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Facilitating fertility decline through economic development: a principal-agent analysis of local bureaucratic incentives in China's fertility transition

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Despite close associations, political science had weak explanatory power for fertility transition. It often depicts the political processes of fertility transition as direct and coercive policies and mechanical execution without consideration of indirect bureaucratic processes. Drawing on principal-agent and economic-driven theories, this study established a novel model using 1980–2000 Chinese provincial panel data: local officials facilitated fertility decline through economic development for career advancement. System generalized method moments (GMM) and ordered logistic regression (OLM) results showed: (1) gross domestic product (GDP) per capita growth (OR = 0.012) and total fertility rate (TFR) decline (OR = 0.026) increased promotion odds, while excessive TFR decline (over 37% within one term) decreased it; (2) the critical age (59) and tenure year (one year before leaving office) positively associated with GDP per capita, industrialization, and lower TFR; (3) GDP per capita and industrialization negatively associated with TFR. Facilitating fertility decline via economic development was an efficient, low-risk strategy for local officials compared to radical birth control campaigns. It was the first study applying principal-agent theory to explain how bureaucratic processes enabled fertility transitions. It combined political and economic-driven theories on fertility transition, advancing political demography and refining the social science paradigm on fertility transition.

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Introduction

The world is undergoing a low fertility transition, with some countries reaching extra-low TFR, including traditionally pronatalist China. Mainstream social science has pursued causal explanations (Caldwell, 1976), dominated by economic and sociological paradigms, while political sciences were under-attended (Weiner and Teitelbaum, 2001; Teitelbaum, 2015).

Economics and sociology have collaborated to propose socio-economic development as the fundamental driver of fertility transition. Economics considered fertility decisions a cost-benefit function and attributed the transition to changing bearing motives (Kirk, 1996). Modern economies demanded higher human capital and offered higher wages, increasing the child-bearing opportunity cost while decreasing the children's utility for labor, savings, and risk mitigation (Leibenstein, 1981). This encouraged parents to invest in themselves and their children's human capital instead of children's numbers (Becker, 1962). In modern societies, wealth flows from parents to children, making pronatalism financially irrational (Caldwell, 1976). Improved child survival and contraceptive access encourage voluntary family planning (Easterlin and Crimmins, 1986). In addition, sociology saw the transition resulting from changing fertility norms and declining community authority. Pronatalism was once a cultural norm and a compulsory duty imposed on parents (Yan, 2009). Only after the erosion of the norm and community authority could parents make independent fertility decisions and use contraceptives. Individualist philosophies undermined fertility roles by encouraging self-development and enjoyment (Lesthaeghe, 1983, 2010). Urbanization and education led people to reject traditional authorities and make rational fertility choices (Lesthaeghe and Surkyn, 1988). Therefore, socioeconomic development fits well with the century-old downward trend of TFR (Fig. 1).

However, the considerable fluctuations in TFR over the past century diverged from the steady economic development, instead closely related to political actions—often overlooked by social science paradigms (Weiner and Teitelbaum, 2001). Figure 1a showed that the average TFR in some modern states dropped from 3.4 in 1900 to 2 in the 1930s, triggering pronatalist campaigns over apocalyptic concerns (Teitelbaum, 2015). Later, the 1960s baby boom and 1980s baby boomlet raised worries of excessive fertility, dubbed a "population bomb" (Ehrlich, 1968),

prompting birth control initiatives. However, the baby boomlet failed to restore TFR to the replacement level, and "low fertility trap" concerns led to renewed pronatalist policies in Europe in the 2000s (Lutz et al., 2006). In contrast to these TFR fluctuations, per capita GDP maintained smooth growth (Fig. 1b).

Regarding fertility transition, political science should have collaborated with economics and sociology to form a complete social science paradigm: economics and sociology explained the overall downward trend of TFR, while political demography explained the fluctuations. The political process can fine-tune excessively high or low fertility rates to prevent rapid fertility transitions from striking social stability (Teitelbaum, 2015).

However, underdeveloped political demography has hindered the interdisciplinary paradigm because previous political, demographic research focused on mechanical and direct fertility policies (Goodkind, 2017; Wang et al., 2018). It did not clarify causal chains between politics and fertility because it emphasized policy decision-making over implementation and limited fertility policies to direct fertility policies, especially China's one-child policy (OCP) (Goodkind, 2017). However, the question remained as to (1) how the government ensures its local agents proactively and effectively implement fertility policies; (2) direct and mechanical-executing policies were not accurate, as most fertility policies were indirect and provided external conditions to encourage parents' voluntary family planning, such as developing education, gender equality policies, encouraging female employment, and providing contraceptives (Sun, 1987; Kirk, 1996). The previous research also sparked unnecessary competition over whether China's fertility declines resulted from policy or economic factors (Hvistendahl, 2017). The flaws and limitations of these research destined it to fail against the economic theories with clearer causality (Greenhalgh, 2018; Wang et al., 2018). This article did not seek to reignite this debate. Instead, it aimed to elucidate bureaucratical processes in fertility transition and enable theoretical cooperation between political science and economics.

Applying principal-agent theory (PAT) and theories of economic-driven fertility transition, we constructed a novel model of China's local officials facilitating fertility decline through economic development (Fig. 2). The principal-agent problem induced an outcome-based incentive system where the central government delegated quantified targets without
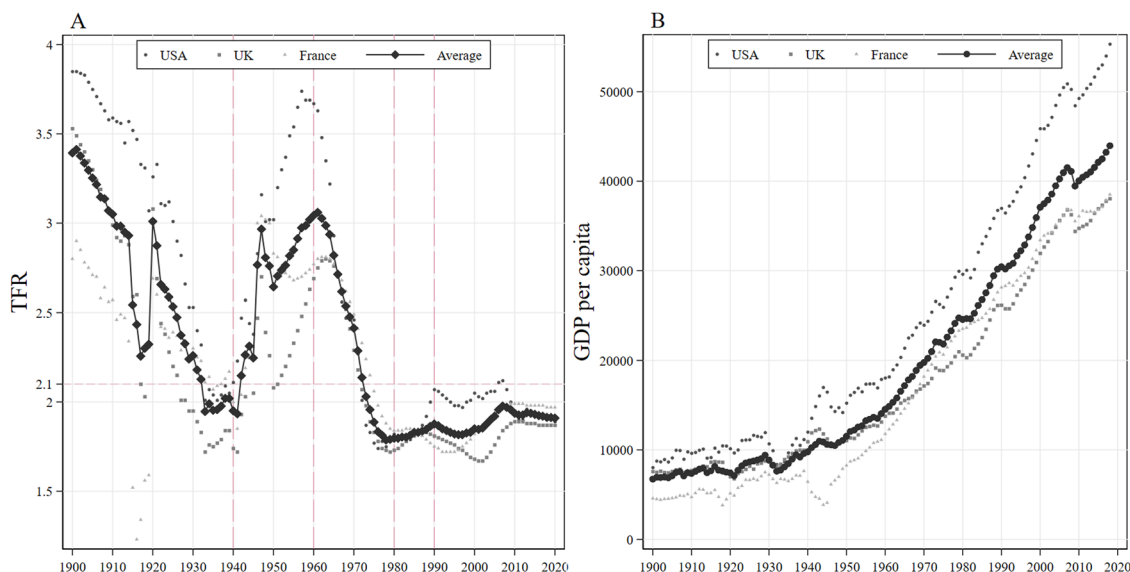

Fig. 1 TFR and socioeconomic changes in major modern states: 1900–2020. A TFR change; **B** Per capita GDP change. Source: OurWorldInData.org. GDP per capita data is expressed in international-$ at 2011 prices.
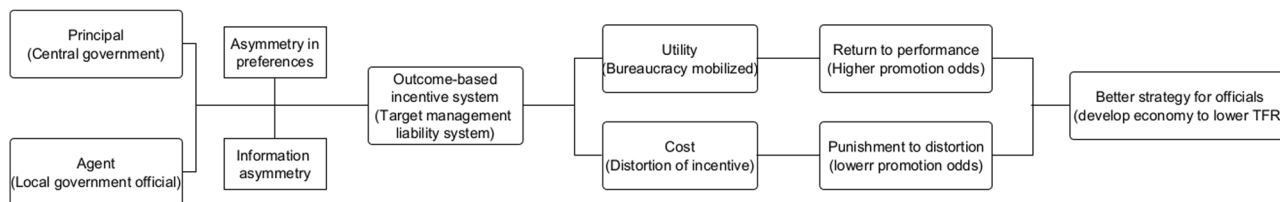
Fig. 2 Theoretical framework: China's bureaucracy relationship based on principal-agent theory. China's central and local governments function via a principal-agent relationship. The central government instituted a results-based target management system with clear rewards and punishments. This system risks incentive distortions, requiring the central government to punish deviant officials.

restricting officials' means unless causing social instability (Li and Zhou, 2005; Cao, 2018; Zhou and Lian, 2020). The system incentivized officials to pursue high-yield, low-risk performance. Developing the economy was low risk and high return for promotion compared to strict birth-control campaigns, which risked the political taboos of "stability overrides everything" (Yang, 2017). Under limited resources and attention, rational officials adopted economic development to accelerate fertility decline. We chose China as the illustrative case due to the rapid TFR decline in China once attributed to the OCP (Goodkind, 2017). To demonstrate that the bureaucratical processes for fertility decline go beyond the mechanical-executed OCP, this study validated that promotion-incentivized officials would strive to develop the economy to reduce TFR. Overall, we constructed a cooperative social science model of fertility decline.

Theoretical review and hypotheses
Principal-agent theory and the relationship between hierarchical governments in China. The PAT's task was to solve the principal-agent problem caused by preference asymmetry and information asymmetry between the principal and agent (Holmstrom and Milgrom, 1991; Miller, 2005). Preference asymmetry leads agents to maximize self-interest over principals' interests. Given their local information advantages, agents prefer risk-averse and indolent actions. Therefore, principals should design incentives for agents to choose proactive actions that serve principals' interests. However, principals cannot easily monitor agents' actions or judge their loyalty, only outcomes. Therefore, principals prioritized incentive systems relying on quantified performance indicators.

Quantified incentives mobilize agents toward principals' targets but may cause a problem of incentive distortion. Incentive distortion refers to situations where the quantified incentive systems lead agents to take actions that deviate from expected results for principals (Holmstrom and Milgrom, 1991; Baker, 2002). The distortion includes (1) selective execution, as agents focus on highly rewarded indicators even if violating principals' total interests (Holmstrom and Milgrom, 1991); (2) the "yes man" problem, where informed and resourceful agents mechanically follow orders to demonstrate efficiency in execution rather than making recommendations that benefit the principal's interests (Prendergast, 1993).

Public management applied PAT to explain government relationships (Miller, 2005; Zhang et al., 2023), including China's central-local governments' relationship (Zhou and Lian, 2020). The central government is the principal, seeking to maximize overall interests but lacking local information. Local governments are agents of executing tasks but do not share goals with the central government, as their goals are career advancement and welfare improvement. However, they have an information advantage within the jurisdiction and generally prefer risk-averse and indolent actions. To mobilize local agents, the central government has established an outcome-based target

management responsibility system (Fig. 2). It delegates considerable discretion to head officials of local governments based on a quantified performance system; it also strongly links performance with rewards or punishments for agents (Bo, 1996; Li and Zhou, 2005).

However, the target management responsibility system risks incentive distortions and counterproductive effects as local officials compete for promotion. Officials may focus only on highly weighted tasks while minimizing efforts on equality and accessibility of public services (Li and Zhou, 2005; Zhou and Lian, 2020). They also exhibit "yes man" tendencies, following orders to display compliance instead of offering optimal schemes (Prendergast, 1993). For example, the economic-first performance evaluation system led some officials to risky budgeting or unstainable infrastructure projects before promotion (Zhang and Gao, 2007; Guo, 2009; Tsui, 2011).

Incentive system, economic development, and fertility decline
Promotion incentives and economic development. The promotion tournament model showed China's economic-first performance evaluation system created strong incentives for local officials to strive for competitive economic performance (Li and Zhou, 2005; Zhou and Lian, 2020). Local officials adopted various strategies to stimulate growth, as empirically demonstrated across studies. For example, they competitively offer preferential policies to attract domestic and foreign investment, such as low-price land, low-cost labor, low-requirement environmental protection, and tax breaks (Chen et al., 2022). They tend to invest in strategic infrastructure projects at critical ages for career advancement, such as 54 for mayors, which can directly contribute to growth and employment figures (Zhang and Gao, 2007). Developing real estate expansion effectively boosted growth figures, especially when economic growth was sluggish. Local officials tightened the land supply and thus pushed up land prices, compelling the rigid demand for house purchases to boost regional GDP growth (Liu and Xiong, 2018).

However, the promotion tournament model faced theoretical and empirical criticism. First, although motivated to spur economic development, officials may lack resources and the ability to boost the economy as the market transition weakens their capability of resource control and social mobilization (Nee, 1989). Second, factionalism influences official selections, enabling the chosen officials to advance regardless of economic performance (Opper and Brehm, 2007). Third, promotion may not require self-achieved economic performance, as officials can be transferred to high economic potential districts if the superior governments decide to promote them (Opper et al., 2002).

Existing research provided an empirical basis for testing these hypotheses that promotion incentives of local officials were related to economic growth in China, while there were also contrary opinions. Synthesizing across these studies, this article derived the following two hypotheses.

H1a: Promotion-incentivized officials strived to develop the economy.

H1b: Outstanding economic performance increased the promotion probability of local officials.

Promotion incentives and fertility decline. China's central government delegated fertility decline targets to local governments, requiring prioritization of fertility decline, as the following cited. The central government focused highly on fertility decline outcomes (Zhou and Lian, 2020), disregarding local government methods unless causing serious social conflicts (Liang, 2006). Underperformance would lead to disqualification from promotion. High-weighted promotion incentives created intense performance competition among local officials (Li and Zhou, 2005). Local officials mobilized subordinates through contracting layer by layer to drive fertility decline, whereby departments and agents must accept fertility decline targets in signed contracts (Greenhalgh, 1994; Ai, 2011).

> "Committees of the CPC and governments at all levels must attach birth controlling as much importance as economic development … Party and government leaders must take on personal responsibility for it" (the CPC and the State Council, 1991).

However, under limited attention, pronatalist culture, and socioeconomic development driving fertility declines, local officials may be unwilling or unable to boost fertility decline. First, officials prefer high-reward tasks under limited tenure and multidimensional tasks (Holmstrom and Milgrom, 1991; Li and Zhou, 2005). Fertility decline may bring fewer promotion incentives than economic performance, as evidenced in Guangdong's slow fertility decline yet fast economic growth and high promotion opportunities for officials (Scharping, 2003). Second, the market transition since the 1980s has weakened the government's capability to control society and steer the fertility transition, while socioeconomic development was seen as the fundamental driver of fertility decline regardless of the government's efforts (Cai, 2010; Zhao and Zhang, 2018).

Existing research provided a foundation and critical perspectives on the relationship between local officials' promotion incentives and fertility decline in China. Synthesizing these studies, this article formulated two hypotheses:

H2a: Promotion-incentivized officials strived to decrease the jurisdictional TFR.

H2b: Outstanding fertility decline performance increased the promotion probability of local officials

The punishment of birth-control campaigns. The outcome-based performance evaluation system can effectively mobilize officials but risks incentive distortions of "yes man," where informed agents follow orders to display efficiency over recommending optimal solutions (Prendergast, 1993). The central government has granted local officials considerable discretion to achieve the fertility decline target, as the official document stated, "*Regarding family planning policy … specific requirements should be put forward based on the different situations in different regions, and classified guidance should be implemented*" (The CCCP, 1997 [1984]). However, when competing for scarce opportunities for promotion, officials may aggressively enforce birth control campaigns to maximize fertility decline performance regardless of social resistance (Minzner, 2009). Imposing sterilization operations was intuitively an immediate method of fertility decline. Local officials may implement such coercive campaigns when conventional birth control methods are insufficient to achieve satisfactory fertility decline performance (Mattingly, 2020).

However, when the birth control campaigns triggered social instability, the central government punished deviant officials (Liang, 2006). The central government delegated power to local governments to a large extent to disperse governance risks and require local officials to maintain regional social stability (Cao, 2018). Like the fertility decline, maintaining social stability was also the top priority of local officials under the "stability overrides everything" regulation (Yang, 2017). When local officials fail to maintain social stability, the central government will dismiss them.

The central government proposed voluntary family planning and punished the deviant officials, stating: "*Family planning policy should be established based on being sensible and reasonable, supported by the people, and implemented through officials' good work…… Barbaric practices and illegal behaviors must be prohibited. Regulations against coercion and forced commands should be reiterated and strictly followed*" (The CCCP, 1997 [1984]). The central government was dissatisfied that the former Family Planning Commission failed to prevent the strict birth-control campaigns in 1983 and thus rejected the Commission's 1984 "Report on the Family Planning Work Situation," replacing the Commission's chairperson that year (Liang, 2006, 2014). Radical birth control campaigns risked social instability and failed officials' promotion opportunities, making it an unwise career move. Accordingly, this article made the hypothesis about radical birth control campaigns.

H3: The radical birth control campaign was not conducive to officials' promotion.

Economic development as a mediator. Although radical birth control campaigns were unreliable for fertility decline, the performance evaluation system still incentivized officials to find a way to accelerate fertility decline. Since "economic development is the best contraceptive" (Singh, 1988), developing the economy seems like a reasonable alternative strategy for officials to lower TFR while avoiding social instability from radical campaigns (Zhao and Zhang, 2018). Officials eagerly spur economic development to provide more job opportunities and higher human capital returns (Gong et al., 2021). This increased childbearing opportunity costs while prolonging women's educational duration, delaying childbearing (Becker, 1962). Empirically, TFR differences between the counties of Jiangsu province and Zhejiang province stemmed from per capita GDP and foreign direct investment (FDI) rather than fertility policy (Cai, 2010). In return, agents with outstanding fertility decline performance would be rewarded, as the document says, "*advanced collectives and individuals in family planning could be commended and rewarded at the discretion of departments through mechanisms formulated by themselves*" (National Government Offices Administration, 1991).

However, there were studies against this alternative strategy. First, the effect of economic development on fertility decline will take time to take effect (Goodkind, 2017), while officials must make competitive performance within tenure (Zhang and Gao, 2007). Second, the mechanism by which economic development facilitated family planning lay in the high opportunity costs in the labor market (Becker, 1962). Still, it was not real in China's pronatalist rural areas, where the labor force was often hiddenly unemployed due to oversupply (Huang, 1985). The opportunity cost of childbearing was extremely low. Synthesizing across these opinions, we derived the following hypothesis.

H4: Officials facilitate fertility decline through economic development.

Data and methodology

Data. We uncovered several novel datasets to investigate the unprecedented linkage between local officials' promotion incentives, economic development, and fertility decline. Specifically, we compiled multiple data sources with leader officials' 1980–2000 provincial panel data and socioeconomic characteristics by "province-year" match. The TFR data for 1980–1990 and 1991–2000 were respectively recorded from the *Handbook of Fertility Rates in Chinese Provinces* (Chen and Coale, 1993) and *Fertility Estimates for Provinces of China* (National Bureau of Statistics of China and East-West Center, 2007). They were then matched with officials' data recorded in the Lingnan Local Officials Database. The Lingnan Local Officials Database contains the resumes of all provincial leaders of the Chinese Community Party and provincial government in Mainland China from 1978 to 2008. Moreover, the socioeconomic data was from the CNKI statistic database, China's most complete digital yearbook database. Because officials' data can only be traced back to 1978 and TFR data after 2001 are inaccessible, this article limited the observation period to 1980–2000.

Due to the unique ethnic fertility policies and stability-prioritized tasks in Xinjiang and Tibet, this article excluded data from these regions. We also followed the approach of Li and Zhou (2005) by excluding officials who left their positions within one year, as such short-term appointments would not impact their jurisdictional area. Ultimately, we obtained 141 provincial party secretaries and 156 provincial governors. We processed individual official cases into panel data using person-year methods, obtaining 1153 cases.

Research strategy. This article adopted two statistical models and mediation analysis to uncover the relationship between the bureaucratic process and the fertility decline based on the PAT. Firstly, based on the system GMM, we used the officials' promotion motivation to predict the performance of economic and fertility decline, corresponding to hypotheses 1a and 2a. As shown in Eq. (1), we took the logarithm of performance as the dependent variable and critical age and critical tenure year that affect promotion as explanatory variables for proxy promotion motivation. Due to reforms of pro-younger cadres and limited tenure in the 1980s, promotion-incentivized officials had to deliver competitive performance at critical ages and critical tenure years to earn promotion opportunities (Zhang and Gao, 2007; Guo, 2009).

Secondly, based on ordered logistic models, we used officials' performance on economic development and fertility decline to predict their promotion odds, corresponding to hypotheses 1b and 2b. As shown in Eq. (2), we took the officials' career turnover as the dependent variable and their performance in economic development and fertility decline as the explanatory variable. Economic development performance was measured by the per capita GDP growth and industrialization growth during their tenure, while the TFR decline during their tenure measured fertility decline performance.

Thirdly, based on the system GMM, we conducted the partial mediation method to test whether promotion-incentivized officials facilitated the fertility decline through economic development (Baron and Kenny, 1986; Preacher and Hayes, 2004). Specifically, we used officials' promotion motivation to predict economic outcomes and then the promotion motivation and economic performance to predict fertility decline outcomes. All models controlled for provincial fixed effects to control the confounder effect caused by provincial birth policies; the reason for this approach was explained further in the section "Fixed effect of provincial birth-control policy".

We used a two-step system GMM to alleviate the endogeneity of the dynamic panel data. In panel data, the dependent variable in this year was associated with its value in the last year. However, when we added lagged dependent variable as an explanatory variable, fixed-effect model (FEM) would not figure out the unbiased estimator due to the dynamic panel bias. The two-step GMM model removed the bias by introducing more instrument variables through two-step transformations. The first step was that the current value subtracts the previous value, and the second was subtracting the average of all future variable values (Arellano and Bover, 1995; Roodman, 2009).

$$\ln(Outcome) = \gamma_0 + \sum \gamma_j Motivation_{it} + \gamma_2 \ln(Outcome)_{i,t-1} + \sum \gamma_j M_j + u_i + \varepsilon \tag{1}$$

$$\ln\left(\frac{P(Y > k)}{P(Y \le k)}\right) = \alpha_0 + \alpha_1 performance_{it} + \sum \alpha_j M_j + u_i + \varepsilon \tag{2}$$

Measurement

Dependent variables. The fertility decline outcome was measured by logged TFR. For Eq. (1), we used it to reflect the relationship between officials' promotion motivation and fertility decline. Specifically, we adopted age-specific TFR, which summed age-specific fertility rates for reproductive-age women in a year. With uniform birth behavior, age-specific TFR indicated average lifetime births per woman. In robustness tests, we alternatively adopted parity progression ratio TFR (PPRs TFR), which measured the proportion of women progressing from one parity to the subsequent higher parity over a period of time. The PPRs TFR aligned with China's encouragement and requirement of birth interval.

Political turnover was officials' ranking change after leaving office. For Eq. (2), we followed the approach of Li and Zhou (2005) and classified political turnover into three categories: (1) *Termination* captured those who were punished, demoted, and resigned from leadership. Resignment from leadership means the official has lost the potential to be promoted and can only wait for retirement. Concretely, the resigning concluded those who would leave leadership to serve as a central or local government advisory committee, vice chairman in the Standing Committee of People's Congress or the People's Political Consultative Conference. (2) *Sideway move* referred to a job change without a change in bureaucratic ranking. (3) *Promotion* referred to advancing bureaucratic hierarchy or expanding actual authority. Concretely, it captured those promoted to serve as State Councilors or members of the Politburo and the Standing Committee of the Politburo and those who were transformed from the provincial governor to the party's secretary.

Explanatory variables. Promotion motivation was measured by the critical age and critical tenure year of officials. Due to China's reforms of pro-younger cadre, professionalization, and limited tenure initiated in the 1980s, age and tenure have become essential factors affecting officials' promotion and induced them to struggle for competitive performance at critical age and tenure years. We followed the approach of Zhang and Gao (2007) to estimate the age threshold affecting TFR by age square. We also used proximity to age 59 to indicate officials' promotion motivation since 60 was a typical age for officials to withdraw from leadership. In addition, we used a dummy variable representing one year before leaving office as a proxy for the critical tenure year, as Guo (2009) showed that officials substantially expanded

Table 1 Variables description[a].

Variable	Measurement	Mean	SD
TFR decline rate (%)	Ratio of present TFR to that of first tenure year − 1	4.359	17.276
TFR decline rate VS. the predecessor's (%)	Difference between TFR decline and that of the predecessor's	0.971	8.802
Per capita GDP growth (%)		45.643	71.333
CPI growth	Consumer Price Index growth	0.22	0.347
Age 59+	1 = Older than 59 years old	0.618	/
Industrialization growth	Industrial added value growth	0.376	0.097
Social investment growth	Total fixed assets investment growth	0.633	1.127
Electricity growth	Electricity power growth	0.228	0.423
Agri-machine energy growth	Total agricultural machine power growth	0.14	0.198
Education	1 = Higher than college	0.641	/
ln(TFR)	Logged Total Fertility Rate	0.618	0.372
Proximity to age 59	−1* absolute of age minus 59	−4.421	3.238
Proximity to turnover year	−1* absolute of year minus turnover year	−2.313	2.193
Age	Real age	59.884	5.409
1 year before turnover	One year before leaving office (1 = yes)	0.217	/
2 years before turnover	Two years before leaving office (1 = yes)	0.191	/
Central connection	1 = precedent incumbency in the central government	0.125	/
Per capita GDP (¥10,000)		0.323	0.393
Industrialization	Industrial added value/GDP	0.376	0.097
Divorce rate	Divorced counts/total population	0.146	0.088
Marriage rate[b]	Num. of registered first marriages (10,000)/total population	0.014	0.004
Rural female labor (%)	Female proportion in rural labor force	45.672	6.428

[a]Growth rate = value that year/value in the first year in office − 1.
[b]The observation of first marriage registrations in each province from 1980 to 1984 was missing. We used the complete data from 1985 to 2000 to fit the optimal random forest algorithm (test set R^2 is 0.93) and fill in the missing values ($n = 266$). The number of registered first marriages accounts for the vast majority (96%) of the number of registered marriages.

budget expenditure in their last one and two tenure years to obtain competitive economic performance. We also used proximity to the year of leaving office (a continuous variable) to make up for the insufficiency of a dummy variable of only one or two years.

Fertility decline performance was measured by the age-specific TFR decline rate within the official's tenure. The decline rate referred to the proportion of the difference between the last-year and first-year TFR to the first-year TFR during officials' tenure. For Eq. (2), we used fertility decline performance to predict officials' promotion odds. In addition, we used the squared TFR decline rate to test the inverted "U" association and estimate the potential threshold inflection point. We also used fertility decline performance based on PPRs TFR in place of that based on age-specific TFR for robustness tests.

Economic growth performance was measured by the per capita GDP growth and industrialization growth within officials' tenure. Both growth rates were calculated by the ratio of the difference between the first- and last-tenure-year values to the first-year value.

Radical birth control campaign was measured by squared TFR decline within one term of officials, as intolerant TFR decline best indicated radical campaigns. The radical campaign made rapid fertility decline but risked society instability, which was intolerant of the central government. Based on Eq. (2), showing competitive performance improves promotion odds, we adopt the squared TFR decline to estimate intolerance thresholds of TFR decline by the central government.

Mediators. Per capita GDP and industrialization rate served as mediators between officials' promotion motivation and fertility decline. Per capita GDP summarized average living standards and economic productivity; Cai (2010) used it to measure economic development and invalidate the OCP's effect on fertility decline. For a supplement, we measured the industrialization rate as the ratio of industrial-added value to GDP, reflecting crucial aspects of growth not seen in GDP.

Covariates. Regarding Eq. (1), which used officials' promotion motivation to predict the fertility decline outcome, we controlled potential confounders affecting TFR, including urbanization, female employment, divorce, and marriage rates. Urbanization referred to the proportion of the non-agricultural population in the total population, while the proportion of rural female employees represented female employment. The marriage rate was the ratio of first marriage registrations to the total population; first marriages comprise 96% of all marriage registrations. The divorce rate was the proportion of the divorced population to the total population.

As for Eq. (2), which used fertility decline performance to predict officials' ordinal political turnover, we controlled confounders that affected officials' promotion odds, including officials' characteristics and performance variables. The former included their education level and whether an official was over 59 years old, while the latter referred to economic performance within the official's tenure, including the growth rates of social investment, power generation capacity, agricultural machinery power, and CPI. All growth rates referred to the proportion of the difference between the last-year and first-year values to the first-year values during the official's tenure. Detailed variable descriptions and measurements are shown in Table 1.

Fixed effect of provincial birth-control policy. All models used province fixed effects to control for provincial family planning regulations differences. We followed the scheme of Feng and Hao (1992), reviewed regulations and amendments from 1980–2000 across multiple policy text databases[1], and summarized that the essential contents of provincial birth-control policies were second-child approval conditions and management services. Significant regulation differences lie in second-child approval conditions, rarely involved in amendments. Thus, following Yang (2006), we considered provincial regulation variations as time-invariant individual effects controllable by province fixed effects.
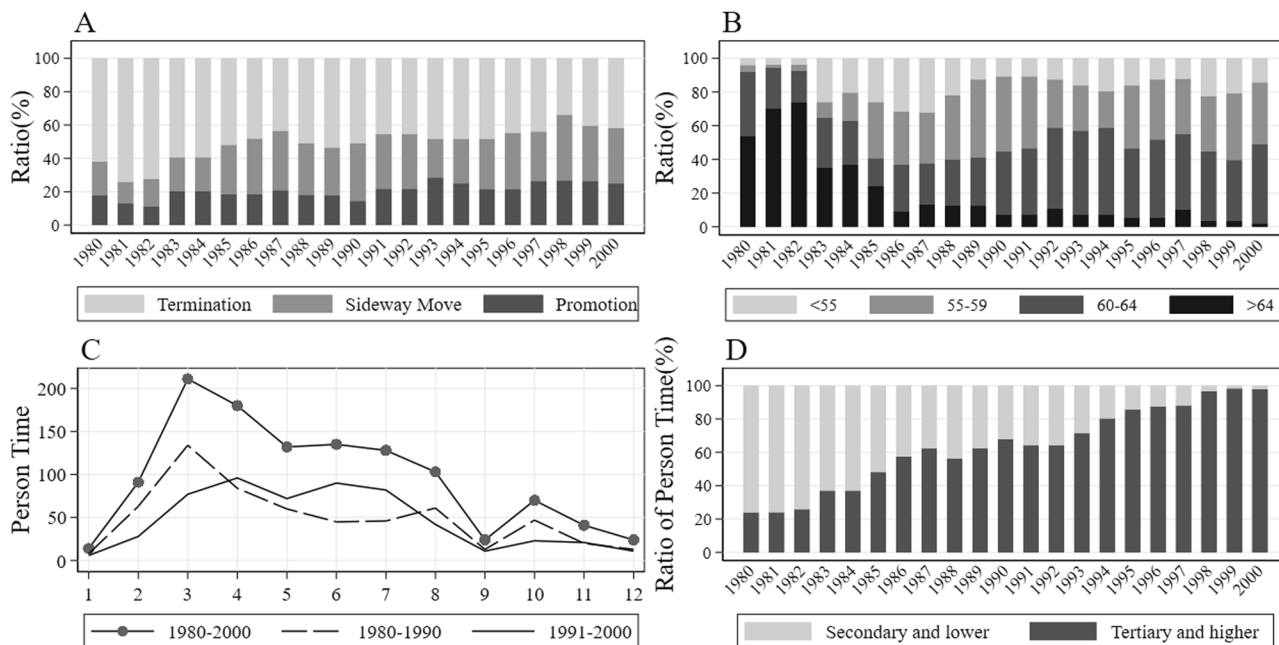
Fig. 3 Description of provincial leaders. A Political turnover structure. **B** Officials' age. **C** Officials' tenure. **D** Officials' education.

Specifically, birth control regulations generally state, "*One couple may only have one child unless meeting certain conditions for second-child approval.*" Based on Feng and Hao (1992), second-child approval conditions fell into three categories: no approval (strict policy), approval for rural couples with one daughter (moderate policy), and approval for rural couples under the birth interval (lenient policy). Five provinces had the lenient policy generally expressed as "*rural couples should have one child, but may apply for a second if facing difficulties.*" Twenty provinces had a moderate policy stating, "*Rural couples should have one child; those with only one daughter can have a second child.*" The remaining provinces strictly prohibited second children for both urban and rural residents.

Despite provincial amendments to family planning regulation in the 1990s, conditions for second-child approval remained unchanged except in Guangdong. Guangdong adopted the moderate policy in September 1998, but this late amendment minimally impacted empirical results. Therefore, we considered provincial regulations as time-invariant fixed effects, given the stability of second-child approval conditions.

Empirical results
Description. Figure 3 showed structures of provincial leaders' person-years about political turnover, age, education, and tenure during 1980–2000. Though the proportion of annual promotion odds increased during 1980–2000, it remained the lowest of the three types of political turnovers (Fig. 3a). The provincial leaders were increasingly younger and higher educated, as the pro-younger and pro-knowledge cadre reforms were initiated in 1982 (Fig. 3b, d). The officials' tenure was increasingly stable, as the curve of the 1990s was smoother than that of the 1980s (Fig. 3c).

Figure 4 depicted China's economic growth and fertility decline from 1980–2000, with a positive association between the ordinal political turnover and development and fertility decline. Per capita GDP grew exponentially during 1980–2000, while TFR remained around 2.5 in the 1980s before falling below replacement level in the 1990s. The per capita GDP and TFR of promoted officials were respectively higher and lower than their

sideway move and termination counterparts. This evidence reflected officials' motivation to make a performance for development and fertility decline. The per capita GDP of promoted officials was higher than their sideway move and termination counterparts, while the TFR of promoted officials was lower than that of their counterparts. This evidence reflected officials' motivation to make a performance for development and fertility decline.

Regression. Tables 2 and 3 showed the results of Eq. (1), which used official's promotion motivation to predict their performance, and Eq. (2), which used their performance to predict promotion odds, respectively. Table 2 showed the FEM as the baseline model, and the coefficients might encounter dynamic panel bias. Estimators of system GMM in Table 2 were more robust than that of FEM, as the coefficients of AR(2) and Hansen test were insignificant, which mean no problem of more than two-order sequence autocorrelation and over-identification instrumental variables.

Promotion of motivation and officials' performance. The officials' promotion motivation was positively associated with economic development. Models 6 and 7 showed coefficients of 0.001 ($P < 0.01$) for proximity to age 59, indicating that an additional one year in officials' age closer to age 59 was associated with an increase in per capita GDP by 10 RMB and an increase in industrialization rate by 0.1%, respectively. A coefficient of 0.002 ($P < 0.05$) for proximity to officials' turnover year in model 6 mean that one year closer to leaving office was associated with 20 RMB higher per capita GDP. One year before leaving office was associated with a 0.3% ($P = 0.08$) increment in the industrialization rate (model 7). Hypothesis 1a was supported. Model 10 in Table 3 showed that one percent higher per capita GDP growth was associated with 1.2% ($e^{0.012}-1$, $P < 0.05$) higher odds of officials' turnover from sideway move to promotion, holding all other variables constant. Hypothesis 1b was supported.

The officials' promotion motivation was positively associated with fertility decline, too. In model 5, the age square coefficient
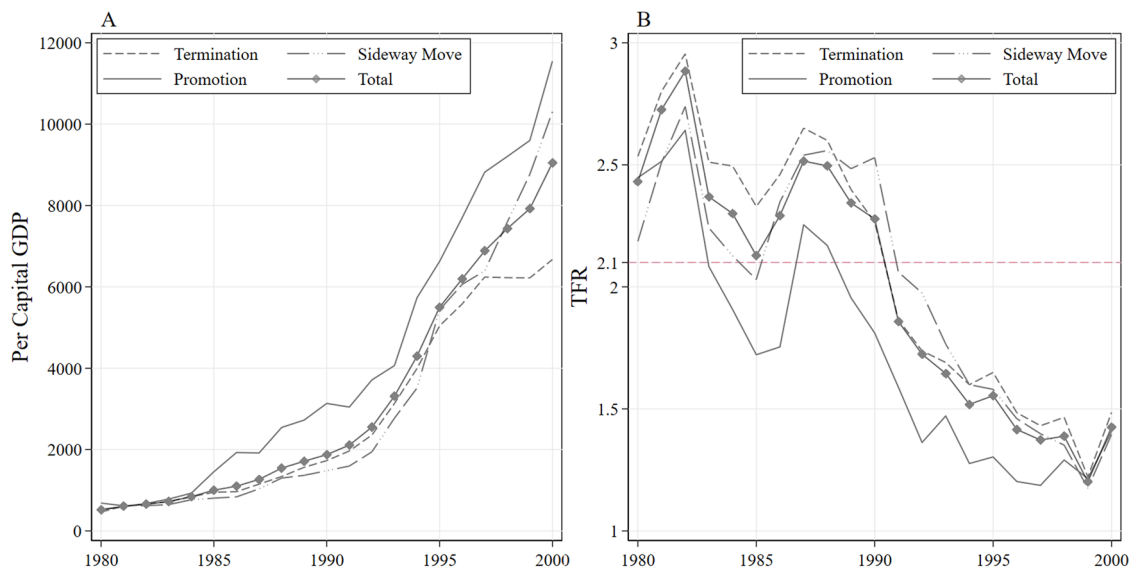
Fig. 4 The effects of promotion tournament. A Political turnover and economic development. **B** Political turnover and fertility decline.

was positive (0.448, $P < 0.05$), indicating a U-shaped association between officials' age and TFR, as demonstrated in Fig. 5b, in which officials aged 59 were associated with the lowest TFR. In model 8, an additional one year in officials' age closer to age 59 was associated with a decrease in TFR by 0.5% ($P < 0.01$). In model 5, one year before turnover was associated with a 1.5% ($P < 0.05$) lower TFR than in other tenure years. Hypothesis 2a was supported. Models 10 and 12 in Table 3, respectively, showed a coefficient of 0.026 ($P < 0.001$) for the TFR decline within his tenure and a coefficient of 0.024 ($P < 0.05$) for the TFR decline compared to the predecessor. They respectively showed that a 1% decrease in TFR during one's tenure or compared to the predecessor's was associated with increased promotion odds by 2.6% ($e^{0.026}-1$) and 2.4% ($e^{0.024}-1$), respectively. Hypothesis 2b was supported.

Economic development as a mediator. However, the results did not show a positive linear association between fertility decline performance and promotion odds for officials. Instead, officials' promotion odds were associated in an inverted U-shape with the declining fertility performance. Model 11 showed a coefficient of −3.759 ($P < 0.05$) for the TFR decline square. It constructed a turning point (37%) for the inverted U-shape association between TFR decline and officials' promotion odds, as shown in Fig. 5a. The promotion odds dropped if the TFR fell by more than 37% within one term. Hypothesis 3 was supported.

Economic development was an effective mediator between officials' promotion motivation and fertility decline. Promotion motivation was positively associated with economic performance: officials' age proximity to 59 and tenure year proximity to leaving office was positively associated with economic performance, including per capita GDP and industrialization rate (model 6 and 7, respectively). Furthermore, these economic outcomes were negatively associated with TFR—a 10,000 RMB rise in per capita GDP associated with 5% ($P < 0.01$) lower TFR, while a 1% increase in industrialization rate associated with 0.152% ($P < 0.05$) lower TFR (model 8). Hypothesis 4 was supported.

Robustness tests. We used the alternative variable for robust tests. Specifically, we converted the algorithm for calculating TFR and TFR decline from age-specific-based to parity-progress-ratios-based, as shown in Table 4. Although less common than age-

specific TFR, PPRs TFR's algorithm accords with birth intervals, aligning with China's requirement for birth intervals. Comparing Tables 2 and 4, coefficients differed slightly, but directionality and significance remained nearly identical. For example, model 3 in Table 4 resembled model 5 in Table 2, showing the U-shaped relationship between officials' age and TFR with a turning point of 59 years old. Age 59 robustly measured officials' promotion motivation since the estimated age threshold affecting TFR using age square was 59, and the proximity to 59 likewise showed that the closer to this age, the lower the TFR.

Conclusion and discussion

Conclusion. Based on novel provincial panel data in China from 1980–2000, we examined local officials simultaneously achieving economic growth and fertility decline for career advancement. Results showed that promotion incentives induced officials to strive for higher economic and fertility decline performance in the critical age (age 59) and tenure year (one year before leaving office) that affected promotion. In turn, economic and fertility decline performance increased officials' promotion odds. In addition, the radical birth control campaign was an unreliable strategy for local officials, as excessive TFR decline (over 37% in a term) may be intolerant of the central government. It may trigger social resistance and sequent punishment of the central government, reducing promotion probability.

Most importantly, officials could facilitate fertility decline through economic development. The closer to age 59 or the year before leaving office, the more likely officials will obtain higher GDP per capita and industrialization. A 1000 RMB increase in GDP per capita and a 1% increase in industrialization were associated with a 5% and 0.152% decrease in TFR, respectively.

Applying PAT and economic-driven theory, we can synthesize a career advancement strategy for local officials under a performance evaluation system prioritizing economic growth and fertility decline. Given limited resources, attention, and scarce opportunities for career advancement, promotion-incentivized officials must maximize both metrics. Developing the economy to enable voluntary fertility decline was efficient and low-risk. In contrast, though immediately lowering TFR, radical birth-control campaigns unwisely risked social instability and subsequent punishment by the central government.

Table 2 Promotion motivation and fertility decline performance.

Dependent variable	FEM as baseline model				System GMM			
	(1) ln(TFR)	(2) Per capita GDP	(3) Industrialization	(4) ln(TFR)	(5) ln(TFR)	(6) Per capita GDP	(7) Industrialization	(8) ln(TFR)
Age	−0.045* (0.018)				−0.053* (0.021)			
Age2 (*10³)	0.380* (0.151)				0.448* (0.183)			
Proximity to age 59		0.001* (0.000)	0.001* (0.000)	−0.005** (0.002)		0.001*** (0.000)	0.001** (0.000)	−0.005** (0.002)
Proximity to turnover year		0.001 (0.001)	−0.000 (0.000)	−0.001 (0.002)		0.002* (0.001)	−0.000 (0.000)	0.000 (0.002)
1 year before turnover	−0.013+ (0.007)	−0.003 (0.003)	0.003+ (0.002)	−0.013+ (0.007)	−0.015* (0.007)	−0.004 (0.003)	0.003+ (0.002)	−0.013+ (0.008)
2 years before turnover	−0.012 (0.012)	0.004 (0.004)	0.003+ (0.002)	−0.013 (0.012)	−0.008 (0.015)	0.004 (0.003)	0.002 (0.002)	−0.009 (0.014)
Central connection	−0.005 (0.012)	−0.014+ (0.007)	0.001 (0.002)	−0.003 (0.012)	−0.007 (0.014)	−0.009 (0.007)	0.000 (0.003)	−0.005 (0.013)
Education (college += 1)	−0.036* (0.015)		0.003+ (0.001)	−0.036* (0.014)	−0.026+ (0.016)	0.012** (0.004)	0.001 (0.002)	−0.024+ (0.014)
Per capita GDP	−0.049* (0.020)	0.000 (0.003)		−0.049* (0.020)	−0.049** (0.017)			−0.050** (0.018)
Industrialization	−0.322** (0.107)	0.045+ (0.026)		−0.326** (0.106)	−0.159* (0.065)			−0.152* (0.066)
Urbanization	−0.045 (0.081)		0.019 (0.013)	−0.039 (0.081)	0.028 (0.023)	0.065* (0.027)	0.021* (0.010)	0.030 (0.021)
Rural female labor	0.000 (0.001)	−0.001 (0.001)	0.001*** (0.000)	0.000 (0.001)	0.000 (0.001)	0.001* (0.000)	−0.000+ (0.000)	0.000 (0.001)
Divorce rate	−0.479*** (0.097)	0.184*** (0.036)	−0.061*** (0.014)	−0.472*** (0.096)	−0.310*** (0.049)	0.080* (0.037)	−0.033* (0.015)	−0.303*** (0.052)
Marriage rate	−0.332 (1.768)	−0.539 (0.453)	0.610** (0.196)	−0.162 (1.752)	−0.306 (1.898)	−1.052+ (0.601)	1.003*** (0.196)	−0.365 (1.957)
Lagged Per capita GDP		1.065*** (0.010)				1.047*** (0.009)		
Lagged Industrialization rate			0.838*** (0.024)				0.868*** (0.030)	
Lagged ln(TFR)				0.778*** (0.023)	0.815*** (0.022)			0.818*** (0.024)
Constant	1.514** (0.457)	0.022 (0.025)	0.013 (0.012)	0.325** (0.099)	1.743** (0.627)	−0.016 (0.013)	0.042** (0.014)	0.185*** (0.049)
Obs	1086	1086	1086	1086	1086	1086	1086	1086
Province-fixed	YES	YES	YES	YES	YES	YES	YES	YES
corr(x, ui)	−0.198	0.184	0.687	−0.186				
Wald					72,989	55,362	136,920	64,911
P - AR(2)					0.375	0.181	0.362	0.413
P - Hansen test					0.374	0.385	0.375	0.381

Robust standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05, +p < 0.1.

Table 3 OLM: the assessment of fertility decline performance of provincial leaders.				
	(9) **Baseline**	**(10)** **Linear performance**	**(11)** **Curve performance**	**(12)** **Vs. Predecessor**
Lagged TFR	−0.595*** (0.153)	−0.288+ (0.173)	−0.326+ (0.176)	−0.822*** (0.244)
TFR decline	0.012* (0.005)	0.026*** (0.005)	0.028*** (0.006)	
(TFR decline)^2 (*10^4)			−3.759* (1.566)	
TFR decline (vs. predecessor)				0.024* (0.011)
Age (59+ = 1)		−1.511*** (0.193)	−1.470*** (0.194)	−1.567*** (0.253)
Per capita GDP growth		0.012* (0.052)	0.012* (0.051)	0.024** (0.009)
CPI growth		−1.980** (0.673)	−1.819** (0.675)	−4.035*** (1.115)
Education (college+ = 1)		0.716* (0.298)	0.660* (0.300)	0.673+ (0.406)
Industrialization growth		−0.084 (1.289)	−0.202 (1.278)	0.068 (1.782)
Social investment growth		−0.441* (0.218)	−0.379+ (0.216)	−0.365 (0.354)
Electricity growth		0.216 (0.188)	0.222 (0.186)	0.083 (0.301)
Agri-machine energy growth		−0.462 (0.654)	−0.516 (0.658)	−0.600 (0.839)
/cut1	−0.350 (0.734)	−1.169 (0.955)	−1.211 (0.951)	−2.183 (1.535)
/cut2	1.661* (0.746)	1.120 (0.973)	1.089 (0.968)	0.321 (1.552)
Province-fixed	YES	YES	YES	YES
Obs	1086	1086	1086	743
Wald λ^2	23,069	15,092	15,458	18,787
Likelihood	−820.1	−745	−742	−480.9

Notes: (1) Ordinal dependent variable Turnover: 0 = termination, 1 = sideway move, 2 = promotion; (2) Robust standard errors in parentheses; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.1$.
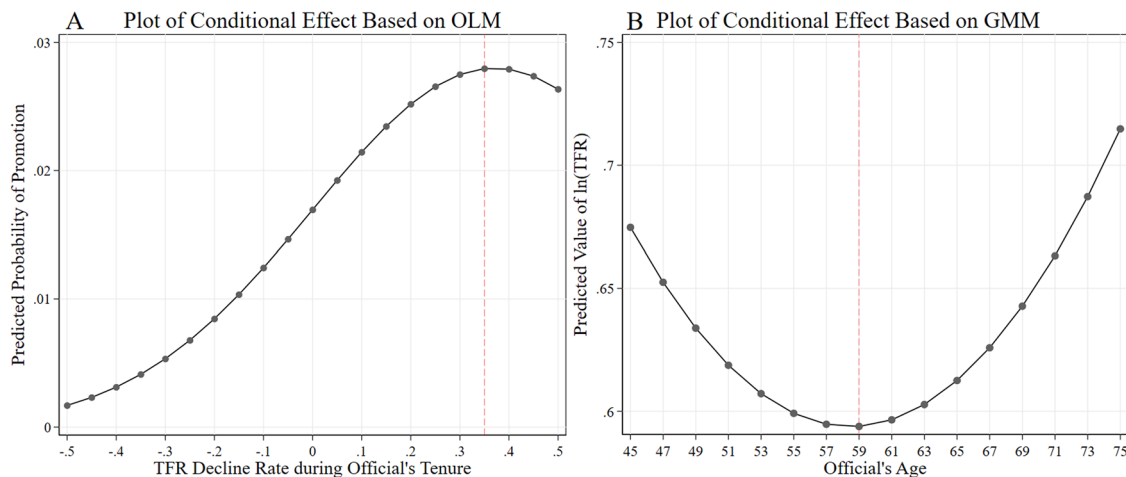

Fig. 5 Conditional effect plot of predicted ln(TFR). A Officials' fertility decline performance and promotion probability. **B** Officials' promotion motivation and fertility decline outcome.

Discussion and contribution. The social science paradigm's inadequacy in fertility transition lay in undeveloped political demography. The political demography was limited because, first, existing studies narrowly focus on direct birth control policies (e.g., one-child policy), emphasizing decision-making over implementation without clarifying the causal mechanisms between bureaucratic processes and fertility decline (Teitelbaum, 2015). Second, such narrow political demography excluded indirect fertility policies and the cooperation between fertility policies and socioeconomic development, even triggering unnecessary debates over whether economic or policy factors primarily drove China's fertility decline (Goodkind, 2017; Hvistendahl, 2017; Wang et al., 2018). However, most fertility policies were indirect policies that provide external conditions to encourage parents' voluntary family planning, such as promoting gender equality and providing accessible contraceptives (Sun, 1987; Kirk, 1996). As a result, people and scholars believed China's socioeconomic development, not family planning policies, predominantly led to the fertility decline.

This article tried to improve the explanatory power of political demography on fertility transition and refine the social science paradigm. It adopted the broad concept of fertility policy and applied PAT to clarify how the bureaucracy achieved the target of fertility decline. It also incorporated the cooperation between political processes and economic development by partial mediation analyses. First, fertility policies were more about indirect policies that provided targets rather than specific measures (Zhou and Lian, 2020). In centralist China, the central government doubts any one-size-fits-all approaches, thus delegating targets and discretion to local officials, requiring localized implementation (Zhou, 2010). Since the central and local governments essentially hold a principal-agent relationship, information asymmetry and preference asymmetry lead to the principal's problem. Locally informed officials are naturally reluctant to proactively achieve targets of the central government, while the central government cannot monitor agents' indolence (Holmstrom and Milgrom, 1991; Miller, 2005). This problem required the outcome-based performance evaluation system linked with

Table 4 Robust tests: promotion motivation and fertility decline performance (PPRs TFR-based).

Dependent variable:	FEM as baseline model		System GMM	
ln(PPRs TFR)	(1)	(2)	(3)	(4)
Lagged ln(TFR)	0.886*** (0.011)	0.889*** (0.011)	0.909*** (0.018)	0.918*** (0.018)
Age	−0.019* (0.008)		−0.021* (0.010)	
Age^2 (*10^3)	0.160* (0.069)		0.179* (0.086)	
Proximity to age 59		−0.002+ (0.001)		−0.002+ (0.001)
Proximity to turnover year		0.001 (0.001)		0.002 (0.001)
1 year before turnover	−0.021*** (0.005)	−0.024*** (0.005)	−0.025*** (0.005)	−0.026*** (0.005)
2 years before turnover	−0.006 (0.005)	−0.007 (0.005)	−0.006 (0.006)	−0.007 (0.007)
Central connection	0.001 (0.008)	0.001 (0.008)	−0.004 (0.010)	−0.003 (0.009)
Education (college+ = 1)	−0.009 (0.007)	−0.005 (0.006)	−0.001 (0.007)	0.003 (0.006)
Per capita GDP	−0.010 (0.008)	−0.010 (0.008)	0.005 (0.010)	0.006 (0.010)
Industrialization	−0.258*** (0.053)	−0.260*** (0.053)	−0.121*** (0.035)	−0.110** (0.034)
Urbanization	−0.041** (0.013)	−0.041** (0.013)	−0.031* (0.012)	−0.031* (0.012)
Divorce rate	0.000 (0.001)	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)
Rural female labor	−0.067 (0.044)	−0.062 (0.043)	−0.078* (0.033)	−0.067* (0.032)
Marriage rate	1.774+ (0.981)	1.922+ (1.010)	2.057* (0.934)	2.171* (0.958)
Constant	0.713** (0.227)	0.117* (0.045)	0.690* (0.310)	0.038 (0.035)
Obs	1086	1086	1086	1086
Province-fixed	YES	YES	YES	YES
corr(x, ui)	−0.064	−0.065		
Wald			146,647	158,011
P - AR(2)			0.290	0.360
P - Hansen test			0.375	0.377

Robust standard errors in parentheses; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.1$.

career advancement, where local officials competed for scarce promotion opportunities by striving for competitive performance on economic growth and fertility decline (Li and Zhou, 2005). Finally, the political process and economic development were not in conflict or unrelated. Instead, officials can facilitate fertility decline through economic growth rather than enforcing radical birth control campaigns.

Limitations. As an exploration of political demography, this article still needs to be improved. First, additional covariates need to be included, i.e., the proportions of ethnic minorities and migrant populations. This article cannot provide such controls due to the data inaccessibility. Nevertheless, the absence of these control variables may have a minor impact on the overall results. The proportion of inter-provincial migrants and remarried individuals was relatively small compared to the total population from 1980 to 2000. Second, the reliability of population data in the 1990s declined compared to earlier periods due to local official intervention (Zhang, 2008). However, the data in this study remained the highest quality currently available. The provincial TFR data for the 1990s used in this study was estimated collaboratively by the East-West Center in Honolulu, U.S.A., and the National Bureau of Statistics of China based on China's 2000 census (National Bureau of Statistics of China and East-West Center, 2007), also adopted by Retherford et al. (2005) for measuring inter-provincial fertility differentials. In addition, while acknowledging underreporting and misreporting, some overseas Chinese demographers argued insufficient evidence of large-scale or widespread 1990s birth underreporting, believing the extent was overestimated. Despite limitations, they contend successive surveys reflected genuine, substantial fertility declines (Zhang and Yuan, 2004).

Notes:

1. Databases of birth control policy texts included "Complete Book of Laws and Regulations of the People's Republic of China (Volume 10)", "Compilation of Family Planning Regulations (Measures) of Provinces, Autonomous Regions and Municipalities" and Peking University Law Database (http://www.pkulaw.cn/).

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Author contributions

Competing interests

Ethical approval

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Additional information

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