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

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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.

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1 Introduction

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 promotion incentives for officials in China may encourage subnational officials 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 a range of alternative economic growth measures that are immune to manipulation by local politicians. 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 litera-

[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.

ture 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.[2]

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, firm entry 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. 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 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. 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

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

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, firm entry, 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 (2) using government expenditures as the outcome variable and find null results.

Our contribution falls into three areas. Our paper provides a new approach to detect the artificial manipulation of local official statistics, which is ubiquitous in many developing countries (Klimek et al., 2012; Martinez, 2021; Karplus, Zhang, and Almond, 2018; Clark, Pinkovskiy, and Sala-i Martin, 2017; Serrato, Wang, and Zhang, 2019; Chen, Qiao, and Zhu, 2021). The existing literature attempts to construct a "real" GDP measure by imposing strong functional forms between the objective measures and GDP statistics. Wallace (2016) uses GDP growth rate minus electricity as an indicator of GDP manipulation. The consistency of his results relies on the assumption that the slope between electricity and economic growth to be 1 (i.e., $GDPgrowth = 1 * \text{electricity growth} + \delta$). In a related and parallel work, Chen, Qiao, and Zhu (2021) construct a "real" GDP index as the weighted average of the official GDP statistics and other objective indicators. This approach fails to escape the bias of GDP manipulation: GDP manipulation not only enters the construction of "real" GDP index directly through the channel of official GDP statistics, but also biases the estimated weights in "real" GDP index. For instance, Martinez (2021) finds that the nighttime light elasticity of GDP is higher in authoritarian regimes because of GDP manipulation. Our empirical framework imposes fewer functional form assumptions and do not require to construct the "real" GDP statistics. By comparing the discontinuities in GDP statistics and non-manipulable growth indicators at the promotion ineligible age of mayors, we provide rigorous evidence of GDP manipulation at the subnational level in China.

Second, We add to the literature in identifying officials' incentives in China, which plays a critical role in urban planning (Wang, Zhang, and Zhou, 2020), public goods provision (Han and Kung, 2015; Cai et al., 2016), and other local economic policies (Jiang and Mei, 2020). Wallace (2016) and Chen, Qiao, and Zhu (2021) use political turnover years to identify officials' promotion incentives.[3] However, mayors' average term in office is around three years in China, which is much shorter than the five-year political cycle. It is common for mayors to

[3]The general election of the city-level people's congress was held every five years, and the mayors' terms are theoretically along with the people's congress. During our sample periods, the general election was held in 2007 and 2012.

get promoted, removed, or retired in the non-turnover years. The opaque nature of political turnovers within CCP elite levels precludes a good measure of promotion incentives of local officials using turnover years. Moreover, it may be hard to find a suitable control group in Chen, Qiao, and Zhu (2021) and Wallace (2016)'s context since almost every mayor wants to get promoted. In our work, the ineligible promotion age creates a clear treatment and control group and generates significant variation in mayors' promotion incentives.

Last but not least, we contribute to the growing literature on the limits of meritocracy (Kung and Chen, 2011; Persson and Zhuravskaya, 2016; Chen and Kung, 2019; Serrato, Wang, and Zhang, 2019; He, Wang, and Zhang, 2020; Wang, Zhang, and Zhou, 2020; Chen, Qiao, and Zhu, 2021). By documenting the substantive GDP manipulation induced by mayoral promotion incentives, we provide direct evidence that without appropriate supervision, the hierarchical officials' incentive system will be distorted. Our results suggest that GDP manipulation undermines officials' accountability. Mayors with better GDP rather than real economic performance are more likely to get promoted. Relatedly, 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.

We organize the paper as follows. The following section discusses the institutional background and the age discontinuity. Section 3 introduces the data. Section 4 discusses the empirical strategies. Section 5 presents the main regression results. Section 6 presents several robustness checks. Section 7 discusses the heterogeneity in GDP manipulation and some dynamic patterns. 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 a more important role in economic management than the central ministries, traditionally in

charge of planning and coordination. This reflects the strategic importance of provincial- and prefecture-level leaders (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. To avoid the potential measurement problems due to the change of the promotion principles, we use data from 2003 to 2013.

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, townships. This paper focuses on prefecture-level mayors. Mayors' promotion decisions are usually made by provincial-level officials. The most common promotion for a mayor is becoming the Party secretary in a same-ranked city (Landry, 2008). Serrato, Wang, and Zhang (2019) give a more general definition of promotion by including the case where mayors are directly promoted to vice-provincial level positions. Except for these two types of promotions, moving to some other positions is also generally regarded as a promotion for the mayors (e.g., assistant governor).

We give a general definition of mayors' promotion in this paper: mayors are placed to either higher ranked or to the same ranked but more "important" positions. Higher-ranked

positions refer to the vice-provincial level positions in this context, and the "importance" is defined based on the probability that a mayor-level official *finally* (i.e., throughout her career) getting promoted to vice-provincial level positions given her current position. For instance, from the anecdotal evidence, assistant governor and Party secretary in prefecture-level cities are usually regarded as the last step to the vice-provincial level positions, they are more important than the other same-ranked mayor-level positions.

We use a data-driven method to rank the "importance" of the mayor-level positions based on the intuition above. The data we use comes from CPED dataset (Jiang, 2018), which includes detailed information about the officials' career path. Appendix A.4 provides a detailed discussion and presents the estimation results. To the best of our knowledge, there is no such comprehensive and objective measurement of the promotion ladder for Chinese officials.

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.[4] 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

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

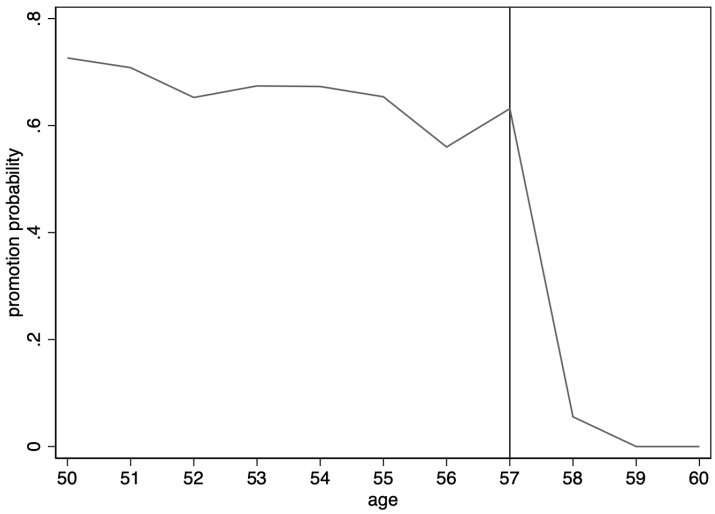
they are 58 or above.[5] The promotion age restrictions in China was relatively consistent during the time periods we investigate.

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

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.

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 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

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

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 Anecdotal evidence of subnational-level GDP manipulation in China

Anecdotal evidence suggests that GDP manipulation at the subnational level before 2013 is ubiquitous in China. In 2017, the provincial governor in Liaoning province admitted to manipulating fiscal revenue and GDP data by at least 20% from 2011–2014. In 2018, the mayor of Tianjin claimed that Tianjin's GDP statistics had been "inflated" by 335 billion yuan, roughly 30% of its total GDP. The governor of Inner Mongolia also acknowledged that his predecessor manipulated fiscal revenue data by a factor of 26.3%. Narrative evidence of GDP manipulation is not limited to the provincial level. Official statistical data in Baotou, Ordos, Tongliao, Tieling, and Yinchuan have all been found to have been manipulated. Furthermore, China's Premier Li Keqiang has allegedly acknowledged of these discrepancies in the country's official GDP estimates.

The veracity of China's official data has also been widely doubted in the literature. Rawski (2001) argues that instead of the 7.1% reported in the official statistical data for 1997–2001, the Chinese economy may have only been growing 2% per year. Using Engel curves to construct alternative estimates of inflation and economic growth, Nakamura, Steinsson, and Liu (2016) show that China's official statistics present a smoothed version of reality. The manipulation of official statistics is not only limited to GDP statistics. Kung and Chen (2011) and Meng, Qian, and Yared (2015) show that career-incentivized officials inflated the food production data and caused huge excess deaths during the Great Leap Forward (1958-1961). By comparing satellite data and the official reported data, Karplus, Zhang, and Almond (2018) find that China's SO2 data is manipulated in regions facing the toughest emission standards. Serrato, Wang, and Zhang (2019) find that misreporting the "one-child-policy" performance was quite ubiquitous in the 1990s and can predict mayoral promotion in China.

3 Data

3.1 Prefecture-level city mayor data

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. The law also stipulates that a mayor must function under the guidance of the city's CPC committee head, and the Party secretary, although they are positioned at the same level (i.e., mayor-level officials). 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.

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
Number of newly registered firms	2,345	695.4	947.2
Elctricity growth rate	2,363	0.106	0.118
ln(TFP)	2,158	1.72	0.54
Term	892	3.91	1.38
Female	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. (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. "Female" is a binary variable, which equals 0 when the mayor is male and 1 when the mayor is female.

The prefecture-level city mayor data is manually collected by the authors. We obtained

data on 892 mayors in 277 prefecture-level cities from 2003 to 2013.[6] The dataset includes mayor's demographic characteristics such as age, gender, and education level. The observations are at the city-year-mayor level.

3.2 GDP and other official statistics

GDP data and other official statistics, such as the share of the agriculture industry, manufacturing industry, and service industry, come from the statistical yearbook. GDP statistics are adjusted to prices in 2000 using the provincial-level price deflator. To avoid the influence of outliers, we winsorize the GDP growth rate at the 1st and the 99th percentiles.

3.3 Light and other non-manipulable indicators of economic growth

Nighttime light data are processed and published by NOAA's National Geophysical Data Center (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 resolution of the original data is around 1km. We aggregate the nighttime light intensity at the city level. City-level electricity consumption comes from the city's statistical yearbook. Firm registration records data is obtained from the State Administration for Industry and Commerce of the People's Republic of China (SAIC). It contains information about the name, location, and registered date of the newly registered firms. There are 2,723,820 newly registered firms during our sample periods (2003-2013). We aggregate the data at the city-by-year level. The firm registration records are used to measure the firm entry. The manufacturing firms' TFP is calculated from the Chinese Industrial Enterprise Dataset. In section 6.3, we discuss the calculation method. The TFP data reported in Table 2 is a weighted aggregation at the city-by-year level, where the weight is firms' output.

Table 2 reports the summary statistics of the main variables used in this paper.

[6]There were 333 prefecture-level cities in China in 2013. We don't include the prefecture-level cities in Xinjiang and Tibet and the autonomous prefectures in our analysis.

4 Empirical Strategies

4.1 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):

$$GDP_{s,it} = \alpha + \beta_{gdp} PI_{it} + \tau age_{it} + \rho \left(PI_{it} * age_{it} \right) + \delta X_{it} + v_t + \mu_i + \varepsilon_{it} \tag{1}$$

$$growth_{nm,it} = \alpha' + \beta_{nm} PI_{it} + \tau' age_{it} + \rho' \left(PI_{it} * age_{it} \right) + \delta' X_{it} + v_t + \mu_i + \varepsilon'_{it} \tag{2}$$

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.[7] 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 (1) identifies the impact of mayoral promotion incentives on statistical GDP growth rate at the promotion eligible age cutoff point. β_{nm} in (2) identifies the impact of mayoral promotion incentives on non-manipulable growth indicators at the promotion eligible age cutoff point.[8]

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. In Appendix A.2, we provide an empirical framework to calculate GDP manipulation extent based on the estimated β_{gdp} and β_{nm}.

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

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

4.2 Potential threats to identification

4.2.1 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 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:

$$GDP_{s,jt} = \alpha + \beta_{gdp} PI_{jt} + \tau age_{jt} + \rho \left(PI_{jt} * age_{jt} \right) + v_t + \mu_i + \eta_j + \varepsilon_{ijt} \tag{3}$$

$$\text{growth}_{\text{nm},jt} = \alpha' + \beta_{\text{nm}} PI_{jt} + \tau' \text{age}_{jt} + \rho' \left(PI_{jt} * age_{jt} \right) + v_t + \mu_i + \eta_j + \varepsilon_{ijt} \tag{4}$$

Where all notation remains identical to that of the equation (1) and (2), except that the subscript j denotes mayor j, and η_j denotes the mayor fixed effects.

4.2.2 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 (2) 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 6.2 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 2, we compare the nighttime light growth

rate, the weighted average of city-level GDP growth rate [9], 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.[10] 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, firm entry 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.

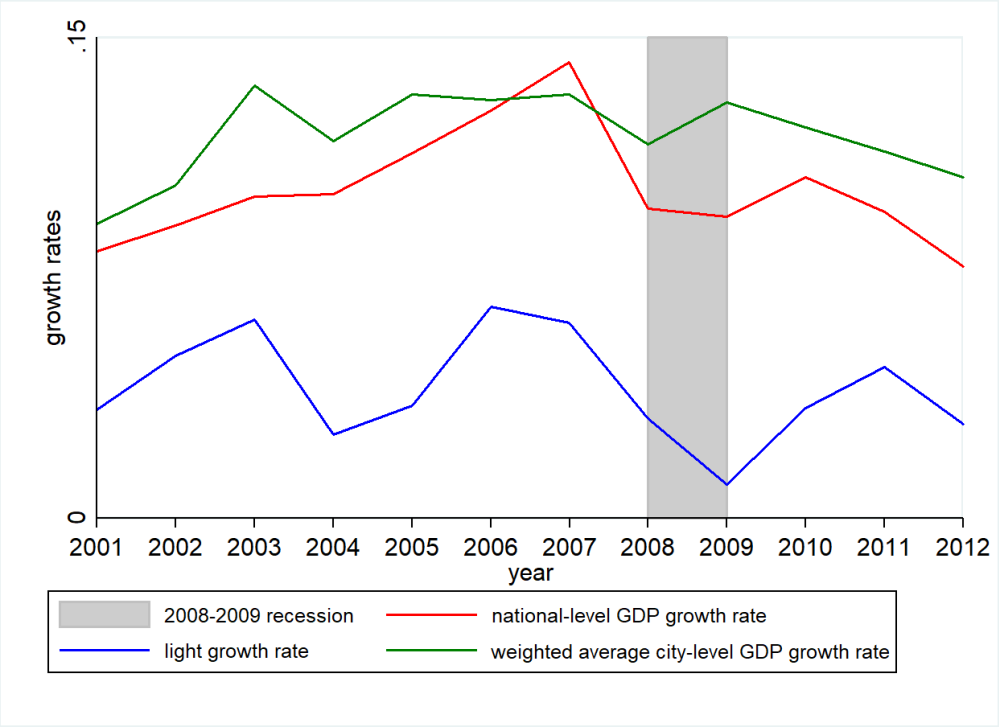
To rule out the possibility that light may be a lagged indicator of economic growth, we explore the relationship between promotion incentives and the lead term of nighttime lights in Appendix A.3 under the same RD framework.

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.

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

[10] 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 2: Comparing different growth measures



5 Results

5.1 Promotion incentive and official GDP statistics

Table 3 presents the effects of mayors' promotion incentives on official GDP growth rate (equation (1)). The variable of interest (PI) is a dummy that denotes mayor i's 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 shows strong and robust evidence of the positive impact of mayors' promotion incentives on city-level official GDP growth rate. Compared to the cities whose mayors are 57 years or younger with strong promotion incentives, cities with mayors older than 57 have approximately 3 percentage points lower official GDP growth rate.

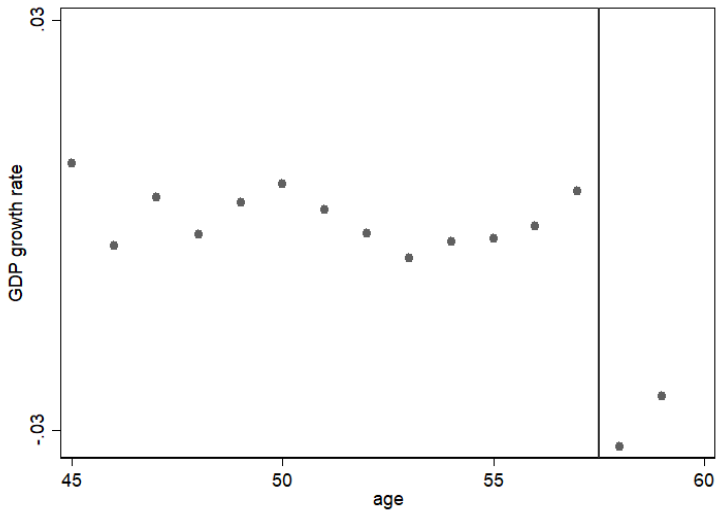
Figure 3 plots the bivariate relationship between age and normalized statistical GDP growth rate after extracting the mayor-level fixed effect. The figure suggests a clear "jump" in statistical GDP growth rate at the age cutoff points, echoing the results in Table 3.

Table 3: Mayoral promotion incentives and official GDP growth rate

	(1)	(2)	(3)	(4)	(5)	(6)
	Official GDP growth rate					
	City FE				City FE + Mayor FE	
PI=1 (age≤57)	0.0340**	0.0309**	0.0219*	0.0227*	0.0326*	0.0280*
	(0.0146)	(0.0147)	(0.0122)	(0.0122)	(0.0166)	(0.0145)
age	-0.00686	-0.00659	-0.00426	-0.00580	-0.0145	0.0358**
	(0.0108)	(0.0108)	(0.0112)	(0.0112)	(0.0151)	(0.0161)
PI*age	0.0112	0.0107	0.00554	0.00676	0.00970	0.00852
	(0.0112)	(0.0109)	(0.0110)	(0.0110)	(0.0128)	(0.0120)
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
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60
Number of unique cities	115	115	237	237	115	237
Obs	295	294	1105	1100	295	1105
R^2	0.129	0.158	0.107	0.112	0.290	0.339

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.

Figure 3: 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.

5.2 Promotion incentives and nighttime light

This section investigates 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.

Table 4 reports the estimation results for equation (2) and (4) using nighttime light growth rate as the outcome variable. The bandwidth selected in each column is the same as that of Section 5.1. The results in Table 4 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 4 plots the bivariate relationship between mayoral promotion incentives and nighttime light growth, indicating that nighttime light growth rate are continuous at the age cutoff.

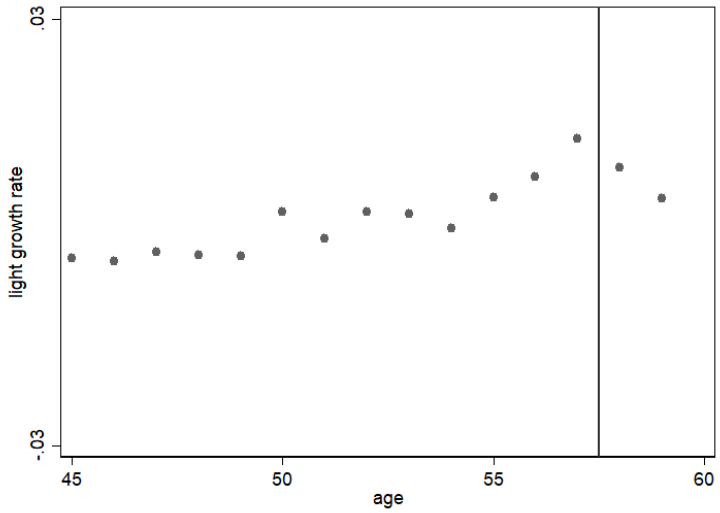
Table 4: Mayoral promotion incentives and nighttime light

Outcome variable	(1)	(2)	(3)	(4)	(5)	(6)
	Nighttime light growth rate					
	City FE				City FE + Mayor FE	
PI=1 (age≤57)	0.00513	0.00422	0.00110	0.00186	0.00418	0.00396
	(0.00693)	(0.00710)	(0.00567)	(0.00573)	(0.00734)	(0.00619)
Age	-0.00977	-0.0110	-0.00912*	-0.00975*	-0.0113	0.0238**
	(0.00621)	(0.00668)	(0.00539)	(0.00543)	(0.0104)	(0.00959)
PI*age	0.0108*	0.0114*	0.00873	0.00872	0.0119*	0.0119*
	(0.00584)	(0.00596)	(0.00542)	(0.00543)	(0.00677)	(0.00665)
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
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60
Number of unique cities	115	115	237	237	115	237
Obs	295	294	1105	1100	295	1105
R^2	0.398	0.416	0.260	0.271	0.585	0.579

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 by the mayor fixed effects 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.

The results presented in sections 5.1 and 5.2 offer evidence that mayoral promotion incentives 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

Figure 4: 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.

two estimators to GDP manipulation. We provide an empirical framework in Appendix A.2 to calculate the extent of GDP manipulation resulting from mayoral promotion incentives. These results suggest that mayors with high promotion incentives tend to manipulate the statistical GDP growth rate by 2.5-3 percentage points.

5.3 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.[11] 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.[12].

The results are reported in Table 5. Columns (1), (2), and (3) use the statistical GDP

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

[12] 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

Table 5: After 2013

Outcome variable	(1)	(2)	(3)	(4)	(5)	(6)
	Official GDP growth rate			Nighttime light growth rate		
PI=1 (age≤57)	-0.00847	-0.00964	0.00214	0.0103	-0.0118	-0.00317
	(0.0177)	(0.0173)	(0.0196)	(0.0307)	(0.0316)	(0.0364)
age	-0.00390	-0.00439	-0.157***	-0.00118	-0.00210	-0.169***
	(0.0123)	(0.0139)	(0.0200)	(0.0214)	(0.0209)	(0.0514)
PI*age	-0.00238	-0.00370	0.00369	-0.00290	-0.00931	0.000386
	(0.0162)	(0.0166)	(0.0188)	(0.0235)	(0.0232)	(0.0281)
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
Age coverage	55-60	55-60	55-60	55-60	55-60	55-60
Number of unique cities	145	132	145	144	132	144
Obs	284	260	284	278	256	278
R^2	0.053	0.086	0.425	0.233	0.314	0.352

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.

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.

6 Robustness checks: "insensitive" lights?

Section 4.2.2 discusses concerns related to the sensitivity of nighttime lights. In this section, we will provide empirical evidence to rule out these concerns. We will also show the robustness of our results to other non-manipulable economic growth indicators.

6.1 Government expenditures

As aforementioned, career-minded mayors may invest government spending in infrastructure projects or constructions to boost GDP 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 6 indicate no significant impact of promotion pressure at the age cut-off point on government expenditure growth. We take this as the evidence that career-minded mayors are unlikely to boost the GDP statistics through government activities when they are approaching the age threshold.

Table 6: Government expenditures

	(1)	(2)	(3)	(4)	(5)	(6)
	local government expenditure growth rate					
	City FE				City FE + Mayor FE	
PI=1(age≤57)	0.00391	0.00199	0.00107	0.00118	0.00576	0.00517
	(0.0206)	(0.0213)	(0.0163)	(0.0169)	(0.0228)	(0.0201)
age	0.0138	0.0156	0.00907	0.00942	0.0091	0.0258
	(0.0162)	(0.0162)	(0.0159)	(0.0155)	(0.0328)	(0.0248)
PI*age	-0.0140	-0.0146	-0.00756	-0.00804	-0.0155	-0.0121
	(0.0210)	(0.0211)	(0.0161)	(0.0157)	(0.0256)	(0.0172)
Demographic Controls		X		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	X	X	X	X
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60
Number of unique cities	115	115	237	237	115	237
Obs	295	294	1104	1099	295	1104
R^2	0.172	0.179	0.201	0.213	0.246	0.414

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.

6.2 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.

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 is small, since its implementation does not affect officials' promotion(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 part, we replicate and extend Chen, Li, and Lu (2018)'s results, and check whether GDP and light growth rate are both 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:

$$y_{it} = \beta_1 * (post_{it} * treatment_{it}) + \beta_2 * X_{it} + \mu_i + v_t + \epsilon_{it} \tag{5}$$

Where y_{it} is the nighttime light growth rate or the statistical GDP growth rate in city i year t. $post_{it}$ is a dummy 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. For the TCZ regressions: $treatment_{it}$ is a dummy that equals 1 for the cities in the two control zones, and equals zero otherwise. For the Great Recession regressions: $treatment_{it}$ is a continuous variable that measures 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 7.

The first two columns in Table 7 suggest 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 reveal a similar relationship, with a smaller standard error. The results in Column (3) and (4) suggest that cities with a higher share of FDI have a lower GDP and light growth rate during the Great Recession. Specifically, during the Great Recession, a 10 percent points increase in the share of FDI in GDP lowers the GDP and light growth rate by 1 percent point and 1.8 percent points, respectively. Overall, the results in Table 7 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

Table 7: 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	-0.0147*	-0.0123***		
	(0.00765)	(0.00433)		
FDI*Recession			-0.010	-0.0189***
			(0.010)	(0.006)
City fixed effect	X	X	X	X
Year fixed effect	X	X	X	X
Promotion incentive controls	X	X	X	X
Number of unique cities	253	253	250	250
Obs	2186	2186	2122	2122
R^2	0.204	0.486	0.214	0.495

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.

shocks. Therefore, the null results of the impact of promotion incentives on nighttime light growth rate reported in Table 4 are unlikely to be driven by the measurement error: if there is no GDP manipulation, the 3 percent point effect of promotion incentives on statistical GDP growth rate should be captured by light.

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 A5 suggest that mayoral promotion incentives have little impact on the lead term of the nighttime light.

6.3 Alternative non-manipulable economic growth indicators

In this section, we use three other non-manipulable economic growth indicators: electricity, firm entry, and manufacturing firm's total factor productivity (TFP) to check the robustness of our results.

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. China's premier

Keqiang Li proposed the Keqiang Index, which is a composition of three alternative indicators to measure real economic growth–electricity consumption, railway freight traffic, and total loans.[13] In this section, We use the city-level electricity consumption growth rate as a dependent variable in RD equation (1).[14] Table 8 Panel A shows that mayors' promotion incentives have a small and insignificant impact on the electricity consumption growth rate.

Firms' entry strongly correlates with economic growth. New entrants are usually firms with high productivity and new technologies (Hsieh and Klenow, 2009; Brandt, Van Biesebroeck, and Zhang, 2012). Firms' entry decisions are sensitive to economic conditions and are procyclical (Gourio, Messer, and Siemer, 2016; Tian, 2018). We use the logarithm of the newly registered firms at the city-by-year level as an alternative measure for real economic growth. The number of newly registered firm data is obtained from the State Administration for Industry and Commerce of the People's Republic of China (SAIC). Mayors have neither incentives, nor access to manipulate this information. The results in Table 8 Panel B indicate a statistically insignificant relationship between mayoral promotion incentives and firm entry at the age threshold.

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 8 panel C suggest that mayoral promotion incentives have a limited impact on firm-level TFP.

Results in all three panels in table 8 are consistent with the insignificant relationship between mayoral promotion incentives and nighttime light growth rate.

[13] https://www.economist.com/asia/2010/12/09/keqiang-ker-ching

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

Table 8: Mayoral Promotion incentives and other non-manipulable growth indicators

	(1)	(2)	(3)	(4)	(5)	(6)
		City FE			City FE + Mayor FE	
Panel A			Electricity growth rate			
PI=1(age≤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)
age	0.0265	0.0231	0.0193	0.0192	-0.00638	-0.0253
	(0.0178)	(0.0184)	(0.0150)	(0.0148)	(0.0365)	(0.0374)
PI*age	-0.0314	-0.0311	-0.0196	-0.0203	-0.0418*	-0.0200
	(0.0211)	(0.0213)	(0.0151)	(0.0150)	(0.0252)	(0.0178)
Obs	287	286	1078	1073	287	1078
R^2	0.052	0.107	0.059	0.064	0.221	0.285
Panel B			ln(newly registered firms)			
PI=1(age≤57)	0.0875	0.0840	-0.122	-0.119	0.0297	-0.131
	(0.100)	(0.0986)	(0.0887)	(0.0876)	(0.108)	(0.0959)
age	-0.192**	-0.200**	-0.256**	-0.255**	0.422***	0.258*
	(0.0939)	(0.0918)	(0.123)	(0.120)	(0.132)	(0.144)
PI*age	0.330***	0.341***	0.239*	0.231*	0.341***	0.193
	(0.0975)	(0.0959)	(0.122)	(0.121)	(0.0943)	(0.117)
Obs	281	280	1063	1058	281	1063
R^2	0.304	0.328	0.244	0.260	0.556	0.606
Panel C			ln(TFP)			
PI=1(age≤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)
age	-0.0669	-0.0708	-0.0316	-0.0300	-0.223**	0.000644
	(0.0757)	(0.0698)	(0.0877)	(0.0883)	(0.0889)	(0.0944)
PI*age	0.104	0.104	0.0386	0.0412	0.115	0.0803
	(0.0777)	(0.0740)	(0.0852)	(0.0857)	(0.0777)	(0.0882)
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
Age coverage	55-60	55-60	51-60	51-60	46-60	46-60

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.

7 Discussions

7.1 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 9), 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 (6) and (7):

$$GDP_{s,ijt}^{turnover} = \alpha + \beta_{GDP}^{turnover} PI_{i(j-1)(t-1)} + \beta_1 X_{j-1} + \beta_2 X_j + v_t + \mu_i + \epsilon_{it} \tag{6}$$

$$growth_{light,ijt}^{turnover} = \alpha + \beta_{light}^{turnover} PI_{i(j-1)(t-1)} + \beta_1 X_{j-1} + \beta_2 X_j + v_t + \mu_i + \epsilon_{it} \tag{7}$$

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 (6) and (7) are reported in Panel A and B of Table 9, 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 9: Adjustment of the potentially manipulated GDP statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A				Official GDP growth rate			
$PI_{j-1,t-1}$	-0.0130**	-0.0052	-0.0161**	-0.0093	-0.0157*	-0.0344**	
	(0.0064)	(0.0091)	(0.0074)	(0.0106)	(0.0088)	(0.0152)	
Turnover							0.0028
							(0.0023)
Obs	585	537	521	464	309	219	2072
R-squared	0.117	0.411	0.449	0.638	0.419	0.697	0.266
Panel B				Nighttime light growth rate			
$PI_{j-1,t-1}$	-0.0051	-0.0002	-0.0040	-0.0003	-0.0012	0.0024	
	(0.00523)	(0.0056)	(0.0057)	(0.0071)	(0.0067)	(0.0128)	
Turnover							0.00189
							(0.00160)
Obs	604	561	536	476	316	224	2072
R-squared	0.203	0.642	0.197	0.630	0.222	0.633	0.501
Sample	the first year when the new mayor is in office						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 9 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 9 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.

7.2 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:

$$\text{Promotion}_{jt} = \alpha + \beta \text{ Performance}_{jt} + v_t + \mu_j + \varepsilon_{it} \tag{8}$$

We focus on the mayors who are younger than 58 in all specifications, since mayors older than 58 are rarely be promoted. The results are reported in Table 10. The independent variable $Performance_{jt}$ is the GDP growth rate or the nighttime light growth rate of mayor j. Where the outcome variable $Promotion_{jt}$ is defined in Appendix A.4, switching on if mayor j is promoted. Column (1), (2), (4), and (5) use the city-by-year level observations, where we check whether mayors' most recent years' performance affect their promotion. Column (3) and (6) use the mayor-level observations, where we examine whether mayors average performance throughout her term affects her promotion. We control for mayor fixed effects μ_j in columns (1), (2), (4), and (5) in Table 10 to control for unobservable mayor-level characteristics (e.g., officials' personnel connections (Jiang, 2018)).

The first two columns of Table 10 suggest that mayors' most recent years' GDP growth rate has a positive impact on their promotion. Specifically, a one percentage point increase in average statistical GDP growth rate in the most recent two years increases the mayors' promotion probability by 1.2 percentage points. In contrast, the impact of nighttime light growth rate on promotion is imprecisely estimated (column (4) and (5)). Column (3) and (6) report the results using the average GDP growth rate and nighttime light growth rate throughout the mayors' term as the dependent variable. The average GDP growth rate and nighttime light growth rate does not significantly impact mayors' promotion. Column (7) is a horse-race regression, suggesting that the most recent years' GDP growth rate play a more

Table 10: The impact of GDP and nighttime light growth rate on mayors' promotion

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcome variable	Promotion dummy						
$\frac{GDP_{s,jt}+GDP_{s,jt-1}}{2}$	1.192*						
	(0.625)						
$GDP_{s,jt}$		0.796**					0.795**
		(0.401)					(0.400)
$GDP_{s,jt-1}$		0.496					0.485
		(0.339)					(0.342)
$\overline{GDP_{s,j}}$			-0.081				
			(0.895)				
$\frac{light_{s,jt}+light_{s,jt-1}}{2}$				-0.521			
				(0.844)			
$light_{s,jt}$					-0.260		-0.251
					(0.592)		(0.597)
$light_{s,jt-1}$					-0.261		-0.213
					(0.560)		(0.560)
$\overline{light_{s,j}}$						-0.579	
						(1.343)	
Year fixed effects	X	X	X	X	X	X	X
Mayor fixed effects	X	X		X	X		X
City fixed effects	X	X	X	X	X	X	X
Obs	787	787	434	787	787	434	787
R^2	0.583	0.583	0.108	0.580	0.580	0.111	0.583

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.

important role in affecting mayors' promotion than the nighttime light.

The results in Table 10 suggest that GDP manipulation distorts officials' accountability in China. 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 be less likely to explain China's rapid growth in the past forty years.

7.3 Heterogeneity in manipulation

We explore the heterogeneous effect of promotion incentives on GDP manipulation by sectors. It provides a robustness check for the main results. Suppose the manipulation extent is prominent in the sectors where the manipulation cost is high, it might be reasonable to assume that some confounding factors drive the overall impact of promotion incentives on GDP manipulation. Additionally, unraveling the heterogeneous effects helps us better understand the mechanisms behind mayors' GDP manipulation behavior.

We re-estimate equation (1) using official GDP growth rate in agriculture, manufacturing, and service sector as the dependent variables. The RD estimation results are reported in Table 11. The results in columns (1) and (2) suggest that mayoral promotion incentives have negligible impact on statistical GDP growth rate in the agriculture sector. In contrast, the mayoral promotion incentives have a large and significant impact on statistical GDP growth rate in manufacturing and service sectors. Although we cannot decompose the nighttime light growth data by sector, our previous results indicate that the GDP manipulation are mainly driven by the discontinuity in GDP statistics.

Two factors may contribute to the heterogeneity in GDP manipulation across sectors. First, the manipulation cost in the agriculture sector is high. The ministry of agriculture uses remote sensing techniques to estimate and monitor crop yield. Second, the agriculture sector only accounts for 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.

8 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

Table 11: Heterogeneity of manipulation

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome variable	Agriculture		Manufacture		Service	
PI=1 (age $\leq$ 57)	0.00214	0.00426	0.0403*	0.0317**	0.0392*	0.0345*
	(0.0249)	(0.0229)	(0.0211)	(0.0156)	(0.0206)	(0.0195)
age	-0.0229	-0.0107	-0.0235	-0.0238	0.0210	0.0250
	(0.0173)	(0.0182)	(0.0184)	(0.0186)	(0.0171)	(0.0156)
PI*age	0.0224	0.0122	0.0300	0.0261	-0.0214	-0.0252
	(0.0178)	(0.0178)	(0.0192)	(0.0186)	(0.0184)	(0.0157)
Age coverage	55-60	51-60	55-60	51-60	55-60	51-60
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Number of unique cities	115	237	115	237	115	237
Obs	230	962	230	962	230	962
R^2	0.448	0.344	0.593	0.455	0.404	0.346

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.

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. 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.

These findings contribute to the growing literature on understanding local officials' behaviors and regional economic development. Our findings suggest that China's mayors tend to manipulate the GDP statistics when they face promotion pressure. In that case, the connec-

tion between China's rapid economic growth and its promotion scheme-based performance may be tenuous. By documenting the substantive GDP manipulation induced by mayoral promotion incentives, we provide direct evidence that without appropriate supervision, the hierarchical officials' incentive system will be distorted.

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.

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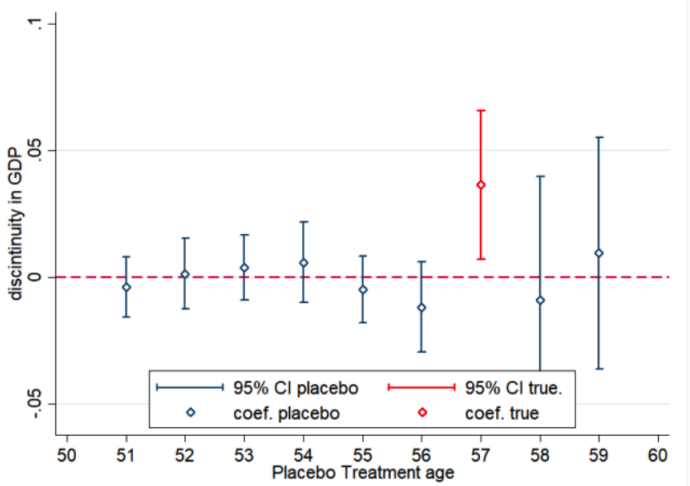
A Appendix

A.1 RD tests

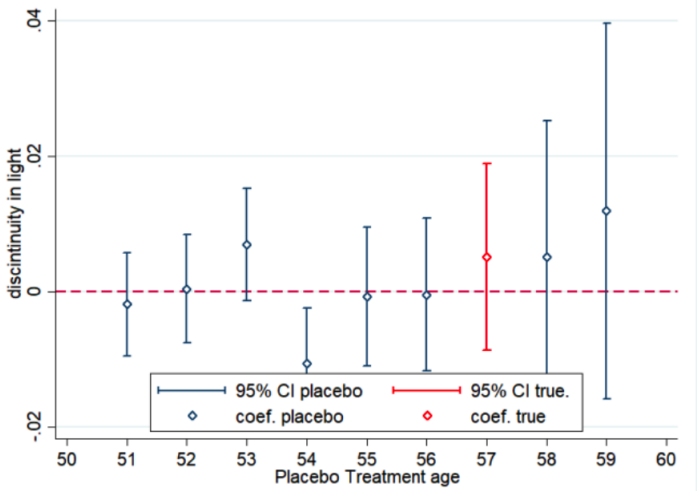
A.1.1 Falsification test

Figure A1: Falsification test in GDP growth rate



Notes: Plot is constructed by estimating RD equation (1) 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 (1) with various selection of treatment thresholds using the analysis sample.

A.1.2 High order polynomials

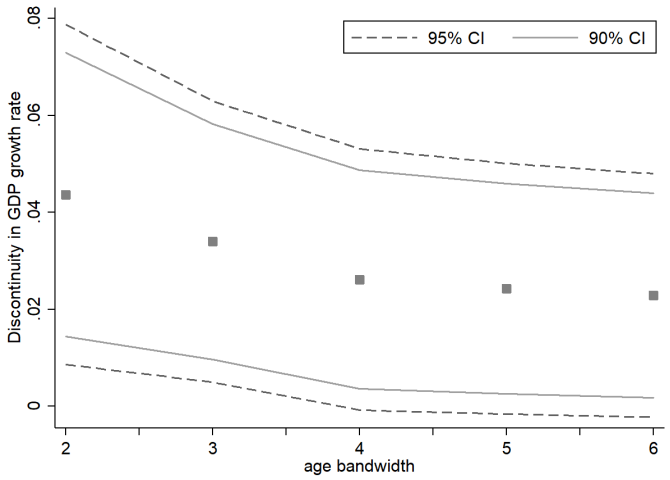
Table A1: High order polynomials

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome variable	statistical GDP growth rate					
PI=1 (age≤57)	0.0533**	0.0371*	0.0267*	0.0501**	0.0453*	0.0430*
	(0.0222)	(0.0226)	(0.0153)	(0.0201)	(0.0290)	(0.0234)
Orders	2nd	3rd	2nd	3rd	2nd	3rd
Mayor fxied 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	231	229	963	958	2174	2161
R^2	0.763	0.769	0.577	0.582	0.491	0.496

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

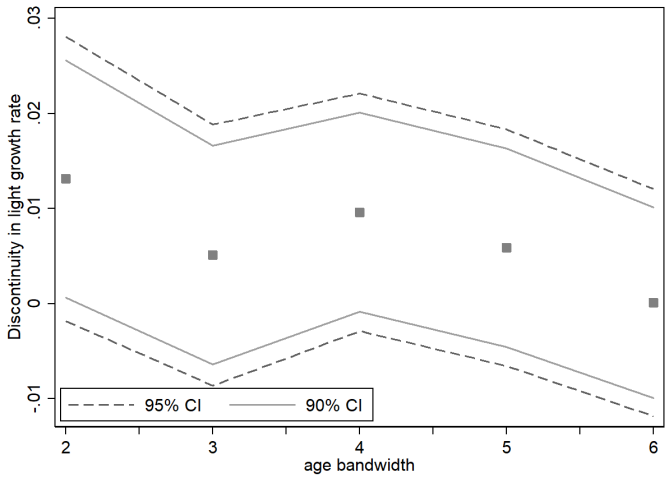
A.1.3 Bandwidth check

Figure A3: Bandwidth check in GDP growth rate



Notes: Plot is constructed by estimating RD equation (1) 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 (1) with various selection of bandwidths using the analysis sample.

A.1.4 Balance test

The results in Table A2 demonstrate the continuity of city and mayor-level covariates at the policy threshold by re-estimating equation (1).

Table A2: Balance test

Outcome variables:	(1) population	(2) # of hospitals	(3) # of theaters	(4) port	(5) gender	(6) bachelor
PI=1 (age≤57)	0.0106	-0.00432	-0.00143	0.0562	-0.00219	0.0872
	(0.0414)	(0.0231)	(0.00331)	(0.0638)	(0.00433)	(0.0737)
age	0.0327	-0.0213	-0.00157	-0.0951	-0.00403	0.0119
	(0.0331)	(0.0207)	(0.00252)	(0.0628)	(0.00603)	(0.0585)
PI*age	-0.0337	0.0291	0.00176	0.116*	0.0000888	-0.0191
	(0.0377)	(0.0269)	(0.00234)	(0.0666)	(0.00453)	(0.0576)
City fixed effect	X	X	X	X	X	X
Year fixed effect	X	X	X	X	X	X
Age coverage	55-60	55-60	55-60	55-60	55-60	55-60
Obs	277	292	285	295	295	295
R^2	0.318	0.202	0.257	0.498	0.062	0.246

Notes: Robust standard errors clustered at the city level in parentheses, *** p<0.01, ** p<0.05, * p<0.1. "population", " of hospitals", and " of theaters" denote the number of population (in millions), number of hospitals (in thousands), and number of theaters in a city (in thousands), respectively. "port" is a dummy that switches on if the city is a coastal city. "gender" is a dummy that equals 1 if the mayor is female. "bachelor" is a dummy that equals 1 if the mayor holds a bachelor's degree or higher.

A.2 Estimation of the GDP manipulation extent

In this part, we provide an empirical framework to calculate the GDP manipulation extent with the estimated RD effects of mayoral promotion incentives on GDP and nighttime light.

We assume that the official GDP growth rate contains two parts: real economic growth and GDP manipulation:

$$GDP_s = f\left(GDP_r, GDP_m\right) + \varepsilon^{gdp} \tag{A1}$$

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 is only influenced by real economic growth (GDP_r), and is orthogonal to the manipulation part of GDP growth rate (GDP_m):

$$\text{growth}_{\text{light}} = h\left(GDP_r\right) + \varepsilon^{\text{light}} \tag{A2}$$

Where $growth_{light}$ denotes the nighttime light growth rate. We assume that mayoral promotion incentives (PI) influence the statistical GDP growth rate (GDP_s) through the channel of real economic growth rate (GDP_r) and GDP manipulation (GDP_m). PI influences nighttime light growth rate only through the channel of real economic growth rate (GDP_r). Differentiating (A1) and (A2) in terms of mayoral promotion incentive (PI):

$$\frac{\partial GDP_s}{\partial PI} = \frac{\partial f}{\partial PI} = \frac{\partial f}{\partial GDP_r}\frac{\partial GDP_r}{\partial PI} + \frac{\partial f}{\partial GDP_m}\frac{\partial GDP_m}{\partial PI} \tag{A3}$$

$$\frac{\partial light}{\partial PI} = \frac{\partial h}{\partial PI} = \frac{\partial GDP_r}{\partial PI}\frac{\partial h}{\partial GDP_r} \tag{A4}$$

We define $\gamma = \frac{\partial GDP_S}{\partial growth_{light}} = \frac{\partial f}{\partial h}$ to normalize the nighttime light growth rate, and to make it comparable to the statistical GDP growth rate. We then combine equations (A3) and (A4) to estimate the effect of promotion incentives on the artificial manipulation of GDP statistics:

$$\frac{\partial f}{\partial GDP_m}\frac{\partial GDP_m}{\partial PI} = \frac{\partial f}{\partial PI} - \frac{\partial h}{\partial PI} * \gamma \tag{A5}$$

Based on the above framework, the key parameters to be identified are $\frac{\partial f}{\partial PI}$ (i.e., the effect of mayoral promotion incentives on statistical GDP growth rate), $\frac{\partial h}{\partial PI}$ (i.e., the effect of mayoral promotion incentives on nighttime light), and the normalizing constant γ.

The effect of mayoral promotion incentives on statistical GDP and light are identified by β_{gdp} and β_{light} in the RD equation (1) and (2), respectively. We employ equation (A6) to

identify γ:

$$lnGDP_{s,it} = \gamma lnlight_{nm,it} + v_t + \mu_i + \epsilon_{it} \tag{A6}$$

All notations in equation (A6) remain the same as in equation (1). The results are reported in Table A3. The point estimate of the γ is quite similar to the results in Henderson, Storeygard, and Weil (2012). It is worthwhile to note that consistency of the estimated GDP manipulation extent will be little affected by the imprecise estimate of γ, as long as the discontinuity in nighttime light (β_{light}) is close to zero.

Table A3: Estimation of γ

	lnlight
lngdp	0.369***
	(0.0694)
Year fixed effects	X
City fixed effects	X
Obs	2428
R^2	0.991

Notes: (1) All standard errors are clustered at the city level, *** p<0.01, ** p<0.05, * p<0.1.

Table A4: GDP manipulation extent

RD age coverage		γ=0.2	γ=0.369	γ=0.5	γ=0.7
age>54	Manipulation	0.031*	0.030*	0.030*	0.029*
	std	(0.017)	(0.017)	(0.018)	(0.018)
age>50	Manipulation	0.027**	0.027*	0.026*	0.025*
	std	(0.013)	(0.014)	(0.014)	(0.015)
age>45	Manipulation	0.024*	0.023*	0.023*	0.022
	std	(0.013)	(0.013)	(0.014)	(0.014)

Notes: (1) City fixed effects, mayor fixed effects, and year fixed effects are controlled in all specifications. (2)Standard errors are obtained based on 500 bootstrapped resamples clustered at the city level, *** p<0.01, ** p<0.05, * p<0.1.

With γ estimated in Table A3, the extent of GDP manipulation is reported in Table A4. We also examine the robustness of our results using a wide range of γ. Point estimates and

confidence intervals are obtained based on 500 bootstrapped resamples clustered at the city level.

The results in Table A4 indicate that due to the small estimates of β_{light}, different values of γ have a limited impact on the GDP manipulation extent estimates. Mayors with high promotion incentives tend to manipulate the statistical GDP growth rate by around 3 percentage points.

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 A5 suggest that mayoral promotion incentives have little impact on the lead term of the nighttime light.

Table A5: 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)
Age	-0.00752	-0.00812	-0.00659	-0.00711	0.0177	-0.143***
	(0.00494)	(0.00546)	(0.00553)	(0.00557)	(0.0122)	(0.00884)
PI*age	0.00719	0.00696	0.00647	0.00640	0.00462	0.00654
	(0.00575)	(0.00599)	(0.00562)	(0.00558)	(0.00652)	(0.00613)
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
Age coverage	55-60	55-60	51-60	51-60	55-60	51-60
Number of unique cities	104	104	223	223	104	223
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 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 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.

Table A6: 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.

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 of officials moving from mayor-level position i to position j: p_{ij} in each position i. Table

Table A7: 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 A6. In the real calculation process, we artificially change $p_{12,12}$ in Table A6 to 1, making state 12 (vice-provincial level position) become an absorbing state. Therefore, the coefficients in column 12 of Table A7 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).

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 A7. And the results are qualitatively robust when we use n=4 and 5.

Table A7 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%).

Figure A5: The promotion road of Yongchang Wang

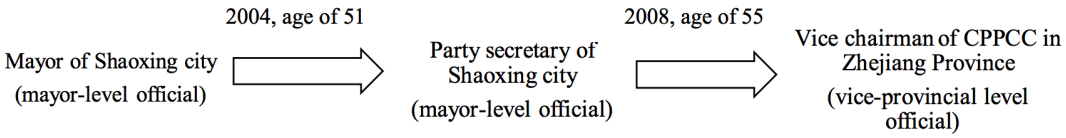
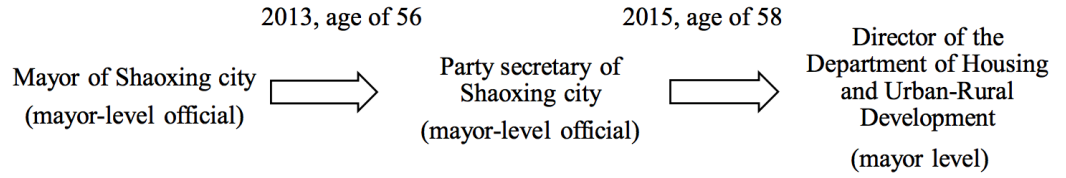


Figure A6: The promotion road of Jianmin Qian



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).

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