X	X	X	X
# of cities	254	254	254	254

Notes: (1) FDI represents the share of FDI in a prefecture-level city's GDP (in 10 %) (2) Promotion incentive controls include PI_{it}, age_{it}, and $PI_{it} * age_{it}$. (3) The time period is 2003 to 2012. (4) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

share of FDI have a lower GDP and light growth rate during the Great Recession. Overall, the results in Table 10 suggest that a 1.5 percent point GDP shock could be easily reflected in nighttime light. The standard errors in Columns (2) and (4) are smaller than the ones in Columns (1) and (3), implying that nighttime light may be more sensitive to economic shocks. Therefore, the absence of significant results regarding the impact of promotion incentives on nighttime light growth rate, as reported in Panel B of Table 3, is unlikely to be due to measurement error. If there were no GDP manipulation, the 3 percentage point effect of promotion incentives on statistical GDP growth rate should be captured by the light data.

Additionally, We use the lead term of the nighttime light as the dependent variable in the RD regression to address the concerns that light may be a lagged indicator of real economic growth. The results in Table A2 suggest that mayoral promotion incentives have little impact on the lead term of the nighttime light.

8.3 Alternative non-manipulable economic growth indicators

In this section, we utilize three other non-manipulable economic growth indicators: electricity, manufacturing firms' employment, and manufacturing firms' total factor productivity (TFP) to check the robustness of our results. It is worthwhile to note that the term "non-manipulable" can be interpreted in two ways. First, it indicates that the data is difficult to manipulate (e.g., nighttime light). Second, it refers to the indicators for which local officials lack incentives to manipulate, such as nighttime light, electricity, manufacturing firms' employment, and TFP.

Electricity consumption is used as a statistical measure of economic growth (Wallace, 2016). It is closely related to economic activity and is hard to manipulate. In this section, We use the city-level electricity consumption growth rate as a dependent variable in RD Equation (12).[23] Table 11 Panel A shows that mayors' promotion incentives have a small and insignificant impact on the electricity consumption growth rate.

The manufacturing sector accounted for more than 30% of China's GDP in 2010. It became the most significant growth engine in China's economy during our sample period (2003-2013), following its WTO accession in 2001. The Ministry of Human Resources and Social Security in China estimates that 1% economic growth results in an increase in employment by 1.5 million.[24] As employment in the manufacturing sector is not considered a primary indicator in the officials' performance evaluation system, mayors lack incentives to manipulate this data. The results in Table 11 Panel B indicate a statistically insignificant relationship between mayoral promotion incentives and manufacturing firms' employment.

Total factor productivity (TFP) measures the production efficiency and directly relates to the quality of the economic growth (Foster, Haltiwanger, and Syverson, 2008; Syverson, 2011). We use manufacturing firms' TFP as an alternative growth indicator to check the robustness of the null results of nighttime light. Firm-level data are adopted from the Chinese Industrial Enterprise Dataset, compiled by the National Bureau of Statistics directly. It is costly for subnational officials to manipulate it. We refer Hsieh and Klenow (2009) and Greenstone, List, and Syverson (2012) to use index method to estimate firm-level TFP. The dependent variable (ln(TFP)) is a weighted average firm-level TFP at the city-by-year level, where the weight is the firms' value added. The results in Table 11 panel C suggest that mayoral promotion incentives have a limited impact on firm-level TFP.

[23] Due to the data availability issues at the city level, we do not use railway freight traffic and total loans in our estimation.

[24] Source: `MinistryofHumanResourcesandSocialSecurity`, retrieved on Oct 26, 2023

Results in all three panels in table 11 are consistent with the insignificant relationship between mayoral promotion incentives and nighttime light growth rate.

Table 11: Mayoral Promotion incentives and other non-manipulable growth indicators

	(1)	(2)	(3)	(4)	(5)	(6)
			City FE		City FE + Mayor FE	
			Elctricity growth rate			
PI=1 (age$\leq$ 57)	-0.00245	-0.00677	-0.00467	-0.00462	-0.0174	-0.00919
	(0.0215)	(0.0220)	(0.0214)	(0.0218)	(0.0239)	(0.0269)
Obs	287	286	1078	1073	287	1078
R^2	0.052	0.107	0.059	0.064	0.221	0.285
			ln(manufacturing firms' employment)			
PI=1 (age$\leq$ 57)	0.0573	0.0827	0.0427	0.0461	0.0521	0.0766
	(0.0819)	(0.0848)	(0.0647)	(0.0635)	(0.110)	(0.0759)
Obs	259	258	972	968	259	972
R^2	0.358	0.387	0.342	0.349	0.574	0.598
			ln(TFP)			
PI=1 (age$\leq$ 57)	0.0292	0.00848	0.0171	0.00178	0.0499	-0.0125
	(0.0665)	(0.0715)	(0.0550)	(0.0560)	(0.0756)	(0.0723)
Obs	259	258	972	968	259	972
R^2	0.493	0.511	0.466	0.480	0.687	0.736
Demographic controls		X		X		
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Mayor fixed effect					X	X
# of cities	112	112	233	233	112	233
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60

Notes: (1) Demographic controls include the gender of the mayor, their education level, and how long the individual served as mayor in the city. (2) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

9 Discussions

9.1 Adjustment of potentially manipulated data

The empirical framework indicates that mayors tend to manipulate GDP statistics when they face promotion pressure. It is critical to note that these results do not imply that all mayors under 57 manipulate the GDP statistics every year when they are in office, nor the GDP manipulation is additive. The additivity of GDP manipulation will lead to

an "explosion" of GDP statistics, which may not be the case in reality. In addition, the manipulation cost increases with the manipulation extent. Mayors may find it hard to further inflate GDP statistics if it has already been manipulated. This section aims to exploit local officials' strategic adjustment of GDP manipulation. It is worth noting that the "strategic adjustment" *doesn't* mean that mayors correct the previous GDP statistics directly. Instead, the new mayors may report a lower GDP statistic in response to their predecessors' potential manipulation. Mayors' promotion decisions are largely determined by their performance in the most recent years (see the results in Table 12), and they are unlikely to get promoted in the first year when they are in office. The research question we explore here is if there exists a strategic and dynamic pattern of GDP manipulation at the subnational level in China. Specifically, do new mayors tend to report a lower GDP growth rate at the beginning of their term if their predecessors potentially manipulate the data?

We focus on the mayor turnover years and include the last mayors' promotion incentive dummy $PI_{i(j-1)(t-1)}$ in equations (18) and (19):

$$GDP_{s,ijt}^{turnover} = \alpha + \beta_{GDP}^{turnover} PI_{i(j-1)(t-1)} + \beta_1 X_{j-1} + \beta_2 X_j + v_t + \mu_i + \epsilon_{it} \tag{18}$$

$$growth_{light,ijt}^{turnover} = \alpha + \beta_{light}^{turnover} PI_{i(j-1)(t-1)} + \beta_1 X_{j-1} + \beta_2 X_j + v_t + \mu_i + \epsilon_{it} \tag{19}$$

Where the dependent variable $GDP_{s,ijt}^{turnover}$ denotes the statistical GDP growth rate in the turnover year (which is mayor j's first year in office) in city i, year t, and the same notation applies in the nighttime growth rate $growth_{light,ijt}^{turnover}$. The main independent variable $PI_{i(j-1)(t-1)}$ is a dummy, which equals one if the last mayor j-1 in city i is older than 53 (but younger than 58) when she leaves the office in year t-1. These mayors are close to their promotion ineligible age with stronger promotion incentives and are more likely to leave inflated GDP statistics to their successors. The results remain robust when we use different definitions of $PI_{i(j-1)(t-1)}$. Current and last mayors' characteristics (age, gender, education) are controlled in X_j and X_{j-1}, respectively. $\beta_{GDP}^{turnover}$ measures the impact of the last mayors' promotion incentives on the statistical GDP growth rate in the first year when current mayor j is in office.

The estimation results of Equation (18) and (19) are reported in Panel A and B of Table 12, respectively. Columns (1) to (6) restrict the sample in turnover years. In columns (1) and (2), we impose no restrictions on the new mayors' age. In columns (3) to (6), we focus on a younger sub-sample. These (new) mayors are at least four years away from the promotion ineligible age, and they are not too pressed to pursue a "good" GDP statistics in the first year when they are in office (i.e., turnover year). We expect to see a larger $\beta_{GDP}^{turnover}$ for these

mayors.

Table 12: Adjustment of the potentially manipulated GDP statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A				Official GDP growth rate			
PI (age≤ 57)	-0.0141**	-0.00682	-0.0174**	-0.0112	-0.0166*	-0.0357**	
	(0.00695)	(0.00998)	(0.00807)	(0.0116)	(0.00938)	(0.0155)	
Turnover							0.00316
							(0.00245)
Obs	585	585	521	521	310	310	2075
R^2	0.109	0.114	0.102	0.130	0.122	0.280	0.088
Panel B				Nighttime light growth rate			
PI (age≤ 57)	-0.0100*	-0.00313	-0.00918	-0.00315	-0.00640	0.00158	
	(0.00595)	(0.00608)	(0.00636)	(0.00739)	(0.00735)	(0.0131)	
Turnover							0.00188
							(0.00155)
Obs	585	585	521	521	310	310	2075
R^2	0.205	0.269	0.198	0.273	0.219	0.322	0.242
Sample				Rotation year			Whole sample
	No restriction		new mayor<54		new mayor <50		
Year fixed effects	X	X	X	X	X	X	X
City fixed effects		X		X		X	X
Current mayors' characteristics	X	X	X	X	X	X	X
Last mayors' characteristics	X	X	X	X	X	X	X

Notes: (1) We focus on the mayor turnover years in this table. (2) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

The empirical results in Panel A, Table 12 indicate that successors tend to report a lower statistical GDP growth rate in the first year when they are in office if their predecessors have strong promotion incentives. This effect is larger for the younger new mayors since they are less pressed to get promoted (the results in columns (5) and (6)). The results in Panel B suggest that predecessors' promotion incentives have little impact on their successors' nighttime light growth rate. The imprecise and small estimates of nighttime light help us rule out the possibility that the decrease in statistical GDP growth rate in Panel A is driven by the decrease in real economic growth rate.

Lastly, in column (7), we check whether the mayors' turnover per se leads to the fluctuations in cities' official GDP growth rate and nighttime light growth rate. "Turnover" in Table 12 is a dummy, which equals one if the year is a mayor's turnover year for city i. Column (7) indicates that, on average, mayors' turnover itself has very little impact on both statistical GDP growth rate and nighttime light growth rate, which is similar to Cai, Henderson, and Zhang (2013)'s results.

9.2 GDP manipulation and officials' accountability

Blanchard and Shleifer (2001) and Li and Zhou (2005)'s promotion tournament framework suggests that competition between local officials in economic performance selects pro-growth officials. In this section, we explore whether the ubiquity in subnational GDP manipulation distorts the promotion decisions and hampers the officals' accountability in China. To empirically test the above hypothesis, we estimate the following equation to explore the impact of statistical GDP growth rate and nighttime light growth rate on mayor j's promotion:

$$\text{Promotion}_{jt} = \alpha + \beta_1 \text{ GDP}_{jt} + \beta_2 \text{ light}_{jt} + v_t + \mu_j + \varepsilon_{it} \tag{20}$$

The outcome variable $Promotion_{jt}$ is a dummy that equals 1 if mayor j is promoted. The results are reported in Table 13. The first three columns explores the determinants of promotion before 2013, and the last three columns explores determinants of promotion after 2013. We focus on the mayors who have served in her office for more than 2 years. Columns (1), (2), (4), and (5) examine whether mayors' most recent years' performance affect their promotion. The observations are at the mayor-by-year level. Columns (3) and (6) examine whether mayor j's average performance throughout her entire term affects her promotion. The observations are at the mayor level.

The horse-race regression results displayed in the first two columns of Table 13 suggest that, before 2013, a mayor's most recent year's GDP growth rate positively impacts their chances of promotion. A one percentage point increase in the average statistical GDP growth rate over the most recent two years boosts the likelihood of a mayor's promotion by 1.3 percentage points. However, conditional on the GDP performance, the nighttime light growth rate does not influence a mayor's promotion. Column (3) indicates that neither the average GDP growth rate nor the nighttime light growth rate through the mayors' whole term significantly impacts mayors' promotion chances. Post-2013, both the statistical GDP growth rate and the nighttime light growth rate cease to have a significant influence on mayors' promotions. This shift can be attributed to other factors, such as environmental protection and political loyalty, becoming crucial in the promotion of mayors. These findings align with our findings in Section 6.3—when GDP growth rate no longer serves as a primary indicator influencing mayors' promotions, the extent of GDP manipulation diminishes.

In summary, the results in Table 13 suggest that GDP manipulation distorts officials' accountability in China before 2013. Mayors with better GDP rather than real economic performance are more likely to get promoted. Without appropriate supervision of GDP manipulation, GDP statistics-based competition between local officials may not be sufficient to

Table 13: The impact of GDP and nighttime light growth rate on mayors' promotion

	(1)	(2)	(3)	(4)	(5)	(6)
		before 2013			after 2013	
Outcome variable			Promotion dummy			
$\frac{GDP_{s,jt}+GDP_{s,jt-1}}{2}$	1.362**			0.742		
	(0.604)			(1.128)		
$\frac{light_{s,jt}+light_{s,jt-1}}{2}$	-0.394			-0.0613		
	(0.934)			(0.445)		
$GDP_{s,jt}$		0.888**			0.0980	
		(0.405)			(0.591)	
$GDP_{s,jt-1}$		0.577*			0.531	
		(0.333)			(0.746)	
$light_{s,jt}$		-0.197			0.00987	
		(0.588)			(0.241)	
$light_{s,jt-1}$		-0.243			-0.233	
		(0.614)			(0.293)	
$\overline{GDP_{s,j}}$			-0.331			-1.387
			(0.870)			(2.046)
$\overline{light_{s,j}}$			-1.319			0.621
			(1.250)			(1.201)
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Mayor fixed effect	X	X		X	X	
Obs	787	787	438	336	336	102
R^2	0.578	0.579	0.442	0.525	0.527	0.708

Notes: (1) $GDP_{s,jt}$ and $light_{jt}$ denote mayor j's current year (t)'s performance in the statistical GDP growth rate and nighttime light growth, respectively; $GDP_{s,jt-1}$ and $light_{jt-1}$ denote mayor j's previous year (t-1)'s performance in the statistical GDP growth rate and nighttime light growth rate, respectively; $\overline{GDP_{s,j}}$ and $\overline{light_{s,j}}$ represent the average GDP growth rate and nighttime light growth rate during mayor j's whole term; (2) The observations used in this analysis are at the mayor(city)-by-year level. The time period is 2003 to 2013. (3) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

explain China's rapid growth in the past forty years.

10 Conclusion

In this paper, we examine the unintended impact of mayors' promotion incentives on regional economic growth and subnational-level GDP manipulation in China. We construct a new estimation framework to identify the extent of GDP manipulation induced by mayoral promotion incentives. We take advantage of the mayors' promotion ineligible age to identify mayors' promotion incentives. We find evidence that mayoral promotion incentives significantly increase the city-level statistical GDP growth rate by around 3.4 percentage points, while their effects on nighttime light growth, electricity, and other non-manipulable economic growth indicators are insignificant and close to 0. This significant gap can be attributed to GDP manipulation when mayors face promotion pressure. We also find that mayoral promotion incentives no longer have a sizeable impact on both official GDP growth rate and nighttime light growth rate after 2013, when the role of GDP statistics in mayors' promotion is weakened. Heterogeneous analyses indicate that the GDP manipulation extent is smaller for mayors with high manipulation costs, and it is smaller in the agriculture sector, where the manipulation costs are high. Further analysis suggests that mayors have incentives to strategically adjust the potentially manipulated data. Successors tend to report a lower statistical GDP growth rate the first year when they are in office if their predecessors have strong promotion incentives. Our results also indicate that the substantive extent of GDP manipulation at the subnational level hampers the officials' accountability in China—mayors with higher GDP growth rates are more likely to be promoted, while mayors with better nighttime light performance are not.

This paper contributes to the growing literature that studies local officials' incentives in regional economic development by documenting that without civilian participation and surveillance, local officials' "top-down" incentives in regional economic development can be distorted. The promotion pressures on mayors can transform performance-based competition among mayors into a contest of data manipulation.

The results of this study have critical policy implications. To render the competition between subnational governments more beneficial to economic growth, the central government must enhance the supervision of local statistical data. Second, our results call for new mechanisms for officials' promotion in China. Last but not least, our results do not necessarily imply that using objective data like nighttime light is superior to GDP statistics.

Without sufficient supervision in centralized regimes, local officials could also readily affect the nighttime light data.

This study has some limitations and we see several directions for future research. Although the RD design improves internal validity, issues in external validity warrant attention. Younger mayors' promotion incentives may not be as strong as the mayors who are approaching 58, and their GDP manipulation extent may be smaller. As aforementioned, they also have incentives to strategically correct the potentially manipulated data. It would be interesting to examine the effect of younger mayors.

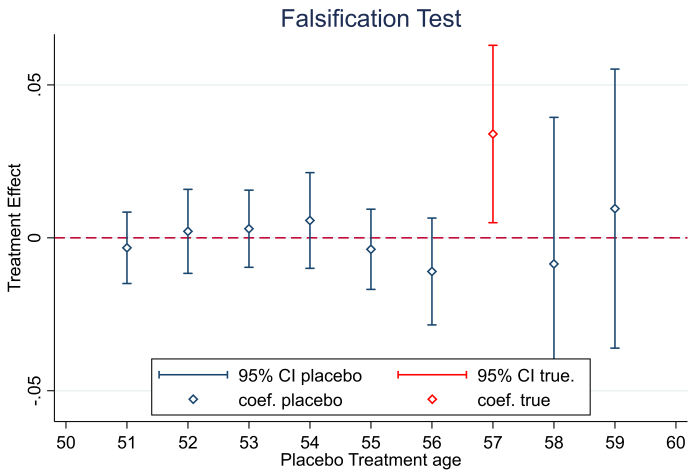
Acknowledgement: We are grateful to the editor and two anonymous referees for their constructive suggestions. We thank Daniel Berkowitz, Ziyang Chen, Maureen Cropper, Claire Duquennois, Steven Durlauf, Anthony Fowler, Yana Gallen, Sebastian Galiani, Osea Giuntella, Daniel B. Jones, Ginger Jin, Peter Murrell, Xiuyan Liu, Bin Qiu, Konstantin Sonin, Richard van Weelden, Colin Xu, Dali Yang, Randall Walsh, Yucheng Wang and seminar participants at the University of Chicago (CCSGR), University of Maryland, University of Pittsburgh, and Southeast University for valuable comments.

A Appendix

A.1 RD tests

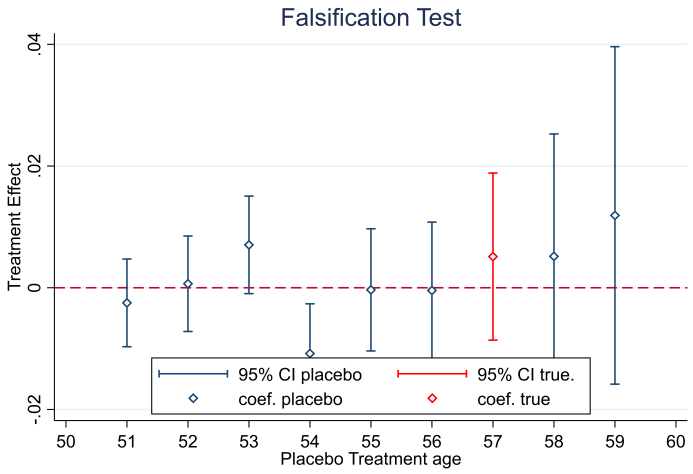
A.1.1 Falsification test

Figure A1: Falsification test in GDP growth rate



Notes: Plot is constructed by estimating RD Equation (12) with various selection of treatment thresholds using the analysis sample.

Figure A2: Falsification test in nighttime light rate



Notes: Plot is constructed by estimating RD Equation (12) with various selection of treatment thresholds using the analysis sample.

A.1.2 High order polynomials

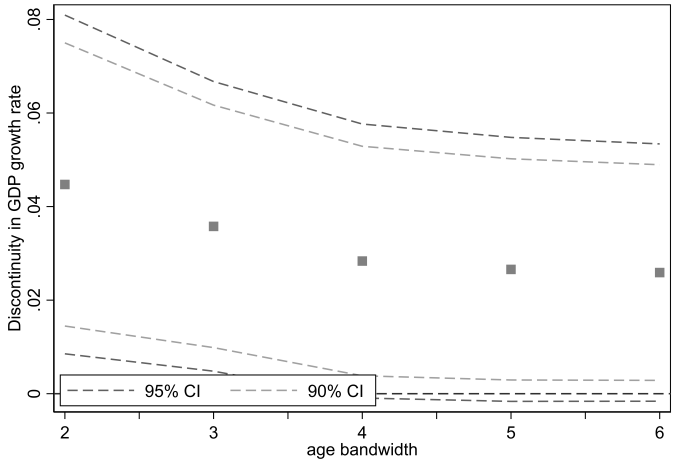
Table A1: High order polynomials

Outcome variable	(1)	(2)	(3)	(4)	(5)	(6)
	statistical GDP growth rate					
PI=1 (age$\leq$ 57)	0.0557**	0.0382*	0.0286*	0.0519**	0.0586*	0.0449*
	(0.0270)	(0.0226)	(0.0167)	(0.0214)	(0.0304)	(0.0250)
Orders	2nd	3rd	2nd	3rd	2nd	3rd
Mayor fixed effect					X	X
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60
Obs	295	295	1105	1105	295	1105
R^2	0.133	0.133	0.101	0.104	0.292	0.329

Notes: Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

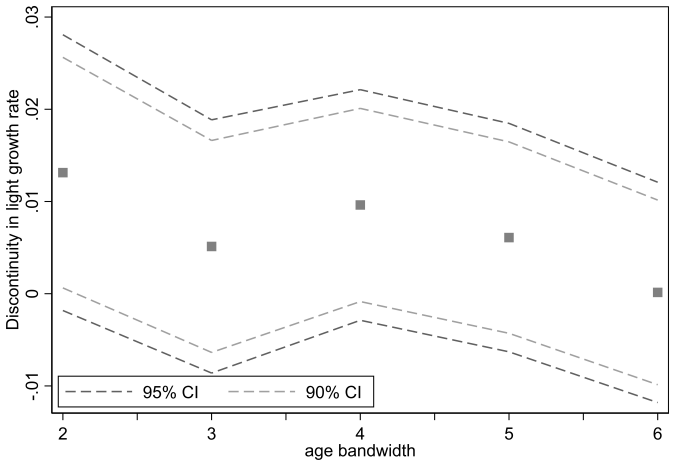
A.1.3 Bandwidth check

Figure A3: Bandwidth check in GDP growth rate



Notes: Plot is constructed by estimating RD Equation (12) with various selection of bandwidths using the analysis sample.

Figure A4: Bandwidth check in nighttime light growth rate



Notes: Plot is constructed by estimating RD Equation (12) with various selection of bandwidths using the analysis sample.

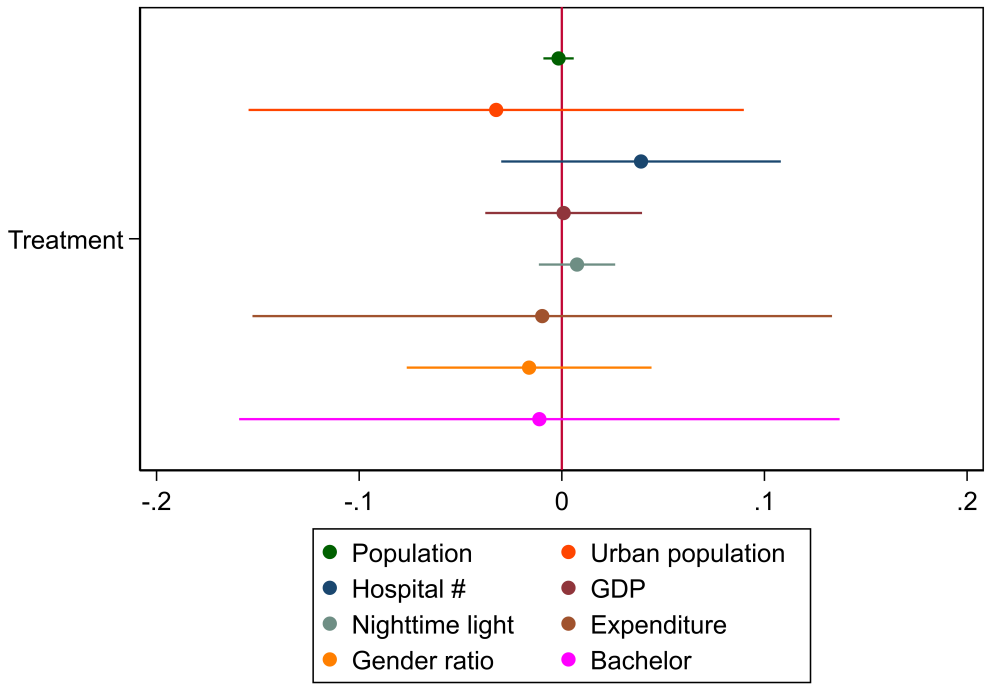
A.1.4 Balance test

In this section, we examine whether the cities governed by mayors who are older than 57 fundamentally differ from those governed by mayors who are younger than 57. The results are presented in Figure A5. Note that, except for the gender and bachelor dummies that capture mayors' characteristics, all other variables represent the average growth rate for the three years prior to the start of each mayor's term. We find no significant differences in all indicators we examined.

A.2 Event-study analysis

The panel structure of our dataset allows us to use an event study approach to check the pretrend. For ease of exposition, the treatment dummy D_i switches on if the mayor becomes older than 57 (i.e., $D_i = 1 - PI_i$). The results in Figure A6 suggest that the effects of promotion incentives on statistical GDP growth rate are unlikely to be driven by city-specific pre-trends. After the treatment occurs (i.e., when mayors turn 58 and lose promotion incentives), the statistical GDP growth rate starts to decline, while the nighttime light growth rate remains unchanged. This pattern provides further support to our main results.

Figure A5: Balance Test



Notes: (1)Except for the gender and bachelor dummies that capture mayors' characteristics, all other variables represent the average growth rate for the three years prior to the start of each mayor's term. (2) The capped spikes (I-beams) plot the 95% confidence interval for the estimates.

Figure A6: Mayoral promotion incentives and GDP growth rate

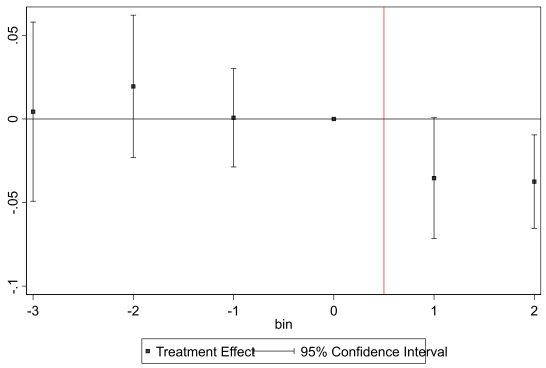


Figure A7: GDP

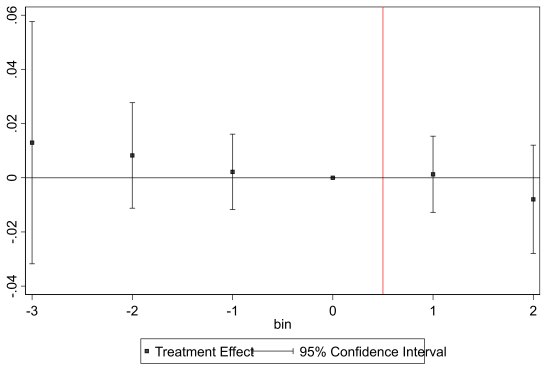


Figure A8: light

Notes: The omitted category $t = -1$ is the calendar year prior to the policy treatment. The capped spikes (I-beams) plot the 95% confidence interval for the estimates.

A.3 Lead term of the nighttime light

We use the lead term of the nighttime light as the dependent variable in the RD regression to address the concerns that light may be a lagged indicator of real economic growth. The results in Table A2 suggest that mayoral promotion incentives have little impact on the lead term of the nighttime light.

Table A2: mayoral promotion incentives and the lead term of nighttime light growth rate

	(1)	(2)	(3)	(4)	(5)	(6)
	lead term of nighttime light growth rate					
	City FE				City FE + Mayor FE	
PI=1 (age≤ 57)	0.00400	0.00289	0.00545	0.00577	0.00244	0.00906
	(0.00747)	(0.00759)	(0.00676)	(0.00659)	(0.00790)	(0.00657)
Demographic controls		X		X		
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Mayor fixed effect					X	X
# of cities	115	115	237	237	115	237
Age coverage	55-60	55-60	51-60	51-60	51-60	51-60
Obs	262	261	984	979	262	984
R^2	0.386	0.405	0.227	0.237	0.530	0.529

Notes: (1) Demographic controls include the gender of the mayor, their education level, and how long the individual served as mayor in the city. (2) Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

A.4 GDP manipulation extent after 2013

Using the same approach as we employed in Section 6.2, we report the estimated GDP manipulation extent after 2013 in Table A3. As expected, the estimates are small and not statistically distinguishable from zero.

A.5 Correlation between GDP statistics and nighttime light

A.6 Definition of promotion

In Figure 1, we report that promotion probability for mayors who are 57 is higher than the mayors who are 58. In this paper, promotion is given a more general definition: mayors are

Table A3: GDP manipulation extent after 2013

Age coverage		γ=0.2	γ=0.369	γ=0.6
55-60	Manipulation	0.003	0.004	0.004
	std.	(0.023)	(0.025)	(0.028)
51-60	Manipulation	0.002	-0.002	-0.005
	std.	(0.013)	(0.015)	(0.018)

Notes: (1) City fixed effects, mayor fixed effects, and year fixed effects are controlled in all specifications. (2)Standard errors in parentheses are obtained based on 500 bootstrapped resamples clustered at the prefecture-level city level.

Figure A9: Correlation between nighttime light and GDP statistics

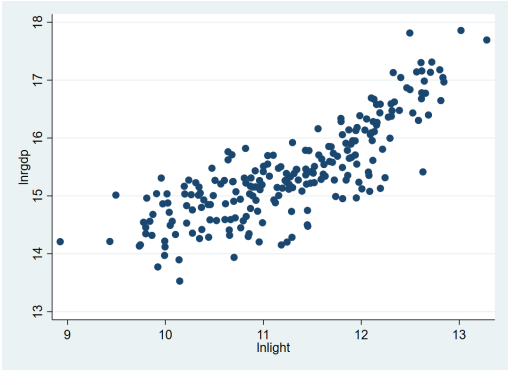


Figure A10: 2007

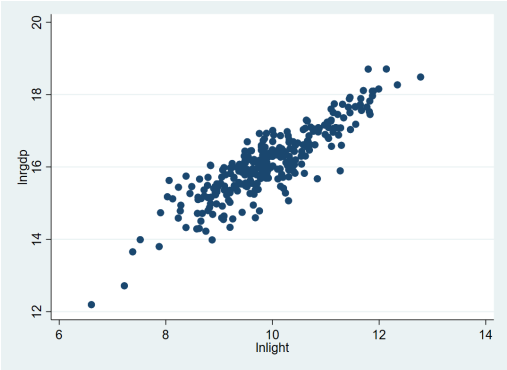


Figure A11: 2015

Notes: The correlation patterns between nighttime light and GDP statistics in other years are similar.

placed to either higher ranked or to the same rank but more "important" positions. Higher-ranked position refers to the vice-provincial level position in this context, and "importance" is defined based on the probability that a mayor level official *finally* getting promoted to the vice-provincial level position given her current position. Some of the mayor-level positions are usually regarded as more "important" and have higher promotion probabilities than the others. In most cases, city secretaries rank higher than mayors in the cities' CCP standing committee. And the assistant governor is usually regarded as the last step to the vice-provincial level position. However, lacking the official documents, the relative importance of other mayor level positions is still ambiguous. It is informative to make a clear and tractable definition of promotion for the mayor level officials to study mayors' promotion incentives.

We use a data-driven method to rank all the mayor-level positions. We first sort 545 mayor level positions into 11 general classifications. Second, we calculate the probability

Table A4: Transition matrix

n=1	1	2	3	4	5	6	7	8	9	10	11	12	13	obs
1	0.16	0.35	0.03	0.1	0.03	0	0.02	0	0	0.01	0.11	0.03	0.16	2049
2	0.02	0.09	0.11	0.06	0.04	0.01	0.05	0.01	0	0	0.13	0.27	0.2	1050
3	0.03	0.05	0.14	0.01	0.01	0.01	0.01	0.01	0	0.01	0.09	0.08	0.54	340
4	0.16	0.03	0.05	0.24	0.03	0	0.03	0.01	0	0.05	0.16	0.07	0.18	924
5	0.09	0.03	0.04	0.12	0.07	0	0.03	0.03	0	0.04	0.17	0.2	0.16	267
6	0.03	0	0.03	0.2	0.14	0.03	0.09	0	0	0	0.03	0.4	0.06	35
7	0.12	0.03	0.02	0.06	0.03	0.01	0.22	0.04	0	0.03	0.21	0.14	0.1	342
8	0.1	0.05	0.01	0.04	0.04	0.01	0.03	0.32	0	0.02	0.16	0.2	0.02	250
9	0.14	0.01	0.03	0.04	0.01	0.02	0.01	0.23	0	0.16	0.34	0	0.01	159
10	0.54	0.02	0.01	0.04	0.03	0	0.02	0	0	0.18	0.14	0.02	0	289
11	0.15	0.09	0.02	0.08	0.03	0.01	0.04	0.04	0.01	0.07	0.3	0.08	0.08	1414
12	0	0	0	0	0	0	0	0	0	0	0	1	0	2328
13	0	0	0	0	0	0	0	0	0	0	0	0	1	

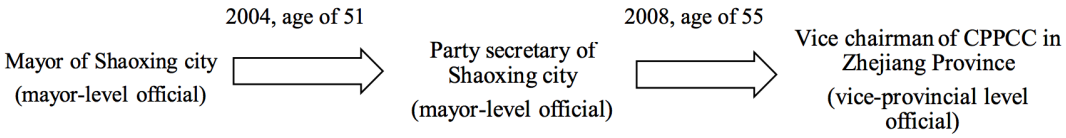
Notes: 1 for mayor; 2 for city secretary; 3 for mayor level positions in Chinese People's Political Consultative Conference and the National People's Congress; 4 for provincial department director; 5 for vice ministry of provincial organizational, united front work, propaganda department and development and reform department; 6 for provincial governor assistant; 7 for vice secretary general in provincial level; 8 for vice mayor/secretary in vice-provincial level city; 9 for mayor level positions in Communist Youth League; 10 for vice prefecture-level city mayor/secretary; 11 for other positions; 12 for vice-provincial level positions; 13 for retirement. 12 and 13 are absorbing states.

Table A5: Promotion probability for mayor-level officials after three steps

n=3	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.06	0.06	0.03	0.05	0.02	0	0.03	0.02	0	0.02	0.09	0.22	0.41
2	0.05	0.04	0.02	0.03	0.01	0	0.02	0.01	0	0.01	0.06	0.38	0.38
3	0.03	0.03	0.01	0.02	0.01	0	0.01	0.01	0	0.01	0.04	0.15	0.69
4	0.08	0.07	0.03	0.06	0.02	0	0.02	0.02	0	0.02	0.1	0.19	0.39
5	0.07	0.06	0.02	0.05	0.02	0	0.02	0.02	0	0.02	0.08	0.31	0.33
6	0.06	0.04	0.02	0.04	0.01	0	0.02	0.01	0	0.02	0.07	0.51	0.21
7	0.08	0.07	0.03	0.05	0.02	0	0.03	0.02	0	0.02	0.11	0.29	0.27
8	0.08	0.07	0.02	0.05	0.02	0	0.03	0.05	0	0.02	0.11	0.39	0.17
9	0.12	0.11	0.03	0.07	0.03	0	0.03	0.04	0	0.03	0.14	0.19	0.2
10	0.11	0.12	0.04	0.08	0.03	0	0.03	0.02	0	0.03	0.13	0.17	0.26
11	0.09	0.08	0.03	0.06	0.02	0	0.03	0.02	0	0.03	0.11	0.24	0.28
12	0	0	0	0	0	0	0	0	0	0	0	1	0
13	0	0	0	0	0	0	0	0	0	0	0	0	1

Notes: The definition of the state 1 to 13 is the same as Table A4. In the real calculation process, we artificially change $p_{12,12}$ in Table A4 to 1, making state 12 (vice-provincial level position) become an absorbing state. Therefore, the coefficients in column 12 of Table A5 represent the probability of official i getting promoted to vice-provincial level position within three steps (i.e., even though official i finally getting retired after three periods, it will count for a promotion for him as long as he once got promoted within this periods).

Figure A12: The promotion road of Yongchang Wang

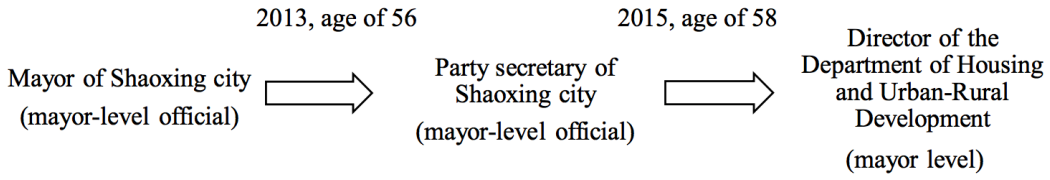


of officials moving from mayor-level position i to position j: p_{ij} in each position i. Table A1 reports the *direct* promotion matrix P. Although officials may be hard to be directly promoted to vice-provincial level positions from some mayor-level positions, they may be first promoted to other more "important" positions. For instance, for the mayors, the direct promotion probability to vice-provincial-level positions is low: $p_{1,12} = 0.03$. However, the promotion probability for them to directly get promoted to the city secretary is $p_{1,2} = 0.35$, and it is much easier for the city secretaries to get promoted to vice-provincial level positions ($p_{2,12} = 0.27$). To capture this indirect promotion pattern, we report the complete promotion probability matrix P' in Table A2, $P' = P^n$. The element P'_{ij} in P' denotes after n steps, the probability of officials who are initially at position i moves to position j. On average, an official changes three positions at the mayor level. Thus, we report P^3 in table A5. And the results are qualitatively robust when we use n=4 and 5.

Table A5 suggests that a mayor has $p_{1,12} = 0.22$ probability of getting promoted to the vice-provincial level positions after three position changes. The following positions have higher promotion probabilities than mayors: city secretary (37.6%), vice ministry of organizational, united front work, propaganda, and development and reform department (31.3%), provincial governor assistant (50.8%), vice secretary general at provincial government or provincial CCP (28.7%), and vice mayor/secretary in vice-provincial level cities (38.7%). Therefore, in our paper, a mayor is regarded as getting promoted if she is placed to these positions.

Admittedly, the actual promotion process in China's bureaucratic system is much more sophisticated than our model. Using the data-driven method with several assumptions, we provide suggestive evidence of Chinese mayors' promotion pattern, and the result coincides with some qualitative and limited evidence of the promotion pattern in China's mayor-level officials (e.g., city secretaries rank higher than mayors in the cities' CCP committee).

Figure A13: The promotion road of Jianmin Qian



References

Bartik, Timothy J. 2005. "Solving the problems of economic development incentives." *Growth and change* 36 (2):139–166.

———. 2018. "Who benefits from economic development incentives? How incentive effects on local incomes and the income distribution vary with different assumptions about incentive policy and the local economy." .

Besley, Timothy and Anne Case. 1995. "Does electoral accountability affect economic policy choices? Evidence from gubernatorial term limits." *The Quarterly Journal of Economics* 110 (3):769–798.

———. 2003. "Political institutions and policy choices: evidence from the United States." *Journal of Economic Literature* 41 (1):7–73.

Blanchard, Olivier and Andrei Shleifer. 2001. "Federalism with and without political centralization: China versus Russia." *IMF staff papers* 48 (1):171–179.

Buntaine, Mark, Michael Greenstone, Guojun He, Mengdi Liu, Shaoda Wang, and Bing Zhang. 2022. "Does the Squeaky Wheel Get More Grease? The Direct and Indirect Effects of Citizen Participation on Environmental Governance in China." Tech. rep., National Bureau of Economic Research.

Cai, Hongbin, J Vernon Henderson, and Qinghua Zhang. 2013. "China's land market auctions: evidence of corruption?" *The Rand Journal of Economics* 44 (3):488–521.

Chen, Shuo, Xue Qiao, and Zhitao Zhu. 2021. "Chasing or cheating? Theory and evidence on China's GDP manipulation." *Journal of Economic Behavior & Organization* 189:657–671.

Chen, Ye, Hongbin Li, and Li-An Zhou. 2005. "Relative performance evaluation and the turnover of provincial leaders in China." *Economics Letters* 88 (3):421–425.

Chen, Yvonne Jie, Pei Li, and Yi Lu. 2018. "Career concerns and multitasking local bureaucrats: Evidence of a target-based performance evaluation system in China." *Journal of Development Economics* 133:84–101.

Clark, Hunter, Maxim Pinkovskiy, and Xavier Sala-i Martin. 2017. "China's GDP growth may be understated." Tech. rep., National Bureau of Economic Research.

Edin, Maria. 2003. "State capacity and local agent control in China: CCP cadre management from a township perspective." *The China Quarterly* 173:35–52.

Ferraz, Claudio and Frederico Finan. 2011. "Electoral accountability and corruption: Evidence from the audits of local governments." *American Economic Review* 101 (4):1274–1311.

Ferreira, Fernando and Joseph Gyourko. 2009. "Do political parties matter? Evidence from US cities." *The Quarterly journal of economics* 124 (1):399–422.

Foster, Lucia, John Haltiwanger, and Chad Syverson. 2008. "Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?" *American Economic Review* 98 (1):394–425.

Greenstone, Michael, Guojun He, Shanjun Li, and Eric Yongchen Zou. 2021. "China's war on pollution: Evidence from the first 5 years." *Review of Environmental Economics and Policy* 15 (2):281–299.

Greenstone, Michael, John A List, and Chad Syverson. 2012. "The effects of environmental regulation on the competitiveness of US manufacturing." Tech. rep., National Bureau of Economic Research.

Henderson, J Vernon, Adam Storeygard, and David N Weil. 2012. "Measuring economic growth from outer space." *American Economic Review* 102 (2):994–1028.

Hodler, Roland and Paul A Raschky. 2014. "Regional favoritism." *The Quarterly Journal of Economics* 129 (2):995–1033.

Hsieh, Chang-Tai and Peter J Klenow. 2009. "Misallocation and manufacturing TFP in China and India." *The Quarterly journal of economics* 124 (4):1403–1448.

Hu, Yingyao and Jiaxiong Yao. 2021. "Illuminating economic growth." *Journal of Econometrics* .

Huang, Luna Yue, Solomon Hsiang, and Marco Gonzalez-Navarro. 2021. "Using Satellite Imagery and Deep Learning to Evaluate the Impact of Anti-Poverty Programs." *arXiv preprint arXiv:2104.11772* .

Huang, Zhangkai, Jinyu Liu, Guangrong Ma, and L Colin Xu. 2020. "The Transformative Effects of Privatization in China: A Natural Experiment Based on Politician Career Concern." *World Bank Policy Research Working Paper* (9261).

Imbens, Guido W and Thomas Lemieux. 2008. "Regression discontinuity designs: A guide to practice." *Journal of Econometrics* 142 (2):615–635.

Ji, You. 2020. "How Xi Jinping dominates elite party politics: A case study of civil-military leadership formation." *The China Journal* 84 (1):1–28.

Jiang, Junyan. 2018. "Making bureaucracy work: Patronage networks, performance incentives, and economic development in China." *American Journal of Political Science* 62 (4):982–999.

Karplus, Valerie J, Shuang Zhang, and Douglas Almond. 2018. "Quantifying coal power plant responses to tighter SO2 emissions standards in China." *Proceedings of the National Academy of Sciences* 115 (27):7004–7009.

Khanna, Vikramaditya, E Han Kim, and Yao Lu. 2015. "CEO connectedness and corporate fraud." *The Journal of Finance* 70 (3):1203–1252.

Klimek, Peter, Yuri Yegorov, Rudolf Hanel, and Stefan Thurner. 2012. "Statistical detection of systematic election irregularities." *Proceedings of the National Academy of Sciences* 109 (41):16469–16473.

Kou, Chien-Wen. 2005. *zhonggong jingying zhengzhi de yanbian*, vol. 2. Wunan Book.

Kou, Chien-wen and Wen-Hsuan Tsai. 2014. ""Sprinting with small steps" towards promotion: solutions for the age dilemma in the CCP cadre appointment system." *The China Journal* (71):153–171.

Kung, James Kai-Sing and Shuo Chen. 2011. "The tragedy of the nomenklatura: Career incentives and political radicalism during China's Great Leap famine." *American Political Science Review* 105 (1):27–45.

Landry, Pierre Francois. 2008. *Decentralized Authoritarianism in China: the Communist Party's control of local elites in the post-Mao era*, vol. 1. Cambridge University Press New York.

Lee, David S and David Card. 2008. "Regression discontinuity inference with specification error." *Journal of Econometrics* 142 (2):655–674.

Li, Hongbin and Li-An Zhou. 2005. "Political turnover and economic performance: the incentive role of personnel control in China." *Journal of Public Economics* 89 (9-10):1743–1762.

Li, Xing, Chong Liu, Xi Weng, and Li-An Zhou. 2019. "Target setting in tournaments: theory and evidence from China." *The Economic Journal* 129 (623):2888–2915.

Liu, Xiuyan, Jiangnan Zeng, and Qiyao Zhou. 2019. "The chosen fortunate in the urbanization process in China? Evidence from a geographic regression discontinuity study." *Review of Development Economics* 23 (4):1768–1787.

Martinez, Luis R. 2021. "How Much Should We Trust the Dictator's GDP Growth Estimates?" *University of Chicago, Becker Friedman Institute for Economics Working Paper* (2021-78).

Maskin, Eric, Yingyi Qian, and Chenggang Xu. 2000. "Incentives, information, and organizational form." *The Review of Economic Studies* 67 (2):359–378.

Meng, Xin, Nancy Qian, and Pierre Yared. 2015. "The institutional causes of China's Great Famine, 1959–1961." *The Review of Economic Studies* 82 (4):1568–1611.

Nakamura, Emi, Jón Steinsson, and Miao Liu. 2016. "Are Chinese growth and inflation too smooth? Evidence from Engel curves." *American Economic Journal: Macroeconomics* 8 (3):113–44.

Qian, Yingyi and Chenggang Xu. 1993. "The M-form hierarchy and China's economic reform." *European Economic Review* 37 (2-3):541–548.

Rawski, Thomas G. 2001. "What is happening to China's GDP statistics?" *China Economic Review* 12 (4):347–354.

Serrato, Juan Carlos Suárez, Xiao Yu Wang, and Shuang Zhang. 2019. "The limits of meritocracy: Screening bureaucrats under imperfect verifiability." *Journal of Development Economics* 140:223–241.

Smart, Michael and Daniel M Sturm. 2013. "Term limits and electoral accountability." *Journal of Public Economics* 107:93–102.

Syverson, Chad. 2011. "What determines productivity?" *Journal of Economic Literature* 49 (2):326–65.

Tang, Wei and Geoffrey JD Hewings. 2017. "Do city–county mergers in China promote local economic development?" *Economics of Transition* 25 (3):439–469.

Wallace, Jeremy L. 2016. "Juking the stats? Authoritarian information problems in China." *British Journal of Political Science* 46 (1):11–29.

World-Bank. 2017. "Special economic zones: an operational review of their impacts." .

Xu, Chenggang. 2011. "The fundamental institutions of China's reforms and development." *Journal of Economic Literature* 49 (4):1076–1151.

Yao, Yang and Muyang Zhang. 2015. "Subnational leaders and economic growth: evidence from Chinese cities." *Journal of Economic Growth* 20 (4):405–436.

Zheng, Siqi, Matthew E Kahn, Weizeng Sun, and Danglun Luo. 2014. "Incentives for China's urban mayors to mitigate pollution externalities: the role of the central government and public environmentalism." *Regional Science and Urban Economics* 47:61–71.