

# Replication of ‘China’s Low-Productivity Innovation Drive: Evidence from Patents’\*

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## Abstract

Can authoritarian regimes mobilize bureaucracies to achieve genuine technological innovation? Ang et al. (2023) document that China’s 2006 innovation campaign led to bureaucratic gaming, as cadres inflated patent counts with easing the registration for low quality patents. This paper first replicates their core findings and then extends the analysis to examine critical heterogeneity in cadre characteristics to answer the following question: Who games? Using data on 4.6 million Chinese patents from 1990-2014 and information on 2,337 party secretaries across 276 cities, I find that party secretary characteristics such as age, education, and gender do not moderate gaming behaviour. This suggests that gaming is not an issue of bad actors but a universal defining feature of target-driven cadre evaluation on bureaucratic performance in authoritarian contexts.

## 1 Introduction

The introduction of comprehensive export controls and investment restrictions for China by the Trump administration marks the intensification of technological competition between world’s strongest superpowers - the United States of America and China. Having only \$300 of GDP per capita in the 1980s, China’s rapid technological advancement has undeniably

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become one of the most salient and largely contested topics of contemporary geopolitics. China's achievements in many fields such as railroads, robotics and EV industry are indeed undeniable. Yet still a critical question arises: to what extent is China an actual rival innovator to the US? This is particularly relevant to address as in 2023 alone, China issued almost three times the size of patents issued by the US. Notwithstanding this, many have raised skepticism regarding the genuine quality of Chinese patents arguing that the excessive filing is a response to government directives rather than market incentives (Atkinson (2024)).

To address this question, Ang et al. (2023) explore how the adoption of 2006 National Medium and Long Term Program for Science and Technology Development by the Chinese Communist Party influenced the quality of registered patents in China. With its adoption, the program essentially assigned numerical patent quotas to local governments, obliging cadres to fulfill the government targets to ensure good performance evaluation score. To study its impact, the authors first develop a metric of measuring patent quality, by classifying a patent as novel only if it represents the first-ever combination of at least two previously uncombined technology domains. Then using a comprehensive data on 4.6 million patents filed between 1990 and 2014, Ang et al. (2023) effectively reveal a strong evidence of bureaucratic gaming. The political competition among cadres increased total patent counts but decreased the share of novel patents. They argue that this is because local officials respond to innovation targets by lowering the threshold for registering patent and thus inflating easily-measured metrics.

The findings of Ang et al. (2023) are very nuanced and help understand the shortcomings of quota-driven governance. Yet their analysis does not answer a critical questions: Are some cadres more likely to game than others? If gaming varies by official characteristics, this reveals fundamental insights about how authoritarian incentives operate. Consequently, contributes to the discussions of Ang et al. (2023) by examining whether individual party secretary characteristics, namely age, education, and gender systematically affect gaming

behaviour This is an important question because younger officials have better prospects for career promotion which theoretically suggests that younger officials are expected to game more aggressively. Furthermore, this will allow to test whether levels of educational attainment or gender constrain or promote gaming.

Using exclusively the same data from the authors I find that age, education, and gender do not influence gaming behavior. This ultimately demonstrates strong institutional pressure which overcomes individual differences in personnel characteristics of cadres. Ultimately gaming behavior is not a problem of “bad actors”, but rather a sign of a structural limitation of cadre evaluation system in promoting innovation.

## 2 Background, Data, and Research Design

Ang et al. (2023) are primarily tasked with analyzing if the notion of authoritarian advantage holds true when it comes to promoting innovation. The literature on authoritarian advantage contends that the centralized top-down control of authoritarian regimes allows large-scale and long-term planning and can give them unique privilege to build and implement infrastructure and development projects. In doing so, they aim to assess whether China can catch up with the United States technologically by mobilizing its bureaucracy and setting ambitious goals for local governments through cadre-evaluation system.

The authors employ an original dataset of 4.6 million domestic patents filed in 333 mainland Chinese cities from 1990 to 2014, paired with comprehensive data on city-level economic indicators and party secretary characteristics. Patent records provide an objective, verifiable measure of innovation output. The key methodological innovation by Ang et al. (2023) is their rigorous “patent novelty” measure: a patent is coded as novel only if it represents the first-ever combination of two previously uncombined technology domains. The authors recognize that raw patent counts can be gamed by filing trivial modifications. In contrast, cross-industry combinations they look for, require genuine technological creativity and are much harder to fabricate. This distinction between total patents and novel share is therefore central to their theoretical contribution.

Their findings reveal a fundamental insight: while China’s 2006 “National Medium- and Long-Term Plan for Science and Technology Development” successfully increased the number of patents registered (even surpassing the United States in 2011), the share of innovative, high-quality patents has steadily declined, from 10.2% in 2006 to 3.7% in 2014. The authors explain this deterioration by widespread bureaucratic gaming. As local officials were now evaluated by their capacity to boost patent registrations, under competitive pressure they have redirected efforts toward easy-to-produce, non-innovative patents to achieve good looking statistical results. Consequently, under such system of incentives, the authors conclude,

the Chinese innovation system is “enormous in scale but low in productivity” (p. 1).

Using two-way fixed effects models with city and year fixed effects, the authors test two hypotheses. H1 contends that intense local political competition after 2006 correlates with higher patent quantity, while H2 contends that it correlates with a lower share of novel patents. Political competition is measured as the inverse standard deviation of fiscal revenue growth among cities within each province. The authors argue that fiscal revenue performance is the primary metric by which provincial governments evaluate and rank city-level officials. They argue this creates tournament-style incentives, and with the increase in the levels of competition intensity we observe an increase in total patents but also decrease in the share of novel patents.

Overall, this paper is highly important in comparative political science for three important reasons. First, it directly contributes the debate on the “authoritarian advantage” by providing nuanced, large-scale empirical evidence that challenges the view of China’s state mobilization as a straightforward success. Second, it moves beyond a simple fail vs succeed dichotomy by distinguishing between the scale and productivity of innovation, offering a more sophisticated framework for evaluating state-led development. Third, it contributes to the literature on principal agent problem by identifying a clear political mechanism—gaming behaviour of cadres. This the authors argue explains why top-down directives for sophisticated and hard-to-measure goals like innovation can produce perverse outcomes. All in all, the conclusions drawn here are highly relevant for understanding the differences of innovation policy between China and the US. The gaming behavior uncovered by the authors helps illuminate key challenges in the political economy of innovation under authoritarian rule.

In this paper, I first replicate the core regression results from Ang et al. (2023)’s Table 4, specifically Models 2 and 3. I test the interaction between political competition labeled as IPC in the original paper and the post-2006 campaign period on both patent quantity and

novel patent share. I use the same two-way fixed effects specification with city and year fixed effects. Standard errors are clustered at the city level, following Ang et al.'s approach (p. 21). I also include exactly the same city-level and official-level controls (log GDP per capita, population growth, FDI, gender, age, education) as the original models.

Afterwards I improve upon it by further extending their analysis through my analysis of the interaction between the cadre characteristics and their tendency to game. While Ang et al. (2023) control for official characteristics as fixed intercepts, I relax this assumption through three-way interactions that allow the treatment effect to vary systematically by context. With this, I specifically assess whether younger, more educated, or female secretaries respond differently to political competition after 2006, which consequently serves to identify conditional average treatment effects. This analysis has important theoretical implications as it allows us to determine whether gaming behavior is heterogeneous across different groups of players or a uniform response to the campaign.

### 3 Replication

Figure 1 and Figure 2 replicate the key descriptive patterns from Ang et al.'s Figures 1 and 3. They essentially reconfirm the divergence reported by the authors between patent quantity and quality after the 2006 campaign.

Consistent with Ang et al.'s findings, Figure 1 above demonstrates the sharp increase in the number of patent filings after 2006. Thus it can be deduced that innovation campaign has indeed mobilized bureaucratic effort toward meeting the numerical targets. Meanwhile Figure 2 below reveals the impact of the campaign on patent quality and signals bureaucratic gaming. As one can deduce from the figure, the number of novel patents constantly increases before 2006, and then while total patents surge, the share of genuinely novel patents declines. The most important empirical pattern here that Ang et al. (2023) found is the simultaneous rise in patent quantity on the one hand, and the decline in quality on the other.

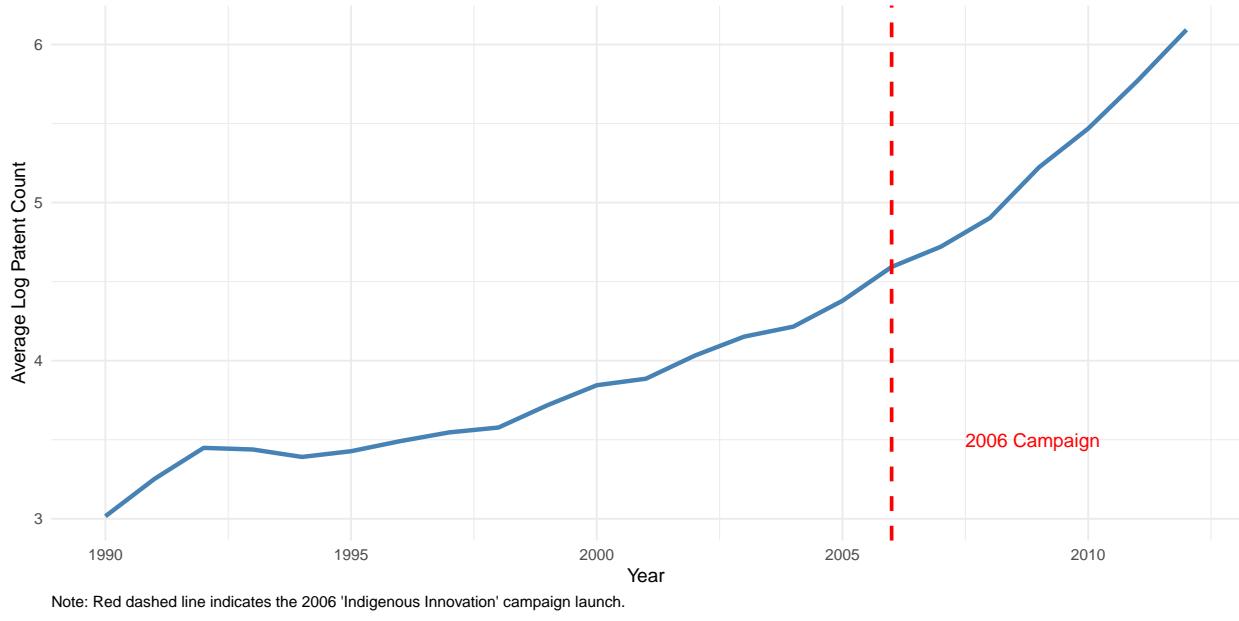


Figure 1: Replication of Ang et al. Figure 1: Patent Quantity Surged After 2006

Table 1 replicates the core regression results from Ang et al.'s Table 4 (Models 2 and 3). These models test whether political competition (IPC) after the 2006 campaign affects patent quantity and quality differently.

The coefficient on  $\text{IPC} \times \text{Post}$  is positive for total patents, indicating that political competition after 2006 increased patent filings. Critically, the same coefficient is negative for novel patent share, indicating that higher competition reduced the quality composition of patents. These results closely mirror the original study's Table 4: there is an 8.4% increase in total patents and a 0.47 percentage point decrease in the share of new patents for every standard deviation increase in competitive intensity after 2006. Officials have indeed responded to innovation goals by inflating the number of patents while sacrificing more difficult-to-measure quality, its degree of novelty. Having confirmed the basic effect of manipulation, I now turn to the central question of this replication work: who games?

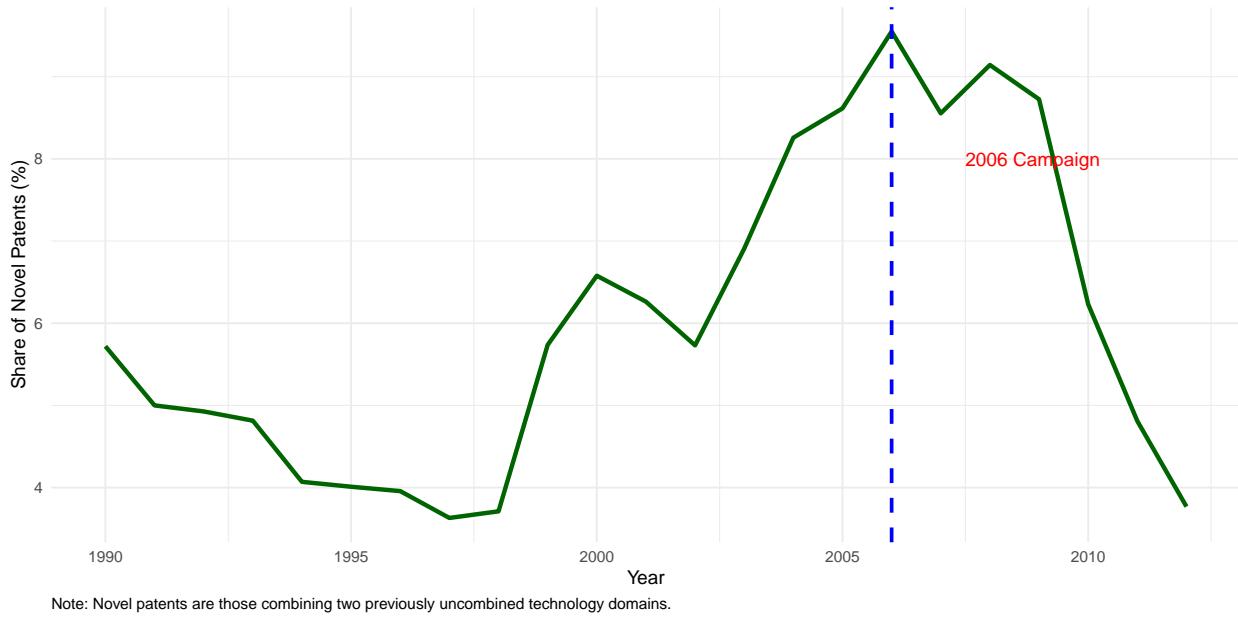


Figure 2: Replication of Ang et al. Figure 3: Novel Patent Share Declined After 2006

Table 1: Baseline Gaming Regressions (Replication of Ang et al. 2023)

Table 2: Baseline Gaming Regressions

	Total Patents (log)	Novel Patent Share
IPC × Post-Campaign	0.084*** (0.022)	-0.470** (0.180)
IPC	0.010 (0.007)	0.078 (0.078)
Num.Obs.	5049	5044
R2	0.912	0.292
Std.Errors	by: citycode	by: citycode

+ p <0.1, \* p <0.05, \*\* p <0.01, \*\*\* p <0.001

## 4 Extension/Discussion

The aggregate gaming effect noted above may mask other heterogeneity, and in cases where gaming is systematically associated with official characteristics, reveals how authoritarian incentive structures operate in practice and suggest targeted rather than uniform policy reforms. The question is the following: do these characteristics of party secretary moderate gaming?

There are conflicting expectations from Chinese political economy theory regarding individual level covariates. Age, for example, is relevant to career horizon theory: younger individuals have longer career horizons and thus more of an incentive to obtain promotable achievements. Therefore, if younger age matters, we should expect greater gaming (Ang et al. 2023). First, 55 is considered to be a ceiling age as officials in their 50s are less likely to be promoted. Second, education may work through two opposing mechanisms (Shirk, 2021). Highly educated government officials may recognize the costs of using low-quality products in the long run and refrain from doing so. On the other hand, education may create better strategies to navigate target systems. Lastly, gender is important as well as female officials in a patriarchal system face more scrutiny and have more to lose than male officials. Testing these moderators is important for principal-agent theory. If game-playing is driven by type, then recruitment or performance evaluations should be the main focus of reforms. If it is universal, then it is a design problem. This is a natural extension of our current argument, as Ang et al. do not analyze the wealth of biographical data they gathered on party secretaries.

I estimate three-way interactions of the form:

$$Y_{it+1} = \beta_1(\text{IPC}_{it} \times \text{Post}_t) + \beta_2(\text{IPC}_{it} \times \text{Post}_t \times \text{Moderator}_i) + \gamma X_{it} + \alpha_i + \delta_t + \epsilon_{it}$$

The coefficient  $\beta_2$  on the three-way interaction is the key quantity of interest. It indicates

whether younger officials reduce novel patent share more or less than older officials when IPC intensifies after 2006. A significant negative  $\beta_2$  would indicate that the moderator group games more (larger reduction in novel patent share); a significant positive  $\beta_2$  would indicate they game less. In potential outcomes terms,  $\beta_2$  tests whether  $E[\tau_i | \text{Young}] \neq E[\tau_i | \text{Old}]$ —that is, whether the Conditional Average Treatment Effect (CATE) differs across observable subgroups. Failure to reject the null ( $\beta_2 = 0$ ) suggests homogeneous treatment effects across official types.

Following Ang et al. (2023), all outcome variables are measured at  $t+1$ , which is a temporal structure strengthening the causal logic by ensuring that bureaucratic incentives precede patenting outcomes. Competitive pressure in year  $t$  leads officials to encourage filings and relax approval thresholds and this actions only materialize as registered patents in the following year. Lagging outcomes also avoids simultaneity bias, preventing political competition and patent filings from being jointly determined within the same year.

To operationalize the moderators, for age I divide party secretaries into 2 dichotomous groups: younger and older. I do so by using the sample median as the cutoff which is appropriate because it avoids imposing arbitrary thresholds and ensures balanced group sizes, which improves the precision of interaction estimates in finite samples. To operationalize the the differences across education, I build a a binary variable equal to one for officials holding a Master's degree or above (edu > 4), distinguishing cadres with advanced human-capital profiles from those with only undergraduate degrees (nearly all have undergraduate, which makes it a baseline).

The results in Table 3 and Figure 3 present a null result. This indicates no systematic heterogeneity in gaming across any party secretary characteristic. The baseline gaming effect  $\text{IPC} \times \text{Post}$  remains negative across all specifications thus confirming that political competition reduces novel patent share post-2006. Furthermore, none of the three-way interactions reach statistical significance,  $\text{IPC} \times \text{Post} \times \text{Young}$   $\hat{\beta}_2 = 0.039$ ,  $\text{SE} = 0.262$ ,  $\text{IPC} \times \text{Post} \times \text{High}$

Table 3: Do Party Secretary Characteristics Moderate Gaming?

	Age	Education	Gender
IPC $\times$ Post	-0.411*	-0.397	-0.387**
	(0.238)	(0.345)	(0.171)
IPC $\times$ Post $\times$ Young	0.039		
	(0.262)		
IPC $\times$ Post $\times$ High Edu		0.012	
		(0.376)	
IPC $\times$ Post $\times$ Female			-0.169
			(0.701)
Num.Obs.	5044	5044	5044
R2	0.292	0.292	0.291

\* p <0.1, \*\* p <0.05, \*\*\* p <0.01

Edu  $\hat{\beta}_2 = 0.012$ , SE = 0.376, and IPC  $\times$  Post  $\times$  Female  $\hat{\beta}_2 = -0.169$ , SE = 0.701 are all statistically indistinguishable from zero.

In all three cases, the confidence intervals overlap zero, and point estimates cluster tightly around zero. Equally important is the fact that all three coefficients are small in magnitude  $|\beta_2| < 0.17$  with confidence intervals tightly centered on zero, ruling out even moderate heterogeneity. In CATE terms:  $E[\tau_i | \text{Young}] \approx E[\tau_i | \text{Old}]$ ,  $E[\tau_i | \text{High Edu}] \approx E[\tau_i | \text{Low Edu}]$ , and  $E[\tau_i | \text{Female}] \approx E[\tau_i | \text{Male}]$ .

Before tuning into the discussion of the results, it should be noted that patent distributions are right-skewed. In other words, this essentially means that innovation in China is geographically concentrated in China's megacities with Shenzhen, Beijing, Shanghai and Guangzhou leading the race for patent production. This is particularly important to note as it raises the possibility that extreme values could influence the null heterogeneity results. To this end, it is particularly useful to apply of winsorized (10% trimmed) to re-estimate the models of measure of novel patent share. This is a practical fix that effectively deals with extreme values without completely throwing away observations like we might do with

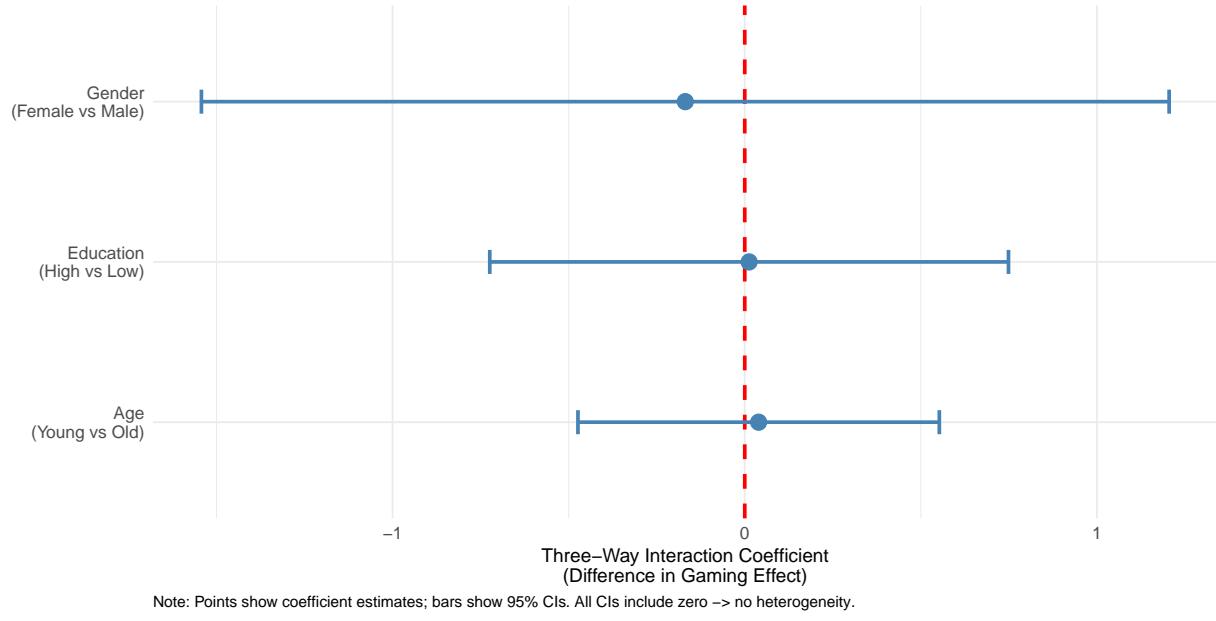


Figure 3: Gaming is Universal: No Heterogeneity by Party Secretary Characteristics

trimming. Essentially, we're saying we limit their influence which in turn helps stabilize our estimates and makes them less sensitive to a handful of extreme observations.

The supplements section shows the detailed results of (Table 4), reconfirming our baseline findings. Across all specifications, the three-way interaction terms still remain statistically indistinguishable from zero. Their magnitudes  $-0.05$  for age and  $-0.016$  for education are substantively minor relative to the baseline  $\text{IPC} \times \text{Post}$  effect. Meanwhile one should note that the gender estimate of  $+0.208$  is not particularly insightful given the limited number of female party secretaries. All in all, it can be confidently concluded that even with winsorized, these results confirm that the characteristics of the cadres do not have a significant impact on the reactions of the participants in the political struggle after 2006. The results remain consistent even when using a more outlier-resistant estimation method which thus serves to strengthen our conclusion that data manipulation occurs regardless of the characteristics of the party committee secretaries.

The universal and homogenous pattern of gaming thus suggests that campaign-style initiatives reshape the bureaucratic environment so deeply that compliance behavior becomes

institutionally embedded. Given the numerical quotas put, data manipulation becomes the most logical response from the local governance . In such environments, the key focus for local cadres becomes appearance. That is the incentive guiding their choices is not the desire for genuine development but the statistical data that appears successful. A broader conclusion therefore suggests that to implement successful reforms the Chinese Communist Party should address the limitaions of cadre evaluation system to address the problem of misaligned incentives. Recent trends in China show that the party is becomes more and more aware of the gaming behaviour and gradually replaces quantifiable targets with multi-dimensional often qualitative evaluation metrics (Ning, 2023). Under such system even highly competent and well-trained cadres are incetivized to game. If cadre evaluation is not upgraded to acuratley capture the qualitative dimensions of complex parameters such as innovation, policy implementation will systematically deviate from the original goals of CCP.

Among the three variables, age is the most theoretically informative aspect of the null results. Ang et al. (2023) suggest that competition for promotion is the primary mechanism explaining the gaming behaviour. Yet, if this gaming strategy was indeed a tool of ambitious officials seeking to advance up the administrative ladder, then we should have observed a decrease in the gambling among older personnel who have reached or are approaching the age limit for promotion. The data, in reality, rejects this not this trend, as gaming is consistent even among officials with limited career prospects. This hints an important nuance: gaming is not conditioned by the promotion incentive, but by much simpler need for bureaucratic survival. Cadres opt for boosting low quality patents to avoid penalties and dismissal and meeting the quota is first and formest a strategy for maintaining one's position rather than competing with colleagues. This therefore leads to an important conclusion: gaming is the direct consequence of the systemic and institutionally driven response to incentives from above, rather than an individual-level strategy for career prospects.

When it comes to education, the theoretical expectation implies be that higher levels of

educational attainment might lead cadres to value genuine innovation more. Yet the opposite could also be argued: with stronger educational backgrounds, cadres may possess the needed skills to manipulate performance metrics more effectively. Having said this, the null result for education indicates that higher levels of formal schooling do not meaningfully increase or decrease gaming behavior. More educated cadres, like their counterparts, face the same structural pressures and are therefore equally likely to inflate performance indicators.

Lastly for interpreting the results of gender, the analysis suffers from a key limitation. The data on gender should be interpreted with caution, as the dataset exhibits limited variation. Only approximately 1.9% of party secretaries in the sample are female which essentially removes the statistical power to detect even moderate gender effects. What this means is that the supermajority of cadres are male and this reduces the statistical power to detect the effects of gender on gaming.

## 5 Conclusion

This paper replicated the main empirical findings of Ang et al. (2023) and extends their analysis by examining how bureaucratic manipulation that emerged after the 2006 Chinese innovation campaign varied depending on the individual characteristics of cadres. Using the authors' original data, variable definitions, and a two-factor fixed-effects model, I first successfully replicated the main finding and reconfirmed that patent quotas increased the scale of patents but reduced their quality. Building on this, I then examined whether the magnitude of this manipulation effect varied by age, education, or gender. My conclusion effectively demonstrates that gaming is not an issue of “bad actors” but a consequence of bad incentives stemming from poor institutional design. The estimated three-factor interactions across all models are statistically indistinguishable from zero and substantively insignificant. The absence of systematic heterogeneity in the intensity of manipulation across different types of cadres. Using a winsorized measure of the share of new patents, I also conducted

a robustness check using which similarly confirms that the manipulation was a universal response to the campaign incentive system.

These findings contribute to the literature on principal-agent problems in authoritarian regimes by clarifying how the design of performance evaluations shapes bureaucratic behavior and generates systematic distortions. When performance quotas are based on measurable yet easily falsifiable metrics, institutional incentives overshadow individual differences, generating a universal incentive to game. The subsequent policy imperative therefore suggests that reforms aimed at improving personnel, such as selecting younger, better-educated, or more diverse employees, are unlikely to reduce manipulation. To achieve genuine improvements in the quality of patents, the central government in China must address the simplistic evaluation system that rewards quantity over quality. Future research could examine how China revised its environmental performance metrics to curb gaming, thereby shedding light on what types of indicators better capture hard-to-measure aspects of bureaucratic performance and more effectively align incentives with policy objectives. Developing robust alternative monitoring systems, linking the career incentives to genuine innovation, and improving institutional oversight can all in some ways mitigate manipulation and better align bureaucratic behavior with long-term development goals.

## 6 Supplementary Material

The data, code, and any additional materials required to replicate all analyses in this article are available at <https://github.com/yourusername/china-patent-replication>.

### 6.1 Robustness Check: Trimmed Mean of Novel Patent Share

A small minority of cities, the technological centers of China, generate disproportionately large patent volumes, which raises a concern and skewed data. In other words, the null heterogeneity observed could also be driven by outliers. For instance cities highly educated cadres might be clustered in richer cities with heavier distributional tails. Consequently, if outliers differ systematically across moderator groups the baseline OLS estimates could generate spurious null results.

To address this, I re-estimate the Extension 1 models using a winsorized (10% trimmed) version of novel patent share as the outcome, which essentially replaces extreme values beyond the 10th and 90th percentiles with the boundary values. This is meant to reduce outlier influence without discarding observations and aligns with robust estimation principles.

Table 4: Robustness Check: Winsorized Novel Patent Share (10% Trim)

	Age	Education	Gender
IPC × Post	-0.279** (0.126)	-0.282* (0.164)	-0.299*** (0.098)
IPC × Post × Young	-0.050 (0.169)		
IPC × Post × High Edu		-0.016 (0.196)	
IPC × Post × Female			0.208 (0.557)
Num.Obs.	5044	5044	5044
R2	0.385	0.385	0.385

\* p <0.1, \*\* p <0.05, \*\*\* p <0.01

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